सत्यमेव जयते

**Government of India**

**Directorate General of Civil Aviation**

# FINAL INVESTIGATION REPORT ON INCIDENT TO M/S AIR INDIA EXPRESS B737-800 AIRCRAFT VT-AYC AT CHENNAI ON 26.12.2022

# FOREWORD

In accordance with Annex 13 to the International Civil Aviation Organisation Convention and the Aircraft (Investigation of Accidents & Incidents) Rules 2017, the sole objective of this investigation is to prevent aviation incidents/ accidents in the future. The investigation conducted in accordance with the provisions of the above said rules shall be separate from any judicial or administrative proceedings to apportion blame or liability.

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

# GLOSSARY

| | | |
|---|---|---|
| 1. | ATC | Air Traffic Control |
| 2. | AIXL | Air India Express Limited |
| 3. | AME | Aircraft Maintenance Engineer |
| 4. | AMM | Aircraft Maintenance Manual |
| 5. | AMP | Aircraft Maintenance Program |
| 6. | AOG | Aircraft-on-Ground |
| 7. | ATPL | Airline Transport Pilot Licence |
| 8. | BITE | Built-in test equipment |
| 9. | BSI | Borescope Inspection |
| 10. | CAM | Continuing Airworthiness Manager |
| 11. | CAMO | Continuing Airworthiness Management Organization |
| 12. | CAR | Civil Aviation Requirements |
| 13. | CPL | Commercial Pilot License |
| 14. | CSN | Cycles Since New |
| 15. | CVR | Cockpit Voice Recorder |
| 16. | DGCA | Directorate General of Civil Aviation |
| 17. | DFDR | Digital Flight Data Recorder |
| 18. | EEC | Electronic Engine Controls |
| 19. | EGT | Exhaust Gas Temperature |
| 20. | ESN | Engine Serial Number |
| 21. | EGTHDM | Exhaust Gas Temperature Hot Day Margin |
| 22. | FL | Flight Level |
| 23. | FOD | Foreign Object Damage |
| 24. | HPTR | High Pressure Turbine Rotor |
| 25. | HPT | High-Pressure Turbine |
| 26. | IFR | Instrument flight rules |

| | | |
|---|---|---|
| 27. | LPT | Low-Pressure Turbine |
| 28. | LH | Left Hand |
| 29. | LPT | Low-Pressure Turbine |
| 30. | LMM | Line Maintenance Manager |
| 31. | MCC | Maintenance Control Centre |
| 32. | MRO | Maintenance Repair and Overhaul |
| 33. | NGV | Nozzle Guide Vane |
| 34. | NNC | Non-Normal Checklist |
| 35. | OEM | Original Equipment Manufacturer |
| 36. | OMSJ | Sharjah International Airport |
| 37. | PIC | Pilot-in-Command |
| 38. | RH | Right Hand |
| 39. | SCF-PP | System/Component Failure- Powerplant |
| 40. | TAT | Total Air Temperature |
| 41. | TSN | Time Since New |
| 42. | UTC | Coordinated Universal Time |
| 43. | VOCL | Calicut International Airport |
| 44. | VOTR | Tiruchirappalli International Airport |
| 45. | VFR | Visual Flight Rules |

# INDEX

# Investigation Report on Incident to M/s Air India Express B737-800 Aircraft VT-AYC at Chennai on 26/12/2022

| | | | |
|---|---|---|---|
| 1. | Aircraft | | |
| | Type | : | Boeing 737 |
| | Model | : | Boeing 737-800 NG |
| | Nationality | : | Indian |
| | Registration | : | VT-AYC |
| 2. | Owner | : | M/s Air India Express Limited (AIXL) |
| 3. | Operator | : | M/s Air India Express Limited |
| 4. | Pilot-in-Command | : | ATPL Holder |
| | Extent of injuries | : | Nil |
| 5. | First Officer | : | CPL Holder |
| | Extent of injuries | : | Nil |
| 6. | Date of Incident | : | 26/12/2022 |
| 7. | Time of Incident | : | 21:21 UTC (approx.) |
| 8. | Place of Incident | : | Chennai |
| 9. | Last point of Departure | : | VOTR (Tiruchirappalli International Airport) |
| 10. | Intended place of Landing | : | WSSS (Singapore Changi Airport) |
| 11. | No. of passengers on board | : | 160 (Excluding Crew) |
| | Extent of injuries | : | Nil |
| 12. | Type of operation | : | Scheduled Commercial Air Transport Operation |
| 13. | Phase of operation | : | En-route |
| 14. | Type of Incident | : | SCF-PP |

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

**Synopsis:** -

On 26/12/2022, M/s Air India Express Limited (AIXL) Boeing B737-800 aircraft VT-AYC operating flight IX-682 from Tiruchirappalli to Singapore was diverted to Chennai due to engine#1 stall. The aircraft was under the command of an ATPL holder, who was Pilot Monitoring (PM) along with a co-pilot, a CPL holder, who was Pilot Flying (PF). There were 160 passengers on board the aircraft along with 06 crew members.

The aircraft took off from Tiruchirappalli airport at 21:09 UTC and had an uneventful flight until the climb phase at FL230. While passing flight level (FL) 230, the crew heard a thud sound followed by a reduction in engine#1 N1 from 98% to approximately 65% N1 with an increase in engine vibration. Subsequently, the engine#1 fuel flow started decreasing and N2 was also dropped. All other engine parameters were within limits and no engine exceedance was observed. The engine#1 thrust lever was brought back to idle as per the non-normal checklist. ATC was informed and the crew decided to divert the aircraft to Chennai. The aircraft landed safely at Chennai by 22:04 UTC.

DGCA-India, vide Order No DGCA-15018(21)/2/2023-DAS dated 23.01.2023, instituted an investigation of the incident under Rule 13 (1) of Aircraft (Investigation of Accidents and Incidents), Rules 2017 by an Investigator-In-Charge.

The probable cause of the incident was the failure to monitor the engine performance degradation trend alerts generated by the OEM, thereby delaying the customer notification report and recommended tasks, which led to the engine stall during the flight.

## 1. Factual Information: -

### 1.1 History of Flight: -

On 26th December 2022, M/s Air India Express Limited (AIXL) Boeing B737-800 aircraft VT-AYC was scheduled to operate flight IX-682 from Tiruchirappalli to Singapore. There were a total of 166 personnel on board (including crew) for the flight sector. Both the cockpit crew members had undergone the pre-flight breath analyzer test at Tiruchirappalli before operating the flight and were cleared to operate the flight.

The aircraft operated the previous flight sector from Sharjah to Tiruchirappalli by a different set of crew. The aircraft departed from Sharjah at 16:16 UTC and reached Tiruchirappalli at 19:54 UTC. After the necessary transit inspection of the aircraft at Tiruchirappalli, the crew did not report any abnormalities; after which the crew operated the incident sector (Tiruchirappalli - Singapore). There was no abnormality reported on the aircraft during previous flights of the day. This was the first flight of the day for the crew and the fifth sector for the aircraft.

There were 160 passengers on board and the flight was operated by 02 cockpit crew and 04 cabin crew. The aircraft took off from Tiruchirappalli at 21:09 UTC. At 21:21:37 UTC, while climb passing FL230, a thud sound was heard by the crew followed by a reduction in engine#1 N1 from 98% to

approximately 65% N1. Subsequently, engine#1 fuel flow started dropping rapidly and EGT increased to 913°C and engine#1 N2 also dropped. Meanwhile, the PIC had taken over control. At 21:21:37 UTC, it was observed from DFDR data that engine#1 Low-pressure turbine (LPT) vibration started increasing and went up to 3.82 units and similarly, at 21:21:43, engine#1 fan vibration started increasing and went up to 2.51 units.

At 21:22:40 UTC, the cabin crew informed the crew that they had heard a sound in the cabin. Crew referred to the non-normal checklist (NNC) for engine high vibration and checked the condition of the engine. As the vibration was below 4 units, the crew did not continue with the checklist. Later, at 21:23:02 UTC, the cabin crew informed the crew about the flame seen from the engine exhaust by one of the passengers. The PIC immediately called out for engine failure non-normal checklist; however, the crew didn't continue with the checklist. At this time, the crew was in contact with Chennai Radar. Thereafter, the crew declared "PAN PAN" to ATC, Chennai at 21:23:32 UTC and informed about the decision to divert to Chennai due to a technical problem. The crew requested the ATC for descent and the same was acknowledged and permitted for descent to FL 150.

At 21:24:33 UTC, while descending, the crew followed the engine fire or severe damage or engine separation NNC. As per checklist, the crew disengaged the auto throttle and the thrust lever of engine#1 was brought to idle power. The crew decided not to increase thrust to avoid further damage and continue the fight with engine#1 at idle thrust. There was no exceedance of engine parameters at any stage. After that, at 21.24.47 UTC, both the LPT and fan vibration started decreasing. All other engine parameters were within limits. Engine#1 was run at idle thrust for the rest of the flight. At 21:32 UTC, the crew referred to the engine surge or stall NNC. The crew, as a precautionary measure, requested ATC for firefighting service on landing and the same was agreed by ATC. The crew prepared the aircraft for an overweight landing. During further descent, the crew started NNC for one engine inoperative landing.

After obtaining the necessary clearance from ATC, Chennai, the aircraft landed safely at Chennai airport on runway 07 at 2204 UTC. During taxing, crew requested ground controller to check for any abnormality in engine#1 and the ground reported no flames/abnormality. The aircraft then taxied to Stand 45 and was parked at 2213 UTC. The passengers were disembarked normally. There was no fire and no injury to any of the occupants on board the aircraft.

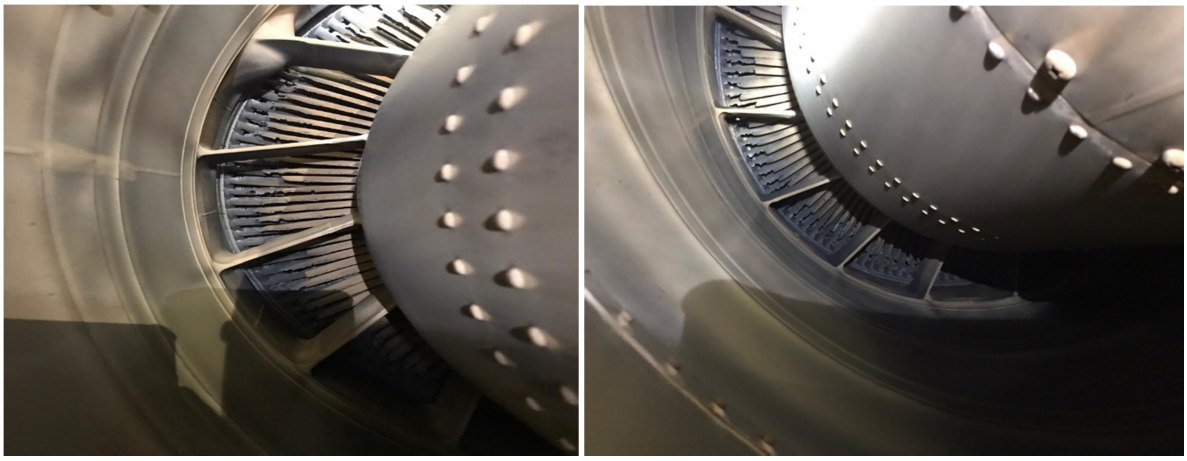
**1.2 <u>Injuries to Persons</u>:** -

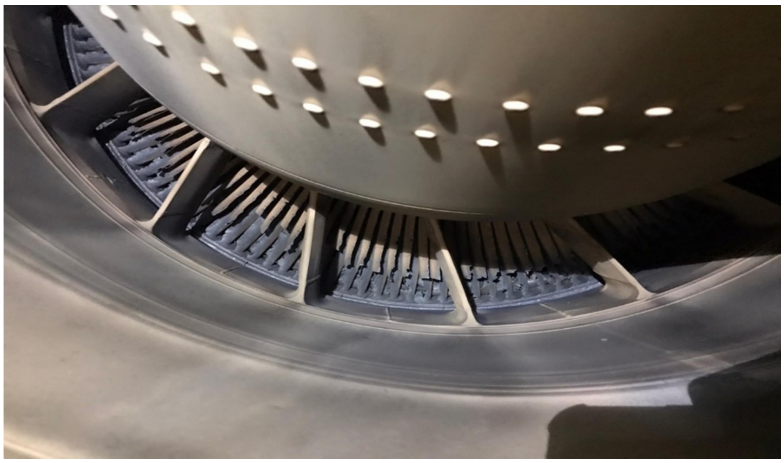
| Injuries | Crew | Passengers | Others |
|---|---|---|---|
| Fatal | Nil | Nil | Nil |
| Serious | Nil | Nil | Nil |
| Minor/None | Nil/06 | Nil/160 | |

Total Personnel on Board: 166

**1.3 Damage to Aircraft: -**

After landing at Chennai, during the detailed inspection by AME, the engine#1 inlet was found with no FOD ingestion or damage. During engine exhaust inspection, damage to the 3rd and 4th stage LPT rotor and stator with missing materials and a lot of broken pieces between the 4th stage stator and rotor. Aircraft declared AOG at Chennai and later the engine was replaced. Damage was limited to the engine and no other damage was reported.





