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Final Investigation Report

on

Serious Incident to M/s SpiceJet Limited

Aircraft DHC-8 Q-400, VT- SUW

on 22 November 2021

Amit Kumar
Investigator-in-charge

K. S. Muthukrishnan
Investigator

FOREWORD

In accordance with Annex 13 to the Convention on International Civil Aviation Organization (ICAO) and Rule 3 of Aircraft (Investigation of Accidents and Incidents), Rules 2017, the sole objective of the investigation of an Accident/Incident shall be the prevention of accidents and incidents and not to apportion blame or liability. 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 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 future accidents or incidents could lead to erroneous interpretations.

Contents

GLOSSARY

AAIB	Aircraft Accident Investigation Bureau
ADD	Acceptable Deferred Defects
AME	Aircraft Maintenance Engineer
ARC	Airworthiness Review Certificate
ARTCC	Air Route Traffic Control Center
ATIS	Aerodrome Terminal Information System
AMSL	Above Mean Sea Level
AOP	Air Operator Permit
ANVS	Active Noise and Vibration Suppression System
AMP	Approved Maintenance Program
AMM	Aircraft Maintenance Manual
ATPL	Airline Transport Pilot Licence
CAR	Civil Aviation Requirements
CDL	Configuration Deviation List
CVR	Cockpit Voice Recorder
CPL	Commercial Pilot Licence
C of R	Certificate of Registration
C of A	Certificate of Airworthiness
CG	Centre Of Gravity
Ctrl	Control
DHC	De Havilland Canada
DFDR	Digital Flight Data Recorder
DME	Distance Measuring Equipment
DGCA	Directorate General Of Civil Aviation
Dia	Diameter
DDPG	Dispatch Deviation Procedures Guide
FL	Flight Level
FRTOL	Flight Radio Telephone Operator's Licence
FIR	Flight Information Region
Ft/ in	Feet / inches
FOD	Foreign object debris
Hrs	Hours
HIRF	High Intensity Radio Frequency
IST	Indian Standard time
IR/PPC	Instrument Rating/ Personnel Proficiency Check
IPS	Inches Per Second
IPC	Illustrated Parts Catalogue
i.r.o	In Respect Of
Insp	Inspection
KG	Kilo Gram
LH/ RH	Left half/ Right Half
Lbs	Pounds
LP/ HP	Low Pressure/ High Pressure

MSN	Manufacturer serial Number
METAR	Meteorological Aerodrome Report
MEL	Minimum Equipment List
MPD	Maintenance Planning Document
MRB	Maintenance Review Board
NDB	Non Directional Beacon
NTC	Notice To Crew
OEM	Original Equipment Manufacturer
PIC	Pilot in Command
PBMS	Propeller Balance Monitor System
Ptn	Position
RTR	Radio Telephony Restricted
RTS	Return to Service
RPM	Revolutions Per Minute
SMS/ HF	Safety Management System/ Human Factors
STC	Supplemental Type Certificate
SRM	Structural Repair Manual
STBD	Star Board
TC	Type Certificate
UTC	Co ordinate Universal Time
UFC	Upper Forward Cowling
VOR	Very high Frequency Omni directional Ranging
WOW	Weight On Wheels

Aircraft and Serious Incident details of DHC- 8 Aircraft VT-SUW on 22 November 2021.			
1.	Aircraft	Type	De Havilland Canada- 8 Q 400
		Nationality	Indian
		Registration	VT-SUW
2.	Owner & Operator		M/s SpiceJet Ltd
3.	Pilot		ATPL Holder
4.	Co- Pilot		CPL Holder
5.	No. of Persons on board		85
6.	Injuries		Nil
7.	Date & Time of Serious Incident		22nd November 2021 at 1012 UTC
8.	Place of Serious Incident		Delhi Airport (VIDP)
9.	Co-ordinates of Serious Incident Site		Lat: 28°34'07" N Long: 77°06'44" E.
10.	Last point of Departure		Gorakhpur Airport (VEGK)
11.	Intended landing place		Delhi Airport (VIDP)
12.	Type of Operation		Scheduled
13.	Phase of operation		Approach
14.	Type of Serious Incident		System/Component Failure or Malfunction (Non-Powerplant) (SCF-N-PP)

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

SYNOPSIS

M/s Spice Jet Ltd DHC- 8 Q400 aircraft, with registration VT-SUW, while operating a scheduled flight from Gorakhpur to Delhi was involved in a serious incident on 22 Nov 2021. The aircraft was scheduled to operate Delhi – Gorakhpur – Delhi. Accordingly, the aircraft had operated Delhi-Gorakhpur sector and the flight was uneventful.

For Gorakhpur -Delhi sector, 80 passengers along with four crew and one company authorized "Category A" license holder (Certifying mechanic) were onboard. The AME was on duty for Delhi-Gorakhpur -Delhi sector. The pilot in command (PIC) was an ATPL holder, who was assisted by a CPL holder Co-Pilot.

The aircraft took off from Gorakhpur airport and the flight was uneventful till the start of the descent into Delhi. When the aircraft started descending into Delhi on approach, one of the passengers noticed an abnormal condition of the RH engine's upper forward cowl (UFC) and informed the cabin crew about the same. The cabin crew apprised the AME onboard.

AME assessed the situation by seeing the damaged RH engine's upper forward cowl through the aircraft's window and alerted the flight crew about the damaged and deteriorating condition of the RH engine's upper forward cowl. He also asked the PIC to take precautions. Flight crew exercised certain precautionary actions. Crew informed Delhi ATC about the situation and requested for a precautionary landing. The same was approved by the Delhi ATC. Subsequently, the aircraft landed safely at Delhi airport.

When the aircraft stopped in the assigned bay, two pieces of RH engine's outboard upper forward cowl got detached and fell on the apron. Meanwhile the airport safety vehicle did the runway inspection and confirmed that no wreckage was found on the runway. Passengers were disembarked normally and no injuries were reported. The aircraft sustained minor damage.

Director General, AAIB appointed Sh. Amit Kumar, Safety Investigation Officer, AAIB as Investigator – In – Charge and Sh. K. S. Muthukrishnan as investigator to investigate into the probable cause(s) of the incident, vide Order No. INV.12011/6/2021-AAIB dated 24th Nov 2021 and subsequent corrigendum under Rule 11 (1) of Aircraft (Investigation of Serious Incidents and Incidents), Rules 2017.

Unless otherwise indicated, recommendations in this report are addressed to the regulatory authorities of the State having the responsibility for the matters with which the recommendation is concerned. It is for those authorities to decide what action is taken.

1. FACTUAL INFORMATION

1.1 HISTORY OF FLIGHT

On 22nd November, 2021, the aircraft had operated in three sectors (Delhi- Varanasi, Varanasi-Delhi and Delhi – Gorakhpur) prior to operating Gorakhpur – Delhi, as fourth sector of the day. After the completion of three preceding sectors neither any defect/abnormality was reported by the respective operating crew nor was any snag recorded in the aircraft technical logbook.

The first two sectors, i.e., Delhi- Varanasi and Varanasi- Delhi were operated by a different set of flight crew. The flight crew were changed to operate Delhi-Gorakhpur- Delhi Sector. Before operating the Delhi –Gorakhpur sector, the flight crew signed the pre-flight medical declaration at Delhi for non-consumption of alcohol or any other psychoactive substance as per prevailing DGCA regulation. The aircraft was under the command of an ATPL holder, and was assisted by a CPL holder Co-pilot.

The aircraft was scheduled to depart at 0840 UTC from Gorakhpur and was scheduled to arrive in Delhi at 1025 UTC. As per transit pre-flight inspection requirements, an authorized maintenance personnel did the pre-flight inspection at Gorakhpur and nil abnormality was recorded in the aircraft techlog. However, one MEL pertaining to aft interphone was carried forward. There were 85 souls onboard including four crews and one company authorized "Category A" license holder AME (Certifying mechanic). AME was on duty for the Delhi-Gorakhpur-Delhi sector.

The aircraft took-off at 0845 UTC from Gorakhpur and the flight SEJ 2954 was uneventful till the start of the descent into Delhi. When the aircraft started descent, one of the passenger noticed and informed the cabin crew that one panel (upper forward cowl) of the RH engine was fluttering and was unusual. Cabin crew passed this information to the onboard AME. AME assessed the situation after seeing the damaged RH engine's upper forward cowl through the aircraft's window and informed the flight crew over intercom that the RH engine's upper forward cowl was not in a good condition and it had fractured. Further, the AME advised the flight crew to take necessary precautionary actions. Meantime, the aircraft had descended to FL100. The flight crew instructed the AME to monitor the condition of the damaged cowl and update on any further deteriorations. Based on AME's inputs, the flight crew took the decision to lock the torque of the affected engine at 15% for rest of the flight. While the aircraft was descending from 7000ft to 2600ft as cleared by the approach radar, the cabin crew updated the flight crew that the cowling had fractured. At 1014 UTC, crew apprised the approach controller about the RH engine's cowl condition and requested for a precautionary landing. When the Approach Controller enquired for any assistance, the crew confirmed that no assistance required during landing. At 1018 UTC, approach controller cleared the aircraft for ILS approach on runway 28. Then at 1024 UTC, tower controller cleared the aircraft for landing on runway 28.