**Engine LPT 3rd and 4th Stage blades were found damaged**

**1.4 Other Damages: -**

Nil.

**1.5 Personnel Information: -**

The cockpit was manned at the time of the incident by the crew of M/s Air India Express. The details of the licenses and ratings are as detailed below:-

### 1.5.1 Pilot in Command: -

| | |
|---|---|
| Nationality | Indian |
| Type of License | ATPL holder |
| Date of InitialIssue of License | 17/04/2015 |
| Valid Up to | 16/07/2025 |
| Class of License | Multi-Engine |
| Category of License | Aeroplane |
| Date of Birth | 14/02/1985 |
| Aircraft Rating | C 152, BE-76, B737 300-900 |
| Date of endorsement as PIC | 07/09/2017 |
| Date of last medical exam | 28/02/2022 |
| Medical Exam Validity | 01/03/2023 |
| FRTO License Valid Up to | 05/05/2024 |
| Instrument Rating | 21/12/2022 |
| Date of last Proficiency Inspection | 21/12/2022 |
| Total flying Experience | 7415:24 |
| Experience on Type | 7195:54 |
| Experience as PIC on Type | 3354:33 |
| Last Technical refresher | 11/03/2022 |
| Date of Joining company | 07/03/2017 |
| Flying release date at company | 10/09/2017 |
| Total flying experience during last 1 year | 868:48 |
| Total flying experience during last 6 months | 482:42 |
| Total flying experience during last 30 days | 72:04 |
| Total flying experience during last 07 days | 08:44 |
| Total flying experience during last 24 hours | 0 |
| Last flown on Type (date) | 25/12/2022 |
| Rest Period before flight | 22:36 |
| Any previous incident/Accident history | Nil |

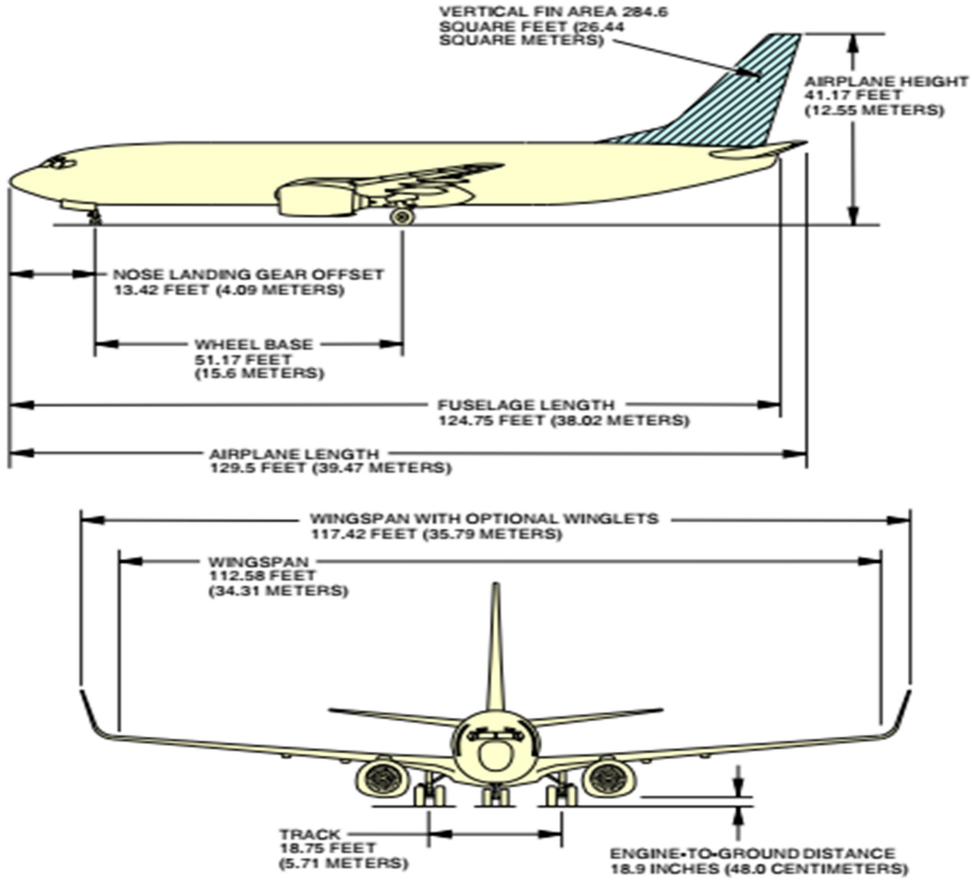
### 1.5.2 First Officer: -

| | |
|---|---|
| Nationality | Indian |
| Type of License | CPL holder |
| Date of Initial Issue of License | 16/10/2014 |
| Valid Up to | 15/10/2024 |
| Class of License | Multi-Engine |
| Category of License | Aeroplane |
| Date of Birth | 24/03/1991 |
| Aircraft Rating | C-172, DA42, B737 300-900 |
| Date of last medical exam | 04/07/2022 |
| Medical Exam Validity | 08/07/2023 |
| FRTO License Valid Up to | 15/10/2024 |
| Instrument Rating | 04/06/2022 |
| Date of last Proficiency Inspection | 04/06/2022 |
| Total flying Experience | 2781:17 |
| Experience on Type | 2581:17 |
| Experience as PIC on Type | NIL |
| Last Technical refresher | 29/06/2022 |
| Date of Joining Company | 05/04/2018 |
| Flying release date at company | 06/03/2019 |
| Total flying experience during last 1 year | 817:28 |
| Total flying experience during last 6 months | 382:58 |
| Total flying experience during last 30 days | 50:34 |
| Total flying experience during last 07 days | 09:01 |
| Total flying experience during last 24 hours | 00:00 |
| Last flown on Type (date) | 24/12/2022 |
| Rest Period before flight | 47:00 |
| Any previous incident/Accident history | Nil |

As per operator, the PIC and first officer were not involved in any incident/accident in the past and their licenses were current. The crew had adequate rest before operating the incident flight.

## 1.6 Aircraft Information: -

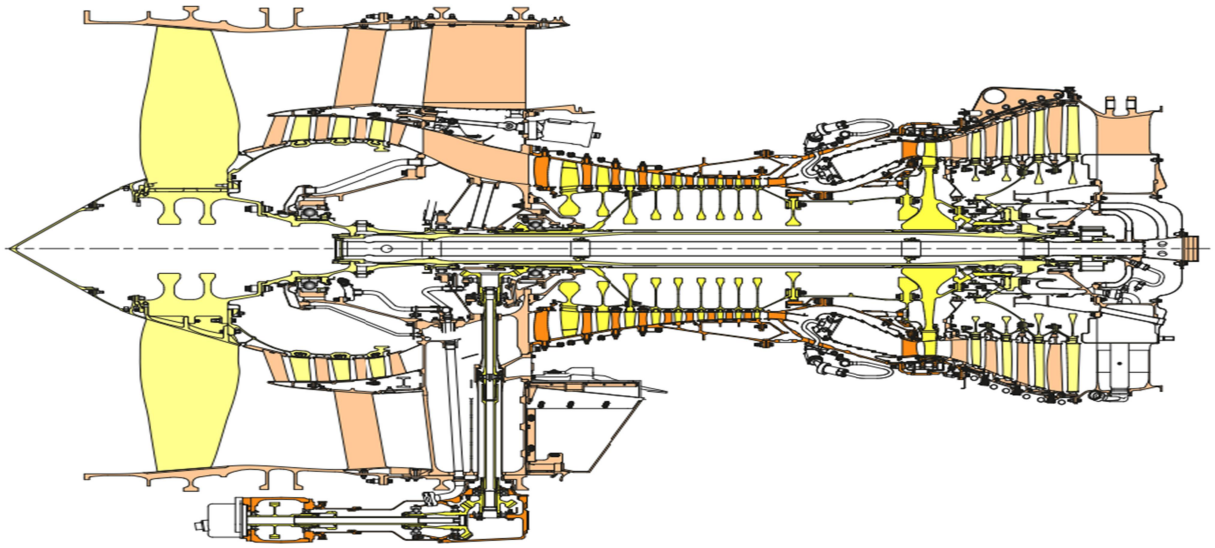
Boeing 737-800 Next Gen (NG) is a twin-engine aircraft fitted with CFM International CFM56-7B series engines, a glass cockpit, and upgraded and redesigned interior configurations. This NG series is an upgraded version of the 737 classic aircraft. The aircraft has a redesigned wing with a larger area, a wider wingspan, greater fuel capacity, higher maximum take-off weights (MTOW) and longer range. The aircraft is certified in the Normal category, for day and night operation under VFR & IFR.




**General Dimensions of B737**

## 1.6.1 Brief Description of CFM56-7B:-

The CFM56-7 is a high bypass, dual rotor, axial flow turbofan engine. The engine fan diameter is 61 inches (1.55 meters). The bare engine weight is 5257 pounds (2385 kilograms). The fan and booster rotor and the LPT rotor are on the same low-pressure shaft (N1). The HPC rotor and the HPT rotor are on the same high-pressure shaft (N2).



**CFM56-7B Engine Cross section**

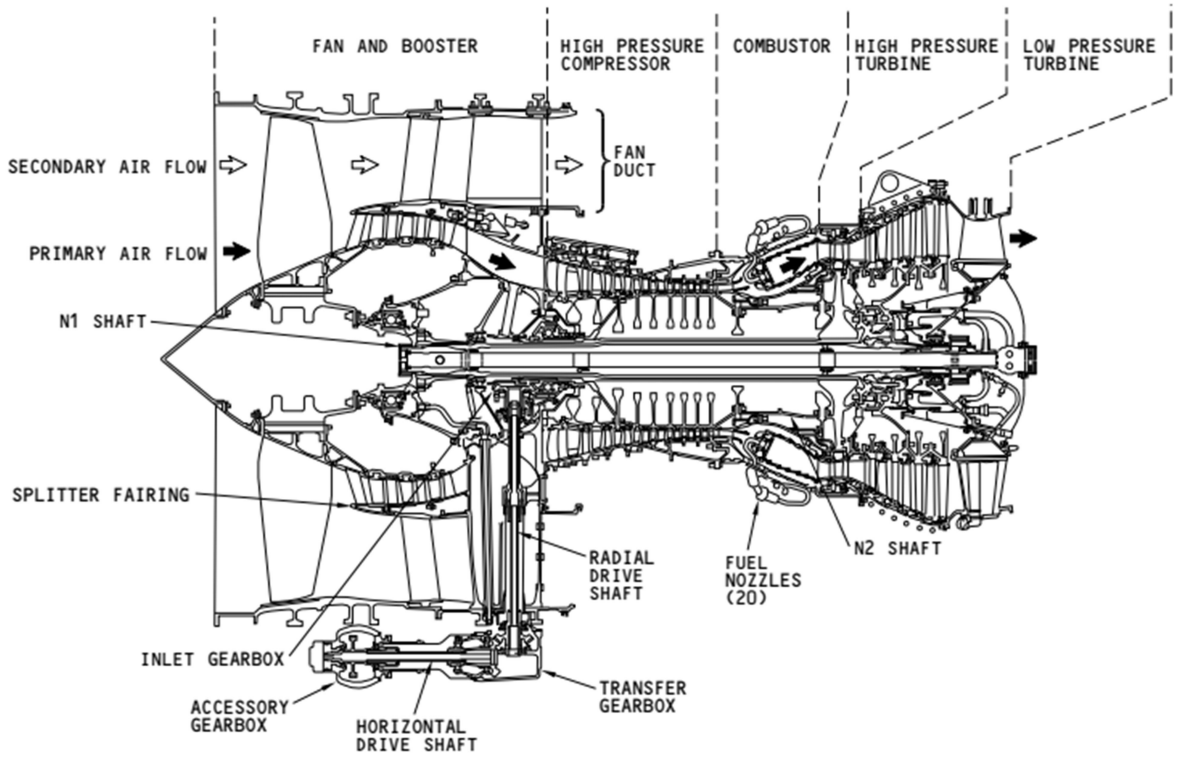
The engine has these sections:

- Fan and booster
- High-pressure compressor (HPC)
- Combustor
- High-pressure turbine (HPT)
- Low pressure turbine (LPT)
- Accessory drive.