The aircraft landed on runway 28, taxied and parked into the assigned bay on its own power. Post landing of VT-SUW, runway inspection was carried out by the airport operator to check presence of

FOD on the runway. However, nothing was found on the runway. Passengers were disembarked normally and no injuries reported. However, the aircraft sustained minor damages.

1.2 INJURIES TO PERSONS

INJURIES	CREW	PASSENGERS	OTHERS
FATAL	Nil	Nil	Nil
SERIOUS	Nil	Nil	Nil
~~MINOR~~/NONE	05	80	Nil

1.3 DAMAGE TO AIRCRAFT

Aircraft sustained minor damages during the incident. RH engine's both inboard and outboard forward cowl, all propeller blade root and propeller hub were found damaged. Details of the damages sustained are given in section 1.12 under Wreckage and impact information.

1.4 OTHER DAMAGE

Nil

1.5 PERSONNEL INFORMATION

1.5.1 PILOT-IN-COMMAND:

Nationality	Indian
Age	50 Years
Date of Joining the Organisation	01-02-17
License Category	ATPL
License issue date	18-07-16
License valid Up to	17-07-26
Endorsements as PIC	P-68, DHC-8
Date of Medical Exam	08-08-21
Medical Validity	14-08-22
FRTOL Date of Issue/Validity	17-05-16 / 16-05-26
RTR Date of Issue	24-09-15
Total Flying Experience	6908.20 hrs
Hours Flown on Type	3585.15 hrs
Previous Flight (Date of Last Flight)	22-11-21
Experience as PIC on Type	3436.22 hrs
Hours flown in last 365 days	683.03 hrs

Hours flown in last 180 days	323.50 hrs
Hours flown in last 30 days	83.50 hrs
Hours flown in last 7 days	24.56 hrs
Hours flown in last 90 days	162.25 hrs
Hours flown in last 24Hrs.	01.51 hrs
Rest period before the flight	21:20hrs
Last IR/PPC	30-04-21/ 16-10-21
Last Annual Line Check (ALC)	04-06-21
Last Ground Refresher	22-03-21

1.5.2 CO-PILOT:

Nationality	Indian
Age	26 Years
Date of Joining the Organisation	23-01-17
License Category	CPL
License issue date	18-03-10
License valid Up to	26-08-25
Endorsements as PIC	C-152, PA-34
Date of Medical Exam	17-11-20
Medical Validity	30-11-21
FRTOL Date of Issue/Validity	18-03-10 /26-04-25
RTR Date of Issue	24-04-12
Total Flying Experience	3511.11 hrs
Hours Flown on Type	3209.29 hrs
Previous Flight (Date of Last Flight)	22-11-21
Experience as PIC on Type	N/A
Hours flown in last 365 days	773.13 hrs
Hours flown in last 180 days	376.13 hrs
Hours flown in last 30 days	85.10 hrs
Hours flown in last 7 days	19.45 hrs
Hours flown in last 90 days	165.06 hrs
Hours flown in last 24Hrs	01.51 hrs
Rest period before the flight	15:05 hrs
Last IR/PPC	12-06-21 / 12-06-21
Last Annual Line Check (ALC)	30-08-21
Last Ground Refresher	19-04-21

1.5.3 ONBOARD (Cat A) AME:

Nationality	Indian
License Validity	23.07.2023
Continuation training validity	29.08.2023
Authorization issue date	10.09.2021
Authorization validity	23.07.2023
Aircrafts authorized	B-737-700/800/900 (CFM56-7B) & DHC – 8 -400 (PWC PW 150) with Task limitations.