**High-Pressure Compressor (HPC):** The HPC is a nine-stage compressor. It increases the pressure of the air from the LPC and sends it to the combustor. The HPC also supplies bleed air for the aircraft pneumatic system and the engine air system.

**High-Pressure Turbine (HPT):** The HPT is a single-stage turbine. It changes the energy of the hot gases into mechanical energy. The HPT uses this mechanical energy to turn the HPC rotor and the accessory drive.

**Low-Pressure Turbine (LPT):** The LPT is a four-stage turbine. It changes the energy of the hot gases into mechanical energy. The LPT uses this mechanical energy to turn the fan and booster rotor.




**Engine General Description**

### 1.6.2 Aircraft General Information: -

| | |
|---|---|
| a) Manufacturer | Boeing |
| b) Type | B737 – 800 NG |
| c) Owner | Air India Express Limited |
| d) Operator | Air India Express Limited |
| e) Manufacturer serial no. | 36339 |
| f) Year of Manufacture | 2009 |
| g) Certificate of Airworthiness issue date | 29/09/2009 |
| h) Airworthiness Review Certificate | 20/09/2022 |
| i) Category | Passenger |
| j) Certificate of Registration | 29/09/2009 |
| k) Minimum Crew Required | Two |
| l) Maximum All Up weight | 79015 kg |
| m) Last Major Inspection | Phase inspection 22 dated 04/11/22 |
| n) Last Inspection | Weekly inspection dated 23/12/22 |
| o) Airframe Hours Since New | 46808 Hours |

### 1.6.3 Engine General Information: -

| | LH | RH |
|---|---|---|
| a) Manufacturer | CFM | CFM |
| b) Type | CFM56-7B | CFM56-7B |
| c) Engine serial no. | 894397 | 894747 |
| d) Time since new (TSN) | 51279 | 46282 |
| e) Cycles since new (CSN) | 17306 | 15678 |
| f) Time since last shop visit (TSLSV) | 18732 | 5879 |
| g) Cycle since last shop visit (CSLSV) | 5602 | 1705 |
| h) Last Major Inspection Carried out | Phase inspection 24 | Phase inspection 24 |
| i) Last inspection Carried out | Phase inspection 29 | Phase inspection 24 |

The aircraft was last weighed on 09/08/2019 and the weight schedule was prepared and duly approved by the DGCA on 22/08/2019. The aircraft was fitted with CFM 56-7B engines. The involved engine was installed on 14.07.2021 in the LH position of the subject aircraft. At the time of installation, the engine had logged 45294:59 TSN and 15571 CSN. The last shop visit was performed on the engine at 32547 TSN and 11704 CSN for performance restoration of the engine. After the last shop visit, the engine was released into service on 01/12/2017. The engine was installed on the company aircraft on 05/12/2017 and after that, it was installed on the other two company aircraft before being installed on the subject aircraft. The airborne vibration monitoring bite inspection for vibration of the engine was last carried out on 08/12/2022 during phase inspection 23 and found satisfactory. As per the records, the next scheduled engine shop visit is planned at 20000 CSN for the replacement of life-limited parts i.e., 2694 cycles remaining as of the date of the incident.

M/s Air India Express has outsourced the engineering activities of its fleet to M/s AIESL. The maintenance activities are carried out as per the approved AMP. The aircraft and its engine were being maintained as per the approved maintenance program consisting of calendar period/ flying

hours or cycles based maintenance as approved by the Directorate General of Civil Aviation (DGCA).

Before the incident flight, on 26/12/22, the aircraft operated four sectors by different sets of crew with nil sector snags and the incident flight was the fifth sector for the aircraft. No similar snag history was recorded as per the airframe logbook. All concerned Airworthiness Directives, mandatory Service Bulletins, and DGCA Mandatory Modifications on this aircraft and its engines were complied with as of the date of the incident.

The pilot Defect Report of the incident flight was as follows:
'Engine No.1 stall at FL230. Overweight landing (not suspecting hard landing). Engine No.1 vibration was 3.3 units, No EGT Exceedance. Parameters were normal.'

The details of the core borescope inspection performed on the engine during the last six months are as follows:

1. The last borescope inspection of the HPT blades was carried out as per SB requirement on 21/9/22 at 50007:29 hours/16940 CSN and found satisfactory. The next due is at 400 cycles i.e., 17342 CSN.
2. The last borescope inspection of the HPC blades was carried out as per SB requirement on 10/6/22 at 16551 CSN and found satisfactory. The next due is at 4800 cycles i.e., 21279 CSN.
3. The last borescope inspection of stage 1 LPTN was carried out as per SB requirement on 06/5/22 at 16425 CSN and found satisfactory. The next due is at 1600 cycles i.e., 18025 CSN.

As per CAMO, the next borescope inspection as per schedule is for HPT blades at 17342 CSN. The subject engine was removed due to an incident at 17306 CSN i.e., 36 flight cycles left for the scheduled borescope inspection.
After the incident, the following actions were carried out before the release of the aircraft:

The engine#1 EEC BITE test was carried out as per AMM 73-21-00-740-803-F00 and found economic fault message 77-10851 "The Bottom Right EGT Signal is Out of Range" for flight leg 01. Engine#1 exceedance BITE test was carried out as per AMM 71-00-00-740-801-F00 and found nil exceedance. Inspection of the engine after an engine stall or possible engine stall was carried out as per AMM 71-00-00-210-801-F00 was initiated. Engine inlet visual inspection was carried out and found no FOD ingestion or damage. Visual inspection of engine exhaust was carried out and found damage to the 3$^{rd}$ stage LPT rotor and 4$^{th}$ stage LPT stator. Further to the inspection, engine#1 was replaced as per AMM 71-00-02-000-801-F00/400-801-F00. Post installation, engine operation was found satisfactory. Aircraft overweight landing inspection was carried out as per AMM 05-51-35-210-801 and no discrepancy was observed. Aircraft were normalized and released for further flights.

### 1.6.4 Customer Notification Report (CNR): -

Customer Notification Reports (CNR) are generated by CFM for their customers during the engine condition monitoring trend shift has been observed. Based on the trend, the CNR will be issued with some recommendations to customers. As of the day of the incident, CNRs are categorized as follows, each of which specifies recommended maintenance actions and priority:

a) CRITICAL- Recommended actions to take before the next flight.
b) URGENT- Recommended actions to take as per the cycles/days called for in the CNR.
c) NORMAL- Recommended actions to take at the next maintenance opportunity

M/s Air India Express CAMO received CNR 20221220046 dated 20/12/22 from CFM with priority status as 'Normal' on engine serial number 894397 installed on VT-AYC LH position. During analysis by CFM, a gradual increase in Delta EGT, Delta Fuel Flow and a decrease in Delta Core Speed were observed, which prompted the subject CNR. To comply with the recommendations of the CFM, the CNR was discussed in the daily morning meeting on 21/12/2022 by AIXL CAMO and it was decided to issue a callout for an actuator test and troubleshoot for defects in the upcoming weekly inspection planned at Tiruchirappalli (VOTR) on 24/12/2022. The remaining recommendations as per CNR were decided for a later date. The callout for the actuator test was issued on 21/12/22 to the Planning Department for issuing to MRO, along with the weekly inspection planned at VOTR on 24/12/2022. However, due to TAT probe fault, the aircraft was grounded at Singapore (SIN) on 21/12/2023. Subsequently, the weekly inspection plan was changed by MCC and it was performed at Sharjah (OMSJ) on 23/12/2022. As the CNR status remained unchanged as 'Normal', it was decided by the CAMO department to perform the issued callout along with the next weekly Inspection on 28/12/2022 at VOTR. Before carrying out any troubleshooting, on 26/12/22 the subject engine experienced a stall and the aircraft diverted and landed in Chennai (VOMM). During inspection, the engine was declared unserviceable. After the receipt of CNR, the aircraft flew for 89:23 flight hours/24 flight cycles. The image of the CNR received by M/s Air India Express is placed below:

The Power of Flight

# Customer Notification Report

| | | | |
|---|---|---|---|
| **Airline/Customer:** | Air India Charters | **Aircraft Tail:** | AYC |
| **Engine Type:** | CFM56-7B27 | **Engine Position:** | 1 |
| **Aircraft Type:** | B737-800 | **Engine Serial #:** | 894397 |
| **CNR Number:** | **20221220046** | **Date:** | 20-Dec-2022 |
| **Priority:** | Normal | | |

**1.0 Observation**

The engine in question has experienced gradual increase in Delta EGT, Delta Fuel Flow and decrease in Delta Core Speed.

**2.0 Analysis**

According to the CFM Diagnostics, the shifts observed on this engine are similar to other engines that have experienced performance deterioration.

Probable Root Cause of Shift(s): Performance Degradation

Engine Install Date: 14 Jul 2021
Shift Start Date: 20-Nov-2022 0:00:00 GMT
Shift End Date: 21-Dec-2022 23:59:59 GMT
Last Flight Date: Cruise: 19-Dec-2022 16:44:57 GMT
Takeoff: 20-Dec-2022 8:27:32 GMT

| Parameter Name | Flight Phase | Engine Position | Value at Start Date | Value as of Now | Overall Change |
|---|---|---|---|---|---|
| Delta EGT | Cruise | 1 | 34.88 DEG_C | 42.09 DEG_C | 7.21 DEG_C |
| Delta Core Speed | Cruise | 1 | -0.71 % | -0.82 % | -0.11 % |
| EGT Hot Day Margin | Takeoff | 1 | 24.98 DEG_C | 4.89 DEG_C | -20.09 DEG_C |
| Delta Fuel Flow | Cruise | 1 | 1.21 % | 2.93 % | 1.72 % |

Note 1 - The analysis and recommendations provided are based strictly on experience with hardware and repairs approved by the OEM, CFM International, Inc., for the subject engine model. Such information may be invalid if non-OEM hardware and/or repairs are used.
Note 2 - CNRs are not Instructions For Continued Airworthiness (ICA), but are recommendations derived from diagnostic information and OEM experience.



**3.0 Recommendations**

Operators may use discretion in determining the actual procedures used, and the order in which these steps are applied.

1. Review maintenance records for recent maintenance or operational events like Ice ingestion, FOD, Fan blade set replacement or cleaning, Pneumatic system faults, ECU faults, T25 faults etc. that could account for the performance shifts

2. Perform AMM TASK 71-00-00-700-807-F00 Test 12 - Actuators Test. Monitor for faults related to T25 sensor, T3 sensor, HPTACC, LPTACC and TBV valves. If faults are found, do the corrective action in the Fault Isolation Manual for the fault that shows.

3. If no faults are found, replace the HPTACC valve per AMM Task 75-21-01-000-801 and 75-21-01-400-801.

NOTE: The HPTACC valve can fail at the butterfly valve and not generate any faults.

4. Perform Borescope Inspection of the HP Turbine, paying particular attention to HPT shrouds (360 degrees, with flexible borescope), per AMM Task No. 72-00-00-200-807 and 72-00-00-200-815.

Note: Look for holes, buckling, etc. in the shrouds in addition to evidence of smeared or melting/ missing metal and signs of excessive rub or burn through. Pay close attention to the HPT Blades. Record the number of HPT Blade Tip Notches remaining. If possible, take pictures and video of the HPT Tip Notches, HPT Shrouds, Nozzles and Nozzle Guide Vanes.