1.6 AIRCRAFT INFORMATION

1.6.1 Aircraft General Description

The aircraft is a high wing monoplane with cantilever wings, T tail, semi−monocoque fuselage and a fully retractable tricycle landing gear. A large portion of the skin panels are bonded assemblies consisting skin, stringers and doublers, or skin sandwich with a honeycomb core. The aircraft is fitted with two PW150A engines driving six bladed variable pitch Dowty propellers. This aircraft is known for the low noise and vibration. The internal noise is reduced due to active noise and vibration suppression system and the external noise signature is reduced due to low RPM and efficient propellers.

The three views of the aircraft with dimensions are depicted below:

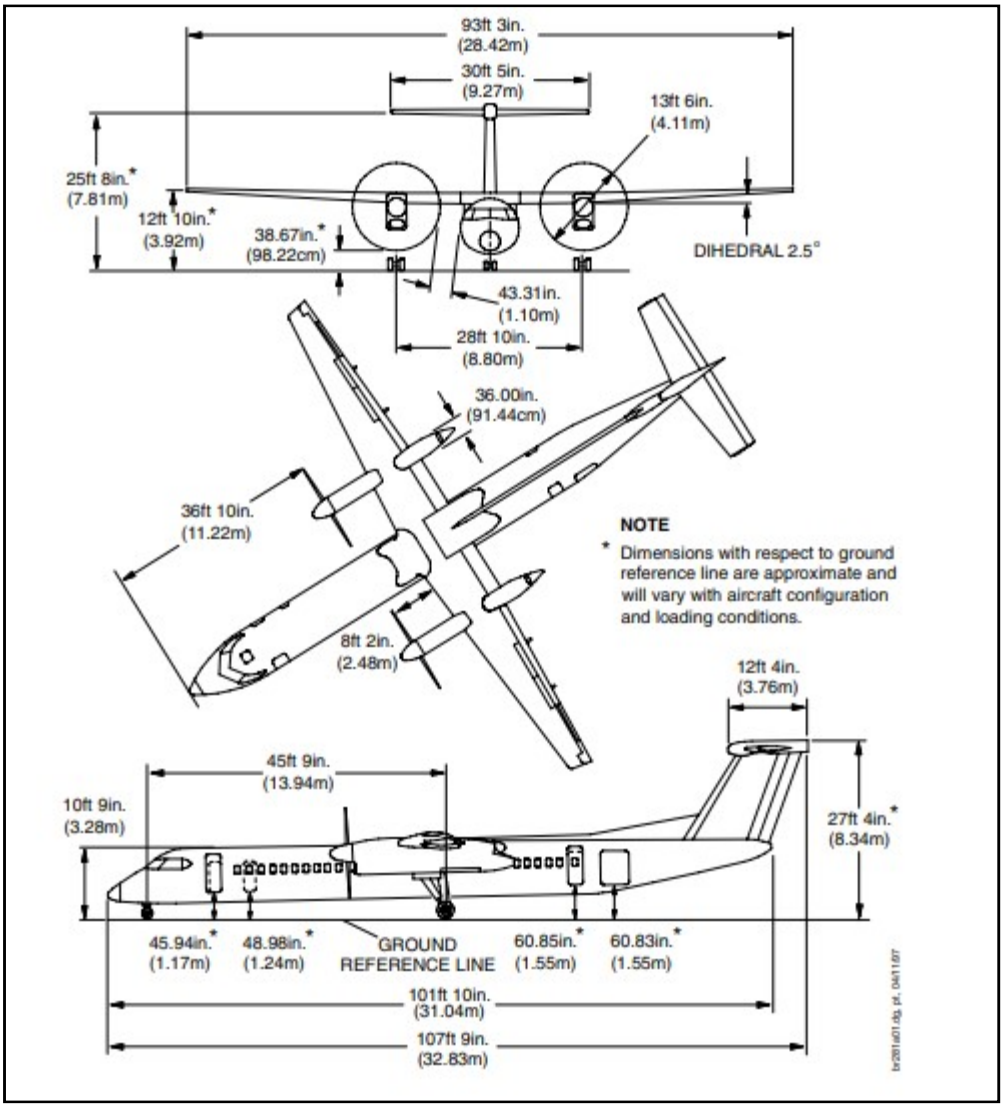


Figure 1 Three Dimensional views

1.6.2 Aircraft (VT-SUW) Specific Information

Aircraft Model	DHC-8-402
MSN	4345
Year of Manufacturer	2011
Name of Owner	NAC Aviation 23 Limited
C of R	Validity: 23-05-2025
C of A	Date of Issue: 25.05.2017
A R C issued	22-05-2021
ARC valid up to	23-05-2022
Aircraft Empty Weight	17913.46 Kg
Maximum Takeoff weight	29574 Kg
Date of Aircraft last Weighed	11-05-2017
Operating Empty Weight	17913.46