5. If nothing found, perform Borescope Inspection of stage 1 LPT per AMM TASK 72-00-00-200-808-F00 Stage 1-3 LPT Blades Borescope Inspection.

6. If problem continues, replace the TBV valve per AMM TASK 75-23-01-000-801-F00 and 75-23-01-400-801-F00 NOTE: The TBV valve can fail mechanically and not generate faults.

7. Perform Borescope Inspection on the HPC per AMM Task No. 72-00-00-200-804 and 72-00-00-200-817 noting any rubs as well as the general cleanliness of the compressor.

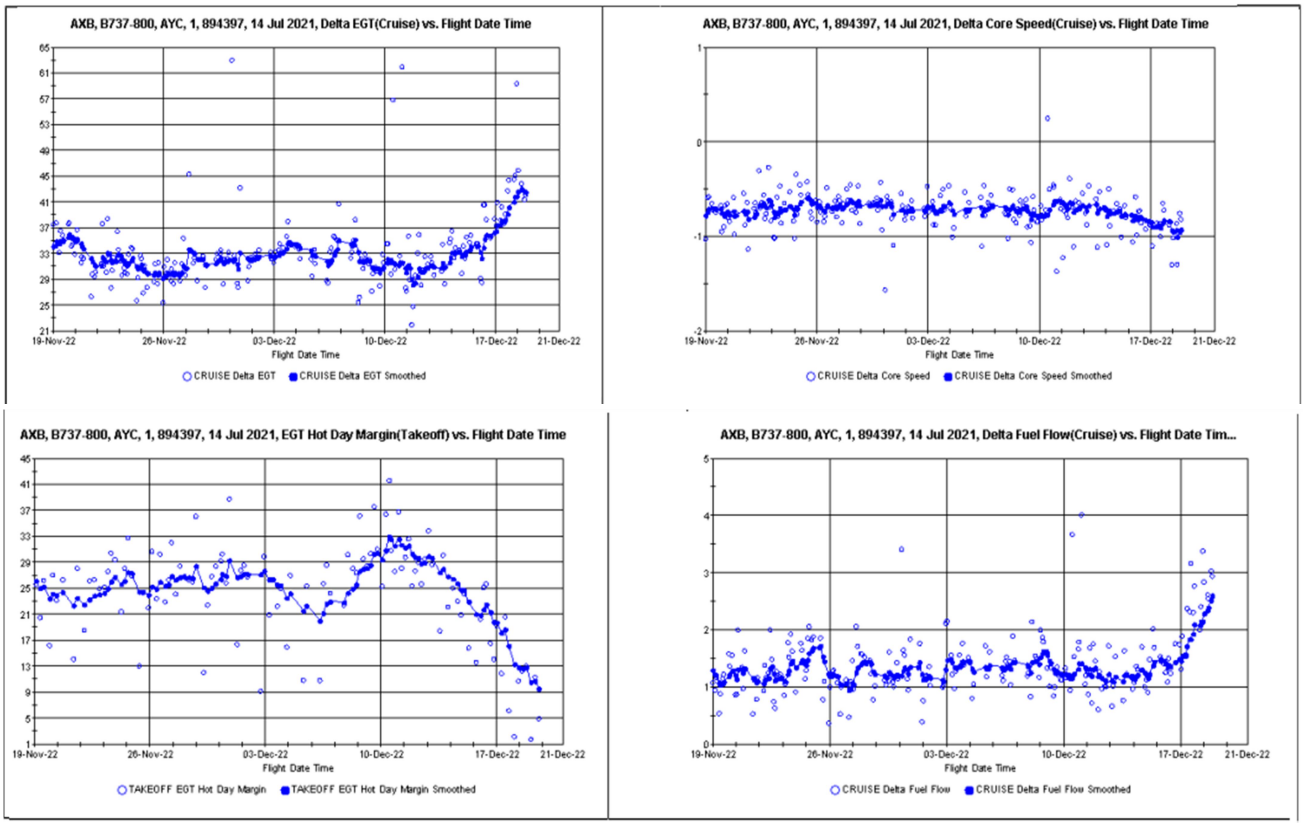
Note 1 - The analysis and recommendations provided are based strictly on experience with hardware and repairs approved by the OEM, CFM International, Inc., for the subject engine model. Such information may be invalid if non-OEM hardware and/or repairs are used.
Note 2 - CNRs are not Instructions For Continued Airworthiness (ICA), but are recommendations derived from diagnostic information and OEM experience.

CFM International, Inc. - Customer Proprietary Information
*** FOR TECHNICAL DATA EXPORTED, EITHER TSU(OTS) OR 22CFR 125.4(B)(5) APPLIES. ***

8. Perform borescope of the Combustion Chamber per 72-00-00-200-805.

9. If no findings, wash engine per TASK 72-00-00-100-804-F00.

10. Please report findings to CFM Diagnostics.




**Graph showing the increase in Delta EGT, Delta Fuel Flow and a decrease in Delta Core Speed vs Flight date time**

Post incident i.e. September 2023, the OEM has updated the CNR classification from Normal/Urgent/Critical to Class A level 1 or 2, Class B level 1,2, or 3. The upcoming CNR modification will advise maintenance actions and timing to complete the recommended tasks for operators. The above change will be effective in minimizing unplanned maintenance actions so that operators can plan the required actions effectively.

### 1.6.5 Engine Condition Trend Monitoring:-

Engine condition is monitored by the Technical Services Powerplant Team of AIXL CAMO using CFM (OEM) engine trend data and borescope inspection reports. Engine Health Monitoring enables the comparison of engine performance trends in the following parameters: a) EGT Margin - Take off b) Delta EGT - Cruise c) Delta Fuel Flow – Cruise d) Delta Core Speed (N2) – Cruise. Engine performance data is transmitted to CFM (OEM) through ACARS. Data is processed through remote diagnostic software by CFM and a report/alert /CNR (Customer Notification Report) is generated. Customers have access to the CFM Customer Web Center, a web-based tool for reviewing engine condition data and assessing engine health. The data is made available by CFM through its “myCFMportal.” CAM / Dy. CAM, in coordination with technical services, is responsible for the implementation of corrective action based on performance reports.

### 1.6.6 Analysis of Trend Plots for Engine using “myCFMportal” Data:-

During the analysis of “myCFMportal” access by the M/s AIXL CAMO department, it was observed that even after the receipt of CNR dated 20/12/22, alerts for performance signatures were

generated by CFM system between 20/12/22 and 26/12/22 and the EGT shift of the subject engine continued. However, it seems that the airline did not monitor the performance alerts nor address the issue properly to carry out the CNR-recommended tasks on an urgent basis.

Further, it is observed that even though the alerts were generated after the issuance of the CNR, a revised CNR was not issued by CFM with a change in priority / additional maintenance recommendations to emphasize the criticality. This observation was informed to the CFM and as per the CFM, the following is the sequence of events:

As per CFM, the first alert for performance signature on the engine was received on 20/12/2022 at 21:31 UTC based on the flight operated by the aircraft on 19/12/2022 at 05:02 UTC. After analysis by the concerned team of CFM, CNR 20221220046 "Normal" for performance degradation was issued on 20/12/2022 at 22:12 UTC according to the following signature observed:

- ΔEGT shift up
- ΔFuel Flow shift up
- ΔN2 shift down
- EGTHDM shift down
- Core Vibe stable

After the CNR was issued on 20/12/22, 8 alerts for performance signatures were generated by the system between 20/12/2022 and 26/12/2022. These alerts have been analyzed and "added to the case" by the concerned team according to the CFM process, because the signature observed was for the same trend that caused the CNR issued for performance degradation (which was already open at the airline's end). If any other parameter shift had been observed, then a different CNR would have been issued with a category based on the criticality, but this was not the case. Hence, the CNR category was not changed by the CFM.

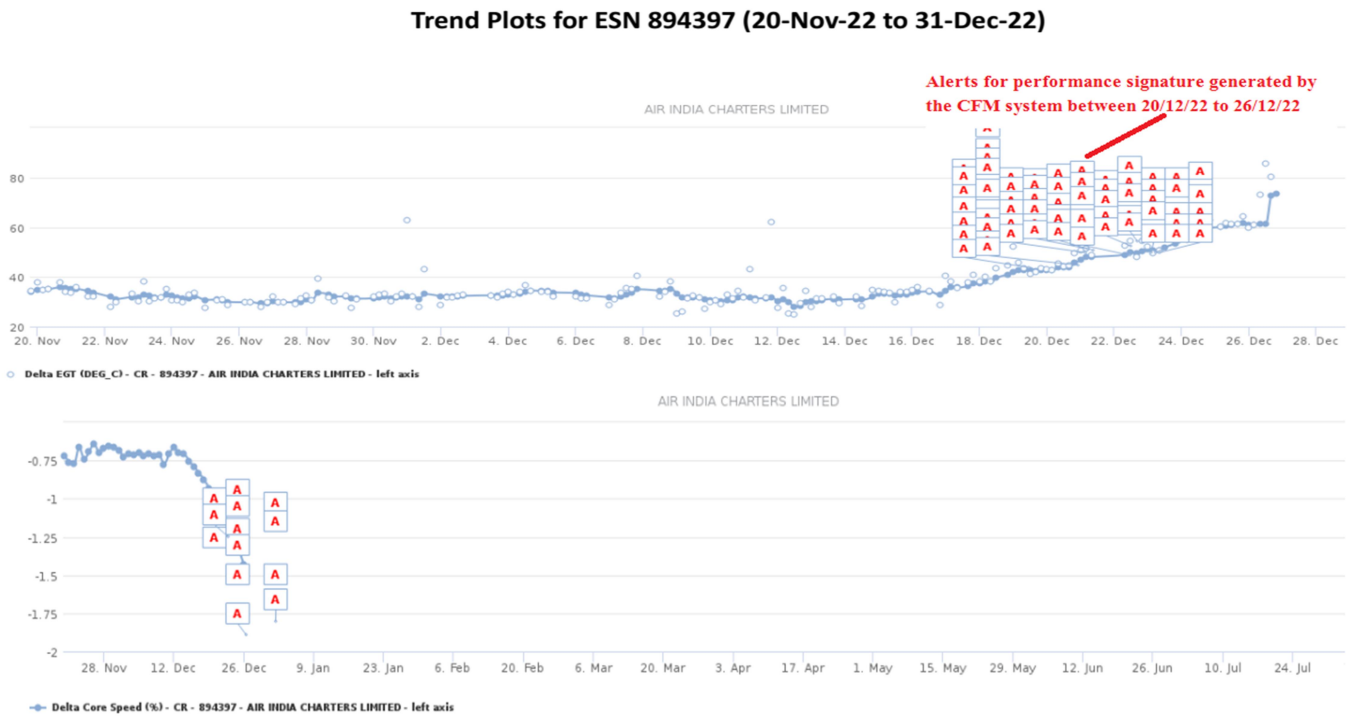



**Image Showing Alerts generated on myCFMPortal for Delta EGT and Delta Core Speed**

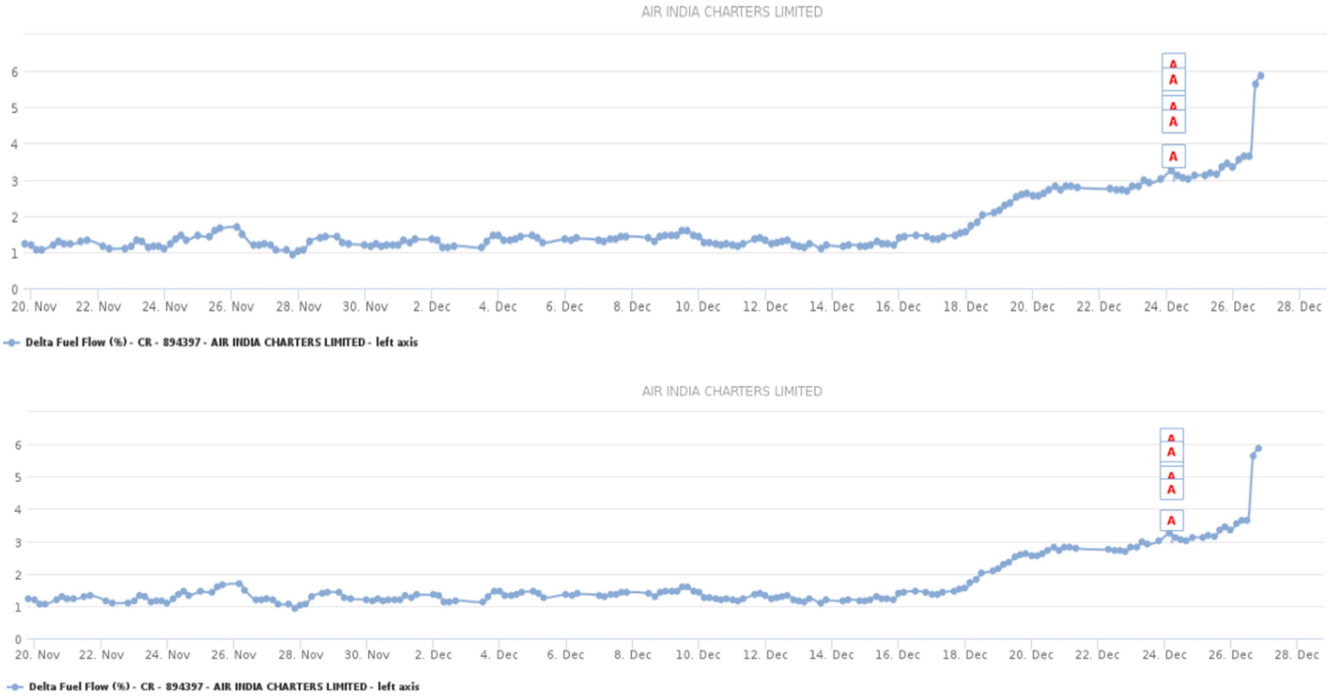



**Image Showing Alerts generated on myCFMPortal for EGT Hot Day margin and Delta Fuel Flow**

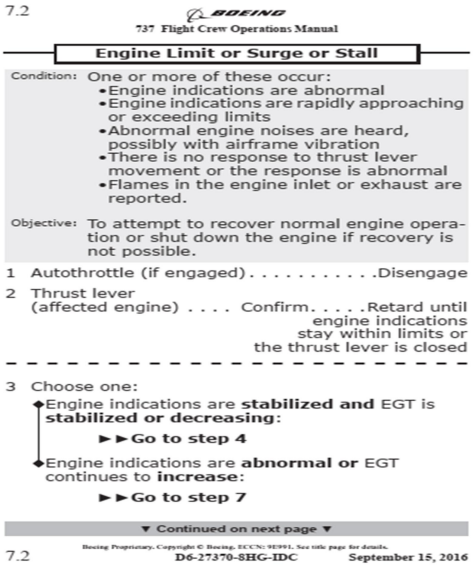
### 1.6.7 <u>Review of Actions taken by CAMO Post the receipt of CNR</u>: -

On receipt of the CNR dated 20/12/222, the same was discussed in the Daily Morning Meeting on 21/12/22. The meeting was attended by AIXL CAMO personnel and AIESL (MRO) representatives. During the meeting, it was decided to issue a callout by technical services for an actuator test and troubleshoot for defects in the upcoming weekly inspection planned at Tiruchirappalli Airport (VOTR) on 24/12/22. Component change and BSI as per CNR task were planned to be carried out at VABB on 02/01/2023 along with 24 months of aircraft grounding. A callout for the actuator test was issued on 21/12/2022 to the planning department for issuing to MRO along with a weekly inspection at VOTR on 24/12/2022. However, due to TAT probe fault, the aircraft was declared AOG at SIN on 21/12/2022 (AOG 20 hours). The weekly inspection plan was changed by MCC and it was performed at Sharjah Airport (OMSJ) on 23/12/22 with a ground time of 4 hours and 29 minutes. As per MCC, no additional callouts were issued or performed due to time and resource constraints, the planned callouts were not issued to MRO along with the weekly inspection at OMSJ. Again, it was decided to perform the issued callout along with the next weekly inspection on 28/12/2022 at VOTR. However, during the flight on 26/12/22, the subject engine experienced a stall, and the aircraft diverted to Chennai.

During analysis of the flights operated by the subject aircraft, it was observed that after the weekly inspection at OMSJ on 23/12/22, the aircraft operated the next flight to VOTR where the AIXL CAMO had planned to perform the CNR issued callout and the aircraft was available on the ground for 2 hours and 23 minutes at VOTR. On 26/12/22, the aircraft had a ground time of 2 hours 55 minutes at Calicut Airport (VOCL), and again, the operator did not plan to carry out the CNR callout tasks. As per the statement of the CAM, the ground time for carrying out the issued callout requires a minimum of 30 minutes and additional ground time if the fault is detected.

Further, the LMM of MRO clarified that they have not received the CNR callout for planning the activity at VOTR or any other station. Hence, the reason for changing the planned activity by AIXL CAMO is not clear, even though the engine generated a series of alerts for performance degradation after the issuance of CNR. The alerts generated by the engine manufacturer systems after the issuance of CNR were not monitored and analyzed, which would have helped the airline to take timely actions to avoid the engine stall incident.

### 1.6.8 Non-Normal Checklist in case of Engine limit or surge or stall: -



7.2

BOEING
737 Flight Crew Operations Manual

**Engine Limit or Surge or Stall**

Condition: One or more of these occur:
- Engine indications are abnormal
- Engine indications are rapidly approaching or exceeding limits
- Abnormal engine noises are heard, possibly with airframe vibration
- There is no response to thrust lever movement or the response is abnormal
- Flames in the engine inlet or exhaust are reported.

Objective: To attempt to recover normal engine operation or shut down the engine if recovery is not possible.

1 Autothrottle (if engaged) . . . . . .Disengage

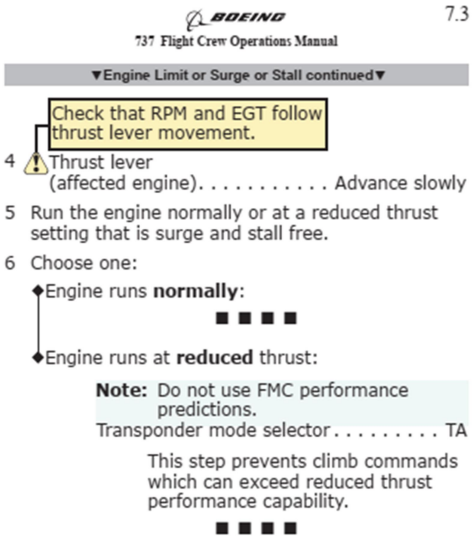
2 Thrust lever (affected engine) . . . . Confirm. . . . .Retard until engine indications stay within limits or the thrust lever is closed

3 Choose one:
- Engine indications are **stabilized and** EGT is **stabilized or decreasing**:
  ►►**Go to step 4**
- Engine indications are **abnormal or** EGT continues to **increase**:
  ►►**Go to step 7**

▼ Continued on next page ▼







BOEING 7.3
737 Flight Crew Operations Manual

▼Engine Limit or Surge or Stall continued▼

Check that RPM and EGT follow thrust lever movement.

4 Thrust lever (affected engine). . . . . Advance slowly

5 Run the engine normally or at a reduced thrust setting that is surge and stall free.

6 Choose one:
- Engine runs **normally**:
  ■ ■ ■ ■
- Engine runs at **reduced** thrust:

**Note:** Do not use FMC performance predictions.

Transponder mode selector . . . . . TA

This step prevents climb commands which can exceed reduced thrust performance capability.

■ ■ ■ ■

During the analysis of CVR data, it was observed that the crew referred to the following non-normal checklist. The checklist sequence is as follows:

| SL No. | Non-Normal Checklist Title | Condition of Checklist | Remarks |
|---|---|---|---|
| 1 | High Engine Vibration | The vibration level is 4.0 units or greater. Airframe vibration may or may not be felt. | As per the CVR data, the crew referred to the checklist at 21:22:47. As the engine vibration level was less than 4 units crew decided not to carry out the checklist actions. At 21:30:34 crew again discussed the checklist and Transponder Mode changed to 'TA'. |
| 2. | Engine Failure or shutdown | One of these occurs<br>•An Engine Failure<br>•An ENG FAIL alert shows<br>•An engine flameout<br>•Another checklist directs an engine shutdown | As per the CVR data, on receipt of the information from the cabin crew that one of the passengers saw flame from the engine exhaust, the crew immediately referred to the checklist at 21:23:04; however, the crew didn't discuss/continue with the checklist actions. |
| 3 | ENGINE FIRE or Engine Severe Damage or Separation | One or more of these occur:<br>•Engine fire warning<br>•Airframe vibrations with abnormal engine indications<br>•Engine separation. | As per the CVR data, the crew referred to the checklist at 21:24:20. As per the checklist, the crew disengaged the autothrottle and engine#1 thrust lever was brought back to idle power. The further steps of the checklist, the captain decided to delay the action as there was no abnormal engine indication. |
| 4. | Engine Limit or Surge or Stall | One or more of these occur:<br>•Engine indications are abnormal<br>•Engine indications are | As per the CVR data, the crew referred to the checklist at 21:31:54 relative time i.e., after 10 minutes of the engine issue. As per checklist condition, the appropriate checklist for the |

| | | | |
|---|---|---|---|
| | | rapidly approaching or exceeding limits<br>•Abnormal engine noises are heard, possibly with airframe vibration<br>•There is no response to thrust lever movement or the response is abnormal<br>•Flames in the engine inlet or exhaust are reported. | condition of the engine was this. |
| 5. | One Engine Inoperative Landing | Landing must be made with one engine inoperative. | As per the CVR data, the crew referred to the checklist at 21:40:46. |

From the above, it seems that the flight crew incorrectly identified the condition of the engine/cause of indications. This may have led the crew to refer to/carry out the less applicable non-applicable checklists initially and then to carry out the correct non-normal checklist. As per the above-mentioned checklist conditions, the appropriate checklist for the engine issue was "Engine Limit or Surge or Stall". Hence, the implementation of the applicable Non-Normal Checklist was delayed. The same was agreed upon by the safety department of the airline.

### 1.7 Meteorological Information: -

Winds were reported as calm. The weather was not a contributory factor.

### 1.8 Aids of Navigation: -

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

### 1.9 Communication: -

Two-way radio communications were available between aircraft and ATC. Neither the crew nor the ATC unit reported any un-serviceability.

### 1.10 Aerodrome Information: -

Chennai International Airport is operated by the Airports Authority of India. The Aerodrome Rescue and Fire Fighting Category (ARFF) available is 9. Chennai International Airport and ATC are controlled by the Airports Authority of India. The Chennai ATC has 24-hour watch hours. It has two runways with orientation 07/25 and 12/30. The aerodrome's elevation is about 52 feet.