Max Usable Fuel	5318 Kg
Max Payload with full fuel	5811.14 Kg
Operating Empty Weight C.G	393.84
Next Weighing due	10-05-2022
Total Aircraft Hours	21407:46
Last major inspection	18-Feb-2020 Base Check 1 + 9 Yearly
Engine Type	PWC 150A
Date of Manufacture LH	24-Sep-2011
Engine Sl. No. LH	PCE-FA0881
Last major inspection (LH)	15-Dec-2019
Total Engine Hours/Cycles LH	22,383:43 / 20,560
Date of Manufacture RH	13-Aug-2007
Engine Sl. No. RH	PCE-FA0409
Last major inspection (RH)	03-Jun-2019
Total Engine Hours/Cycles RH:	22,814:50 / 22,418
Aero mobile License	Validity: 23-05-2025
AD, SB, Modification	Complied on the date on date

The aircraft VT-SUW bearing MSN 4345 was manufactured in the year 2011 and is owned by NAC Aviation 23 limited, Ireland. The Aircraft was inducted by the operator in its fleet on 01 Jun 2017. The aircraft was registered under category 'A' in Certificate of Registration(C of R). The Certificate of Airworthiness under "Normal category" (subdivision Passenger / Mail / Goods) was issued by DGCA on 25.05.2017. The specified minimum operating crew is two and the maximum all up weight is 29,574 Kg. At the time of incident, the Certificate of Airworthiness, ARC and Aero Mobile License were valid.

Scrutiny of the Technical Log Book and Pilot Defect Report (PDR) revealed that on the day of incident, there were 13 open deferred defects (under ADD) and one MEL pending for action. Out of 13 ADD one was related to the RH engine propeller re-torque and rest is not relevant to this incident. Fueling panel instruction placard was found torn/faded during the layover inspection on 30 Oct 2021. Same was deferred under the (ADD) acceptable deferred defects and was not rectified within the time frame of 90days due to non availability of spares and was extended by further 30 days with the approval of PHCA as per Organization deferment Policy. However, same was carried out on 09 Mar 2022.

1.6.3 ENGINE FORWARD COWL

1.6.3.1 General Description

The nacelle encloses the engine mounting structure that supports the propeller, gearbox, engine, systems and cowlings. Engine aerodynamic and operating loads are transferred through the structure to the nacelle centre section and wing box. The forward nacelle extends forward from the wing front spar frame and contains the main support structure for the propulsion system.

The Forward Nacelle consists of following components:

1. Forward Nacelle Access Panels
2. Forward Nacelle Fairings
3. Forward Nacelle Struts

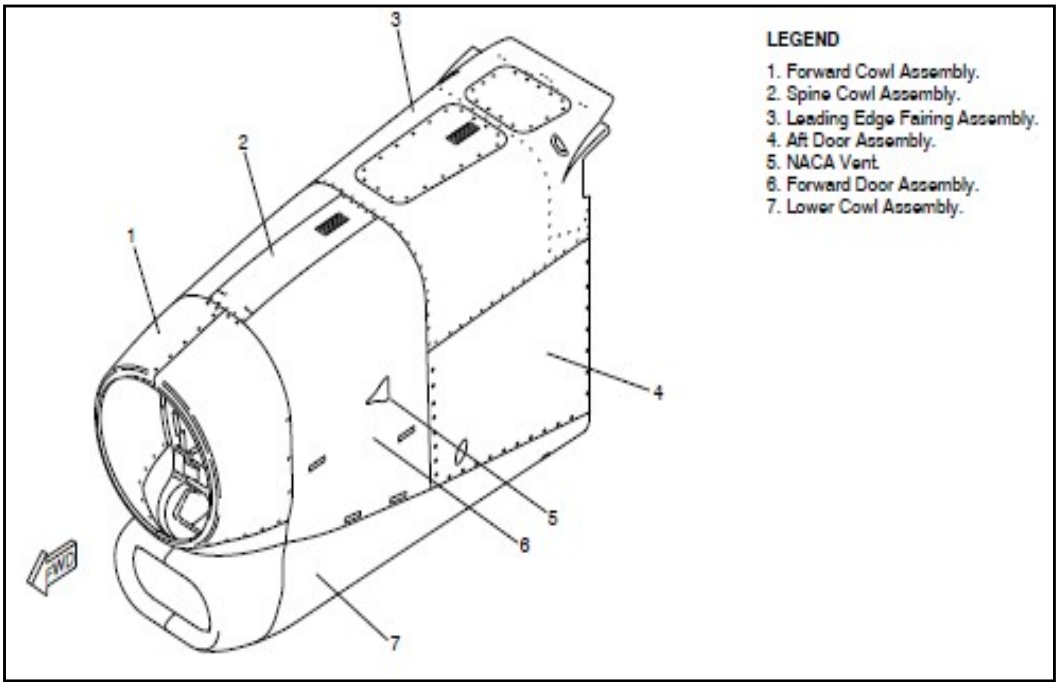


Figure 2 Engine Nacelle

Forward Nacelle Access Panels

The engine upper forward cowl (Part No 87144002-005) comes under the forward nacelle access panel (Refer fig: 3). It is made up of carbon epoxy composite, with copper mesh High Intensity Radio Frequency (HIRF) Lightning protection provided on its outer surface. The cowling is attached to the nacelle using Camloc fasteners. The cowling is sealed on its aft and lower edges using a non−conductive elastomeric seal bonded in place. The cowling is installed in an area subjected to multiple sources of vibrations from spinning propeller, rotating equipment inside the engine and also from the aerodynamic swirl from the propellers.