### 1.11 Flight Recorders: -

#### 1.11.1 CVR: -

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

The communications with the ATS unit were carried out by the PIC till the time of the incident and later the communications with the ATC were made by the first officer and PIC. The relevant portion of the CVR transcript is placed below:

| TIME (Hrs) | FROM | CONVERSATION | REMARKS |
|---|---|---|---|
| 21:05:20 | FO | IX682 request Taxi | |
| 21:05:23 | TOWER | Taxi to RWY 09 holding point via taxiway 'A' Express India 682 | |
| 21:06:35 | PIC | "You Have Controls" | PIC designates FO as PF for the sector |
| 21:08:35 | Tower | Trichy Express India 682 wind 040 degree 05 knots RWY09 cleared for take-off | Aircraft was cleared for take-off |
| 21:21:40 | FO | ok. You have controls | PIC took over the controls. |
| 21:21:44 | FO | Identifying engine#2, N1 is deteriorated N2 seems fine, EGT is within limits, oil pressure and temperature fine, quantity and the vibration is went up to 3.3 | |
| 21:22:09 | PIC | Engine vibration we have just stopped our climb. ok | |
| 21:22:18 | PIC | Chennai IX-682 sir we are having a technical problem. Leveling off at this level only. Will get back to you | |
| 21:22:39 | cabin crew | Go ahead. Some sound came captain | Call on PA system made by cabin crew and informed about the sound heard in the cabin |
| 21:22:47 | FO | Checklist sir non normal engine high vibration. Condition, the vibration level is 4.0 units or greater | Crew referred to the engine high vibration and stated that the checklist was not applicable as the vibration was well within the limits. |
| 21:22:53 | PIC | Negative, but still go ahead | |
| 21:23:01 | cabin crew | Passenger reported fire coming from the engine | Again, call on PA system made by the cabin crew and informed that one of the passengers reported an exhaust flame from the left engine |
| 21:23:04 | PIC | Go to the engine failure checklist | |
| 21:23:30 | PIC | We are declaring a "PAN PAN" and would like to divert to Chennai | Declared "PAN PAN" to ATC. |
| 21:24:20 | FO | Engine fire or severe damage or separation non-normal checklist | crew referred to the engine fire or severe damage or engine separation checklist. Crew disengaged the auto throttle and engine#1 thrust lever was brought back to idle. The further portion of the checklist to cut off the affected engine and pull the engine fire switch, the captain decided to delay the action as there was no abnormal engine indication. |
| 21:24:23 | FO | One or more of these occur:<br>•Engine fire warning<br>•Airframe vibrations with abnormal engine indications. That is applicable sir<br>•Engine separation. Not applicable<br>Auto throttle if engaged disengage | |
| 21:24:33 | PIC | disengaged | |
| 21:24:34 | FO | Thrust lever affected engine confirm close | |
| 21:24:36 | PIC | Confirm no1 engine | |
| 21:24:37 | FO | I confirm no1 engine captain | |
| 21:24:40 | PIC | checked | |
| 21:24:41 | FO | Engine start lever affected engine confirm cut-off | |
| 21:24:44 | PIC | So, this we will just delay. Ok because there is no abnormal engine indications and we just confirm the fire situation. We will run the engine at the reduced thrust. | |
| 21:24:57 | FO | So, we are bypassing this one | |
| 21:25 | FO | Engine fire switch affected engine confirm pull | |
| 21:25:03 | PIC | We are just standing by in this position. We will get feedback ok. | |
| 21:26:25 | PIC | Now any fire flames are there | PIC asked the cabin crew about the current situation. |
| 21:26:27 | cabin crew | Negative captain….not clear | |
| 21:29:03 | FO | And can we continue with the checklist as a precaution | |
| 21:29:06 | PIC | Do You want to shut down the engine or do you want to run the engine at a reduced thrust | |
| 21:29:25 | PIC | Engine fire warning is not the condition. Airframe Vibration with abnormal engine vibration again that is not the condition right now what do you say | |

| TIME (Hrs) | FROM | CONVERSATION | REMARKS |
|---|---|---|---|
| 21:29:54 | FO | Engine failure or shutdown. One of these occurs<br>• An engine failure……. negative<br>•An ENG FAIL alert……. negative<br>•An engine flameout<br>•Another checklist directs an engine shutdown. | Crew discussed the engine failure or shutdown checklist and concluded that the checklist conditions do not apply to the situation. |
| 21:30:12 | PIC | Go to the engine high vibration checklist once more | Crew again referred to the engine high vibration checklist and concluded the checklist actions do not require to continue. |
| 21:30:34 | FO | Engine high vibration. Condition the vibration level is 4.0 units or greater. | |
| 21:30:37 | PIC | This is also now not applicable. But still, we go ahead with the checklist | |
| 21:31:27 | FO | Transponder mode selector to "TA" | |
| 21:31:28 | PIC | Confirm transponder mode to "TA" | |
| 21:31:39 | PIC | Ok we will check surge or stall checklist | |
| 21:31:54 | FO | Engine limit surge or stall<br>Condition: One or more of these occur:<br>•Engine indications are abnormal | Crew referred to the engine limit surge or stall checklist and concluded that one of the checklist conditions applies to the condition of the engine/indications. |
| 21:31:58 | PIC | checked | |
| 21:31:59 | | •Engine indications are rapidly approaching or exceeding limits | |
| 21:32:01 | PIC | ok | |
| 21:32:01 | FO | •Abnormal engine noises are heard, possibly with airframe vibration<br>I think this is applicable | |
| 21:32:07 | PIC | This is applicable | |
| 21:32:20 | FO | Auto throttle (if engaged). ... disengage | |
| 21:32:21 | PIC | disengaged | |
| | FO | Thrust lever (affected engine). ... Confirm. ... Retard until engine indications stay within limits or the thrust lever is closed | |
| 21:32:27 | PIC | Engine indications are within limits now. So, it is closed | |
| 21:32:51 | PIC | Thrust lever<br>(Affected engine) . . . Advance slowly. I am not doing it. Because I don't want to damage the engine further | |
| 21:35:42 | PIC | The facts are we are having a problem with engine1 and none of the checklists are directing for a shutdown. So, we are running the engine at a reduced thrust. As of now no fire warning nothing and what else we are overweight captain and we are doing a precautionary landing into Chennai RWY 07 | |
| 21:38:05 | PIC | Request fire assistance on landing just as a precautionary | PIC requested for fire assistance on landing at Chennai as a precautionary measure. |
| 21:40:41 | PIC | Good morning, ladies and gentlemen this is an announcement from the flight deck we are having a small technical problem with the No. engine so we are landing in Chennai and landing will be in 15 minutes | PIC announced to the passengers and informed them about the problem and decision to divert to Chennai |
| 21:40:46 | FO | One engine inoperative landing checklist. Condition Landing must be made with one engine inoperative. | Crew followed the one-engine inoperative checklist |
| 21:53:02 | FO | Approach checklist complete | Crew completed 'Approach Checks |
| 22:01:51 | FO | Landing checklist | Crew completed 'Before Landing Checks |
| 22:02:32 | Tower | Clear to land RWY 07 IX682 | Landing clearance granted by ATC |
| 22:07:03 | PIC | Just ask the ground if fire attendees can see anything on the ground on Engine#1 | Crew asked the ground team to check the condition of the engine#1 |
| 22:07:37 | Ground | IX682 ground. We are observing everything normal on engine#1 | |

### 1.11.2 DFDR: -

The aircraft was installed with a Solid-State Flight Data Recorder. Relevant data was used for analysis. Following are the salient observations made from CVR & FDR:

| Time (Hrs) | CVR and DFDR Events |
|---|---|
| 21:06:35 | The PIC designates FO as Pilot flying for the sector. |
| 21:08:35 | Take-off clearance was issued by ATC |
| 21:08:53 | TOGA was engaged and the throttle resolver angles were recorded to be 81.56 % for both engines. |
| 21:09:23 | The aircraft took off from runway 09 of Trichy Airport. All the engine parameters were recorded to be within limits during take-off. The EGT was recorded as 936 degrees for engine#1 and 888 degrees for engine#2. |
| 21:16:11 | Passing FL 140 the aircraft was handed over to Chennai radar |
| 21:16:50 | Chennai Radar has cleared the aircraft to FL 330 |
| 21:21:37 | The N1 of engine#1 started dropping from 98% and consequentially, engine#1 N2 also dropped. The engine#1 fuel flow started dropping rapidly and the #1 EGT also shot up to 913 degrees for 2 seconds and then it started decreasing. During this time the auto throttle and Autopilot were engaged.<br>The throttle resolver angles were recorded to be 71.72deg for both engines and both the bleeds were in the ON position. |
| | an increase in vibration of engine#1, fan (max recorded to 2.51 units) and low-pressure turbine (max recorded to 3.82 units). |
| 21:24:10 | FL150 was selected and the aircraft started the descent. The Auto Throttle (AT) and Autopilot (AP) were still engaged. |
| 21:24:33 | The AT was disengaged and both the thrust resolver angles were selected to 51.15 deg. |
| 21:24:40 | Engine#1 thrust lever was retarded to 36.39 degrees |
| 21:47:35 | The engine#1 Bleed switch was selected OFF. |
| 21:48:02 | APU was switched ON |
| 21:50:15 | BLEED AIR SWITCH parameter started recording as ON |
| 21:50:24 | Engine#2 BLEED switch was switched OFF during descent passing 4627AFE |
| 21:50:33 | ECS RIGHT PACK was put to OFF during descent passing 4500ft AFE |
| 22:01:16 | Crew selected flap 15 for landing |
| 22:02:32 | Landing clearance was issued by ATC. |
| 22:03:50 | Aircraft landed safely on RWY 07 at VOMM and the weight recorded during landing was 73 tons |
| 22:07:13 | While taxing to the allotted stand no.45 the first officer asked the fire fighting team to check for any abnormality on the left engine. |
| 22:07:37 | The ground team confirmed no fire/abnormality on the left engine. |
| 22:12:59 | Both the engines were shut down |

### 1.12 Wreckage and Impact Information: -

Not Applicable.

### 1.13 Medical and Pathological Information: -

Both the crew had undergone pre-flight breath analyzer examination before operating the flight at Tiruchirappalli and was found negative.

### 1.14 Fire: -

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

**1.15 Survival Aspects: -**

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

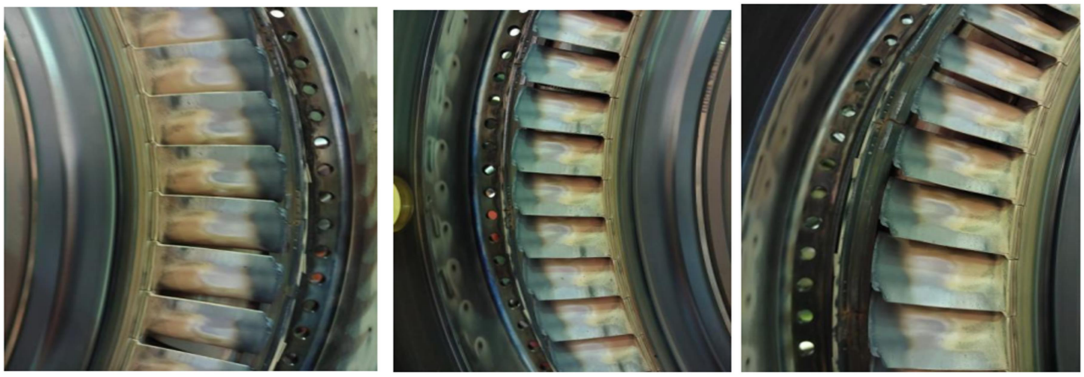
**1.16 Tests and Research: -**

**1.16.1 Strip Report from M/s AIESL:**

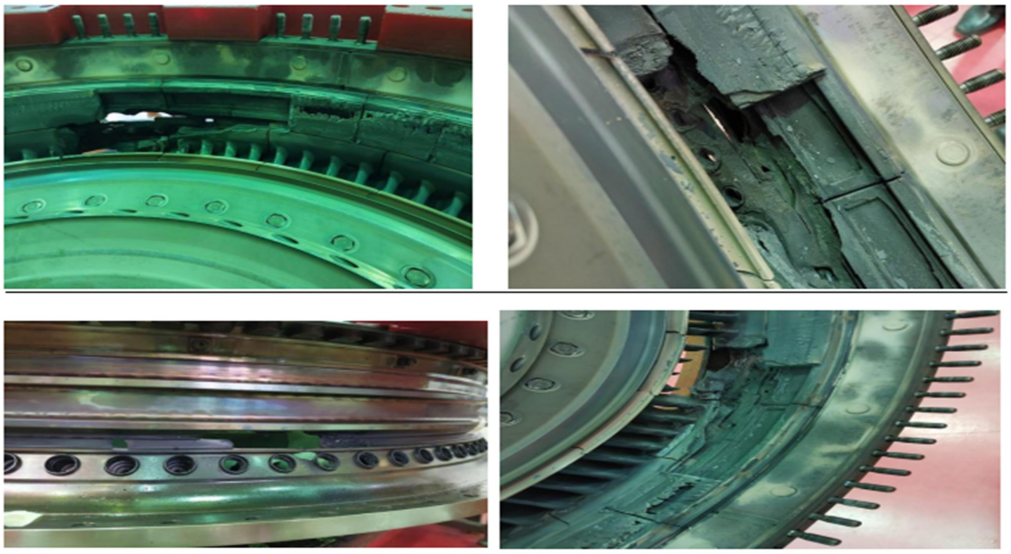
After the incident, engine#1 ESN 894397 was replaced at Chennai due to 4th stage turbine blades being found burnt out at the tips. As per the agreement between M/s Air India Express and M/s AIESL (MRO), the damaged engine was sent to M/s AIESL. The Engine was inducted in the MRO facility in Mumbai and Engine Disassembly and inspections were carried out. During the incoming borescope inspection, damage was noticed on HPTR onwards with missing Qty.3 shrouds and HPT blade T/E with missing material.

During the engine disassembly, the following are the observations:

1) All HPT Stage#1 blades were found with missing material on the trailing edge tip. Indicating wear with shroud trailing edge area

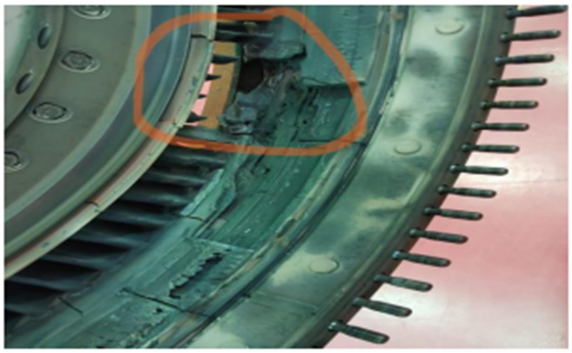
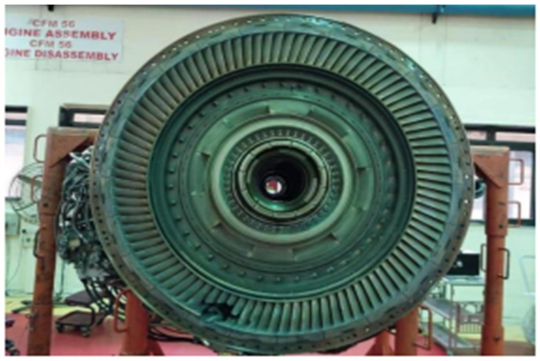


2) HPT shroud Qty.3 was found missing along with HPT case and also found with missing material between 6-7 O'clock position

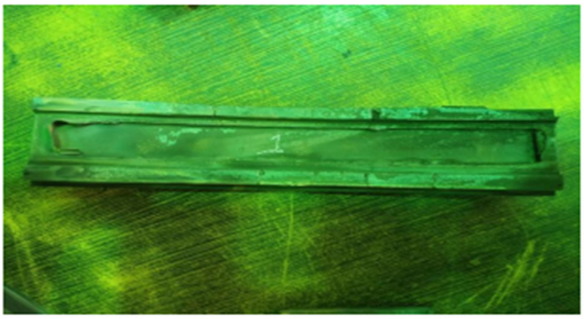
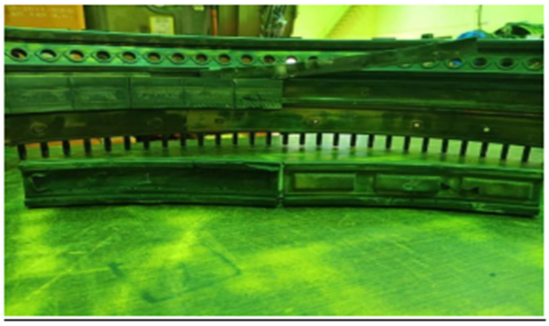


3) Adjacent HPT shroud was found with missing material and heavy burning.

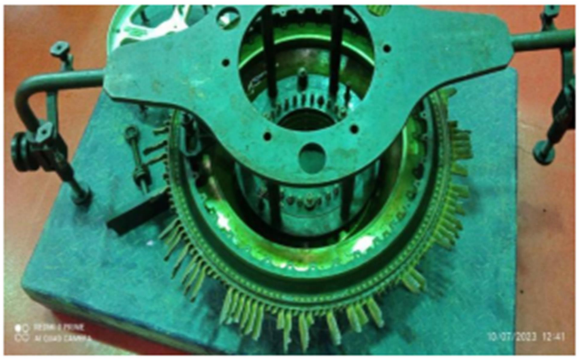

4) HPT hanger support was having missing shrouds (No. 1) observed with missing Air Baffle

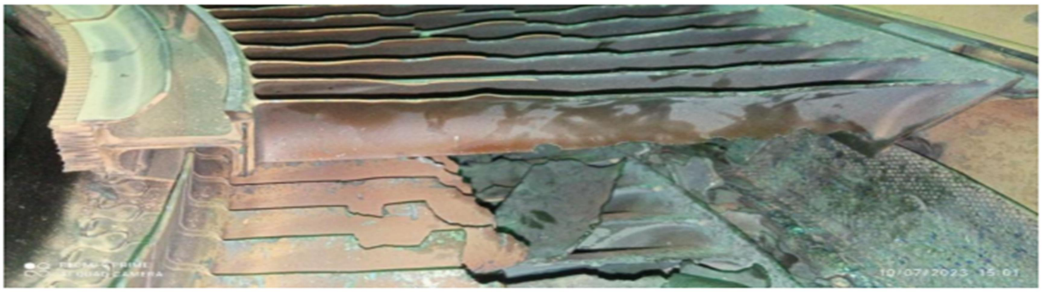
5) PT stage#1 Nozzles with missing material at the Outer platform area.

6) LPT Rotor Stator Assembly stage#1 to stage#4 was found extensively damaged with missing Material

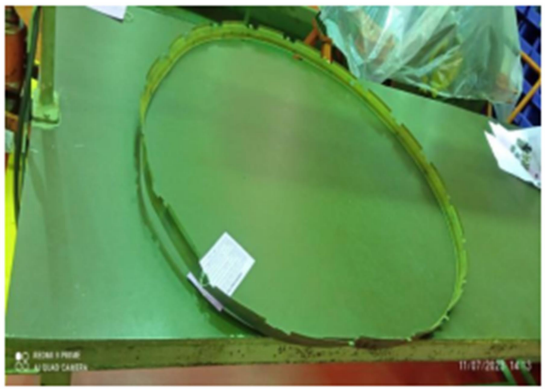
7) LPT NGV stage#1 to stage#4 was found extensively damaged

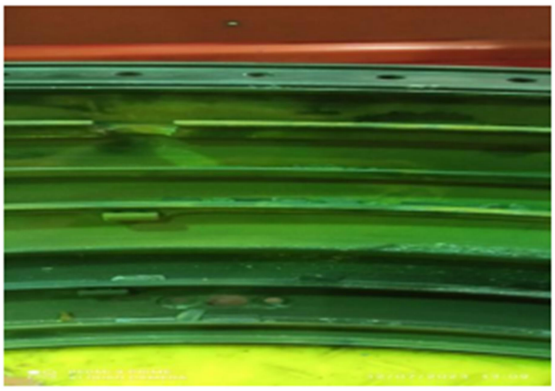


8) LPT Stationary Seal Segment from stage#1 to stage#2 was found with missing honeycomb /missing material and damaged seals

9) LPT Rotating air seal was found damaged/wear


10) All other LPT hardware found damaged/distorted





11) LPT Turbine Rear Frame Assembly - Found with dents on strut area and TRF frame. Dents found with damage exceeding the manual limit

The above findings were shared with CFM for their investigation and suggestions to understand the engine failure mode. Based on the CFM input and engine disassembly observation, arrived at the following conclusions:

i. No foreign object was noticed during the engine disassembly.
ii. HPT blade T/E noticed with missing material indicating abnormal blade rub with shroud T/E.
iii. HPT shroud liberation is a known condition for CFM. The most typical scenario is when the HPT Shroud's liberation damages the HPT Blades and that results in the immediate engine shutdown.
iv. The affected HPT stage#1 shroud P/N 2080M28P09 (N500 material) was introduced as per the SB 72-0740 standard. This part number shroud material testing demonstrated equivalent performance at normal operating temperature. However, when the cooling flow is compromised and the operating temperature elevates, it is susceptible to accelerated corrosion and oxidation.
v. Cooling flow was compromised due to HPT hanger cooling holes plugging. The HPT shrouds that are not liberated are found heavily burned through, which is a clear sign of lack of cooling.
vi. HPT hangers with P/N 1808M6106 were installed on the engine which did not have air filters. Hence, through SB 72-0816 and SB 72-0961, CFM recommends the customer's choice to install the HPT hangers having air filters to decrease the possibility of similar issues.
vii. Accelerated corrosion and oxidation lead to burn-through the area liberated in the LPT direction without causing secondary damage to HPT blades.
viii. The engine operated at severe burn-through and without HPT shrouds let the hot gas affect the HPT hangers. After burning or liberation of HPT shrouds and C-clips, the hot gas gets deeper into the cavities of HPT Shroud Support, where the normal temperature is much lower and this leads to the HPT Shroud Support burn-through.

## 1.17 Organizational & Management Information: -

Air India Express Limited (AIXL) is a wholly-owned subsidiary of Air India, operating as a separate AOC for scheduled operations. AIXL was launched in May 2005 and operates as a low-cost carrier, under the brand name Air India Express (AIX). This low-cost arm of Air India is headquartered in Kochi, Kerala. Air India Express operates an impressive fleet of 27 Boeing 737- 800 Next Generation (NG) aircraft.

AIXL CAMO is a CAR-M, Subpart G approved organization for the Aircraft fleet of Boeing 737-800NG aircraft which is structured under the management of the Accountable Manager of AIXL. AIXL CAMO holds the privileges according to CAR M, Subpart G to manage the continuing airworthiness of commercial air transport aircraft as listed on the approval certificate and its Air Operator Certificate (AOC) S-14. The main CAMO facility of AIXL is located at Thiruvananthapuram and is approved by DGCA vide Letter No: F/KOCHI/AICL/1887 dated 18/12/2015.

AIXL operates on domestic and international networks. Air India Express is a low-cost airline that provides convenient connectivity to short/medium haul international routes in the Gulf and South East Asia. Maintenance of Boeing 737-800NG aircraft of Air India Express aircraft (Line and Base maintenance), Engine, APU and components are carried out by AI Engineering Services Limited (AIESL), which is approved by the DGCA under CAR 145 maintenance organization, with whom Air India Express has the contract for comprehensive maintenance.

## 1.17.1 Continuing Airworthiness Management Exposition, Duties and Responsibilities (Relevant portion): -

**Continuing Airworthiness Manager (CAM)**

CAM shall be nominated with the responsibility of ensuring that the organization is always in compliance with the CAME. The Continuing Airworthiness Manager (CAM) is responsible for determining what maintenance is required, when it must be performed and by whom and to what standard, in order to ensure the continued airworthiness of the aircraft being operated. Continuing Airworthiness Manager will ensure that all maintenance is carried out on time and to an approved standard for its managed fleet.

1. Ensure proper work planning and technical follow-up.
2. Coordination of scheduled maintenance, Airworthiness Directives/DGCA Mandatory modifications, replacement of service life limited parts and component inspection to ensure the work is carried out properly.
3. Coordinate with all the CAMO persons and contracted and subcontracted organizations to meet the compliance of continuing airworthiness.

**Technical Services (Powerplant)**

Reports to CAM / Dy. CAM. Manager - Technical Services (powerplant) is in charge of all powerplant and related projects on the aircraft. Some of his responsibilities are as follows:

1. Monitoring of Engines Life Limited Parts in the fleet.
2. Life development of Engine components and systems including correspondence with aircraft Manufacturers and Component Vendors in matters relating to Life Development Programs, Product Improvement Programs and Technical problems.
3. Investigation of major defects and preparation of major defect reports pertaining to powerplant and accessories.
4. Condition Monitoring and trend monitoring of Engines and suggest remedial measures.

## 1.18. Additional Information: -

Nil.

## 1.19 Useful or Effective Investigation Techniques: -

Nil.

## 2. Analysis: -

### 2.1 Maintenance Aspects: -

The aircraft VT-AYC was issued a Certificate of Registration on 29.09.2009 by DGCA-INDIA and prior to the incident, the last ARC was issued on 20.09.2022. The last major inspection was phase inspection 22, performed on 04.11.2022 and the weekly inspection was performed on 23/12/2022. The aircraft had accumulated a total of 46808 airframe hours since new. On the date of the incident, the aircraft had operated 04 flight sectors without any defects being reported in any of these sectors prior to the incident sector.

The involved engine ESN: 894397 was installed at the #1(LH) location and had accumulated a total of 51279 time since new and 17306 cycles since new. The engine had accumulated 5602 cycles since the last shop visit.

The operator had received a customer notification report dated 20/12/2022 with priority status as "normal" from the engine manufacturer CFM on the performance degradation of engine #1 installed on the subject aircraft. The AIXL CAMO discussed the CNR during the daily meeting conducted on 21/12/2022 and decided to issue a callout to MRO to carry out a few tasks. The same was planned along with the weekly inspection at VOTR on 24/12/2022. The weekly inspection was changed by MCC and the same was carried out at OMSJ on 23/12/2022. The weekly inspection was carried out in a ground time of 4 hours and 30 minutes.

As per the Aircraft Maintenance Program (AMP), the weekly inspection period is 75 hours/7 days, whichever comes early. At the time of the weekly inspection at OMSJ, the aircraft had completed 65:35 hours of flying after the last weekly inspection carried out on 18/12/22. After the inspection, the aircraft operated the next flight to VOTR on 24/12/2022 where the aircraft had a ground time of 2 hours 23 minutes. This was the station where the operator had planned to perform the callout issued on 21/12/22. However, the operator didn't carry out the callout issued at VOTR as planned earlier. Thereafter, the aircraft was transiting through other stations. On 26/12/2022, again, the aircraft had a ground time of 2 hours 51 minutes at CCJ and no actions were taken to perform the issued callout. During the fifth sector of the day on 26/12/2022, the engine stalled and the aircraft diverted to Chennai.

As per the statement of CAM, MCC and powerplant personnel, the CNR tasks were not carried out due to aircraft movement changes and no proper ground time available to carry out the tasks. However, during the analysis of ground time, on two occasions, proper ground time was available, ie at VOTR on 24/12/2022 and at CCJ on 26/12/2022 to perform the isuued callout tasks. As per

the statement of LMM of MRO, the MRO didn't receive any callouts from the AIXL CAMO to plan the inspections at any of the stations. Further, as per CAM, the ground time required for the issued callout is approximately 30 minutes and additional time if any fault is observed.

During the analysis of the "myCFMPortal" data, it was observed that even after the issuance of CNR dated 20/12/2022, there were a series of alerts for the performance degradation of the engine parameters. The technical services powerplant team under AIXL CAM failed to monitor the alerts generated by the manufacturer's systems. As per the statement of CAM, before further evaluation could be carried out on the engine after the holidays from 24/12/22 to 26/12/22, the engine stalled. However, the data from "myCFMportal" showed that the alerts were generated by the OEM systems between 20/12/22 to 26/12/22. This implies that there is no proper monitoring of the "myCFMportal" to analyze the performance degradation by the concerned department. Also, there is no system existing in the organization to monitor the "myCFMportal" during the weekends/holidays and take appropriate action in case of further performance degradation of the normal/CNR affected engine.

The CFM (OEM) was contacted to check even though, after the issuance of CNR dated 20/12/22, there were a series of alerts generated by the OEM system. The OEM did not change the priority of the CNR issued/alerted the airline to take immediate action. The OEM clarified that as the alerts were generated for the same parameters for which the CNR was issued, as per the existing system of CFM, the CNR category remains unchanged.

Post incident engine was replaced in Chennai and the engine was sent to the AIESL Mumbai facility for strip analysis. During the engine disassembly, no foreign object damage was observed. The damaged photographs and findings were shared with CFM for their input. As per CFM, HPT shroud liberation is a known condition for the CFM engine as seen in this case. The most typical scenario is when the HPT Shroud's liberation damages the HPT Blades and that results in immediate engine damage/shutdown. This occurs especially when the engine operates more in a dusty environment. The same was discussed and recommended at customer choice by CFM through CFM56-7B SB 72-0816 and SB 72-0961, wherein the improved HPT hanger with air filters was introduced, which will reduce the plugging of the cooling holes. Further, CFM was advised to perform the CNR task as soon as possible by the airline even though; the CNR was issued with normal priority.

From the above, it is inferred that the failure on the part of AIXL CAM in monitoring the continuous engine performance degradation alerts generated by CFM and the delay in performing

the CNR recommended task by CFM, even though the priority was normal, led to the engine stalling during the subject flight. Hence, the serviceability of the engine was a factor that contributed to the incident.

## 2.2 Operational Aspects: -

The first officer was the Pilot Flying (PF) and the PIC was the Pilot Monitoring (PM) for the sector. The same was decided by the crew during the pre-flight briefing. Both the flight crew were holding valid licenses for operating the type of aircraft and had sufficient flying experience for the duties assigned to them. The subject flight was the fifth flight of the day by the aircraft and for both the flight crew it was the first flight of the day. The weather was normal throughout the flight and no significant changes were observed. During landing at Chennai airport, the visibility was 5000m and winds were reported as calm. Hence, the weather had no role in this incident.

The aircraft took off from Tiruchirappalli airport at 21:09 UTC and had an uneventful flight until the climb phase at FL230. At 21:21:37 UTC, while climbing and passing FL230, a thud sound was heard by the crew followed by a reduction in N1 to approximately 65%. Subsequently, engine#1 fuel flow started dropping rapidly and EGT shot up to 913℃ and engine#1 N2 also dropped. Immediately, the PIC took over control. It also observed that engine#1 Low-pressure turbine (LPT) vibration started increasing and went up to 3.82 units and similarly, at 21:21:43 Engine#1 fan vibration started increasing and went up to 2.51 units. All other engine parameters were within limits.

At 21:22:40 UTC, the cabin crew informed the crew that they had heard a sound in the cabin. The crew referred to the engine high vibration checklist. Later, the cabin crew informed the crew about the flame seen from the engine exhaust by one of the passengers. The crew immediately referred to an engine failure non-normal checklist and were found discussing that the checklist was not applicable. At this time, the crew was in contact with Chennai Radar. Thereafter, the crew declared “PAN PAN” to ATC Chennai and informed them about the decision to divert to Chennai due to engine#1 problem.

At 21:24:33 UTC, while descending, the crew followed the engine fire or severe damage or engine separation and the thrust lever of engine#1 was brought to idle. The crew decided not to increase thrust to avoid further damage and not to shut down engine#1 as all engine parameters were within limits. Engine no#1 was run at idle thrust for the rest of the flight.

Thereafter, approximately at 21:32 UTC engine surge or stall non-normal checklist was carried out i.e., after 10 minutes of the engine problem. As per the conditions mentioned for the engine surge or stall checklist, the checklist appears to be appropriate for the engine issue. The crew, as a precautionary measure, requested ATC for firefighting service on landing and the same was agreed upon by ATC. The crew prepared the aircraft for an overweight landing and finally, crew followed one engine inoperative landing non-normal checklist. The crew selected flap 15 for landing and the aircraft landed safely at Chennai Airport on Runway 07 at 2204 UTC.

As per the non-normal checklist sequence followed by the crew, it is observed that the flight crew seems to have correctly identified the engine parameters but misidentified the condition of the engine/cause of indications. This may have led the crew to carry out the correct non-normal checklist only after initially carrying out the less applicable NNCs. Hence, the implementation of the applicable non-normal checklist was delayed.

From the above, the crew handling the aircraft was not a factor in the incident except for the delay in following the appropriate non-normal checklist.

## 3. Conclusion: -

### 3.1 Findings: -

1. The aircraft had a valid Certificate of Registration and Airworthiness Review Certificate at the time of the incident. The last ARC was issued on 20/09/2022.
2. The aircraft was maintained by the certified aircraft maintenance program and the applicable Airworthiness Directive and Service Bulletins were complied with.
3. The maintenance of the Air India Express Limited aircraft has been outsourced by the AOC holder to AIESL, which is a DGCA approved CAR 145 maintenance repair organisation.
4. The operating cockpit crew members had valid licences and ratings for operating the aircraft.
5. Both the operating crew members were subjected to pre-flight breath analyzer test prior to the flight at Tiruchirappalli and were cleared for the flight.
6. Duty time of both crew members was within the defined limits.
7. The aircraft was released from Tiruchirappalli in a serviceable condition, for a scheduled revenue passenger flight. There was no similar snag/defect reported prior to the incident sector. The subject flight was the fifth flight of the day by the aircraft.

8. The first officer was the Pilot Flying and the PIC was the Pilot Monitoring, for the flight sector and for both the flight crew it was the first flight of the day.
9. The aircraft took off from Tiruchirappalli airport at 21:09 UTC and the climb was uneventful without any abnormal indications till the climb phase at FL230. The crew heard a thud sound and immediately, observed that engine#1 N1 and N2 started dropping, along with fuel flow to engine #1 also dropping. The engine#1 EGT shot up and started decreasing. During this time, the auto throttle was engaged.
10. PIC took over control and informed the ATC regarding the engine issue.
11. The cabin crew informed the crew that they also heard a loud sound in the cabin. After some time, the cabin crew again informed that one of the passengers had reported observing flame from the engine exhaust.
12. Crew referred to the non-normal checklists and retarded engine#1 thrust lever to idle position. After the checklist action, there were no abnormalities/indications observed by the crew and they continued the flight to Chennai.
13. The crew prepared the aircraft for an overweight landing and selected flap 15 for landing. The aircraft landed safely at Chennai Airport on Runway 07 at 2204 UTC.
14. During the analysis of CVR and DFDR data, it is observed that the flight crew seems to have correctly identified the engine parameters, however, misidentified the condition of the engine/cause of indications. This may have led the crew to carry out the correct non-normal checklist only after initially carrying out the less applicable NNCs. Hence, the implementation of the applicable non-normal Checklist was delayed.
15. On arrival at Chennai, during inspection, AME observed that all blades of the Low-Pressure Turbine (LPT) 3$^{rd}$ and 4$^{th}$ stages were damaged. Hence, the engine was replaced and sent to the shop for strip analysis.
16. The findings made during engine strip analysis and as per the inputs of CFM, the HPT liberation seen in this case is a known condition for the CFM engine. Further, the analysis did not indicate any foreign object damage.
17. During analysis of engineering records, it was observed that a CNR was issued by CFM with priority as “normal” on the involved engine on 20/12/22 for performance degradation.
18. AIXL CAMO discussed the CNR during the daily meeting on 21/12/22 and decided to issue a callout to MRO to carry out the CNR recommended tasks during the weekly inspection planned for 24/12/22 at VOTR. However, the weekly inspection was changed to 23/12/22 at OMSJ and the CNR recommended task was postponed to the next weekly inspection.

19. During the analysis of “myCFMportal” access of AIXL CAMO, it was observed that even after the receipt of CNR there were a series of alerts generated by the OEM system between 20/12/22 to 26/12/22 for further performance degradation of the engine.
20. The AIXL CAM failed to monitor the performance signatures generated by CFM systems and continued to operate the aircraft without performing the CNR recommended tasks, which led to the engine stalling during the flight.
21. As per AIXL CAMO, the weekly inspection was changed to OMSJ on 23/12/22 due to aircraft movement changes. However, it was found that after the weekly inspection, the aircraft operated the next flight to VOTR only where they initially planned to perform the CNR task and the aircraft was on the ground for 2 hours and 23 minutes for the next flight.
22. As per the CAM, the minimum ground time required to carry out the issued callout on 21/12/22 is 30 minutes plus extra ground time if any fault is detected.
23. The analysis of the ground time data of the aircraft shows that after the weekly inspection on 23/12/22 on two occasions, there was sufficient ground time to perform the CNR issued callout by the CAMO.
24. As per the LMM of MRO, the callout issued by AIXL CAMO was not received by the MRO for planning the CNR recommended tasks during the weekly inspection.

### 3.2 Probable Cause: -

The probable cause of the incident was the failure to monitor the engine performance degradation trend alerts generated by the OEM, thereby delaying the customer notification report and recommended tasks, which led to the engine stall during the flight.

## 4. Safety Recommendations: -

In-view of the findings DGCA HQ may take necessary action.

Jinu Thomas

Jinu Thomas
2024.04.23 17:51:57+05'30'

(Jinu Thomas)
Assistant Director of Air Safety
Investigator-In-Charge

Date: 23.04.2024
Place: Kochi