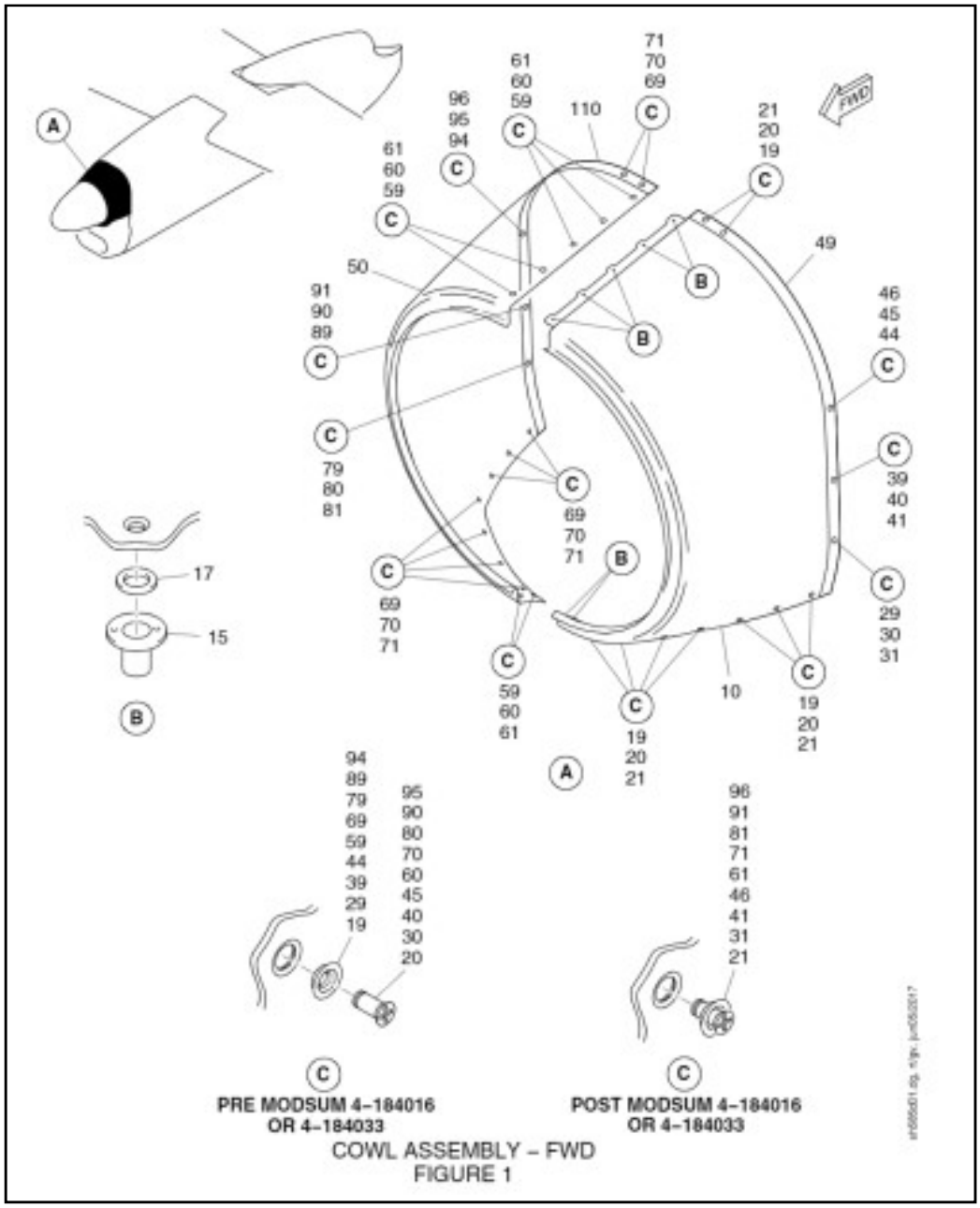


Figure 3 Upper Forward Cowl

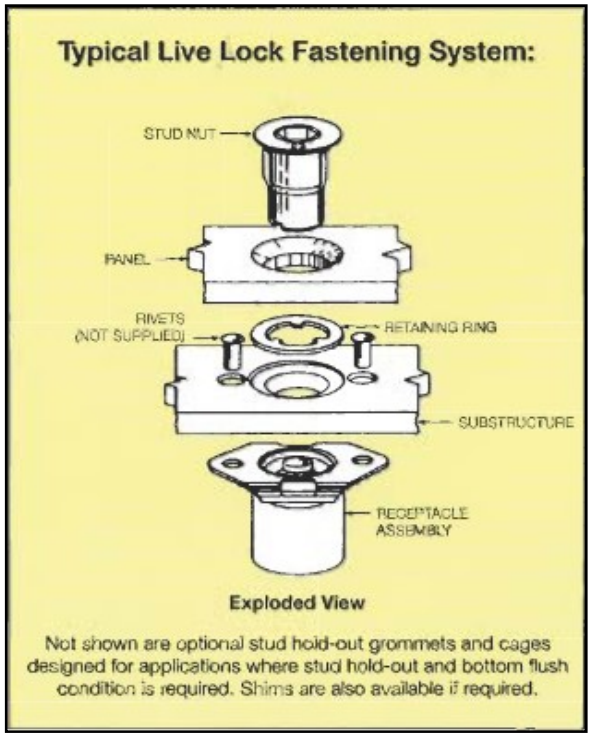
Table 1: Parts shown in the above diagram.

FIG ITEM	PART NUMBER	NOMENCLATURE
1-1B	87144002-005	UPPER FORWARD COWL
15	2383R03-00-1DL	RECEPTACLE
17	2383WI06-08BP	SHIM
23	2383GF14-01BP	GROMMET
60	2383SG04-01BP	STUD
21	2383S0401G1401BP	STUD GROMMET ASSY

The outboard and inboard upper forward cowls are joined together by means of metal straps, at top and bottom of the Upper forward cowls. Top and bottom metal strap are riveted to inboard composite upper forward cowl by rivets. However, outboard upper forward cowling is seated on the metal straps and fastened by Camloc fasteners. The receptacles are riveted to the metal straps. Further as per OEM's load analysis; the maximum load that can be sustained by a rivet and a Camloc fastener were found 47 Ibs and 141Ibs respectively.

In Q400 aircraft the engine's Upper Forward cowls (UFC) are installed with quick-release Camloc fasteners. The use of this fasteners helps in quicker removal and installation of the cowls.
A Camloc fastener is made up of three parts

- Grommet.
- Stud nut and
- Receptacle.



The grommet and stud can be purchased as a complete assembly. The Stud nut is secured with the grommet using a locking ring or retaining ring. Once the stud nut is assembled it cannot be removed out of the grommet due to the raised portion of stud nut at the end and the lock ring (spring clip) will prevent it from falling out. Notches in the stud nut engage with tabs in the receptacle and push the spring loaded upper plate during the installation of the stud nut. The stud makes a ratcheting sound during the installation process. This is due to internal locking mechanism on the receptacle. If the ratcheting sound is not heard during the installation process, it indicates a failed receptacle.

Figure 4 Camloc Fastener

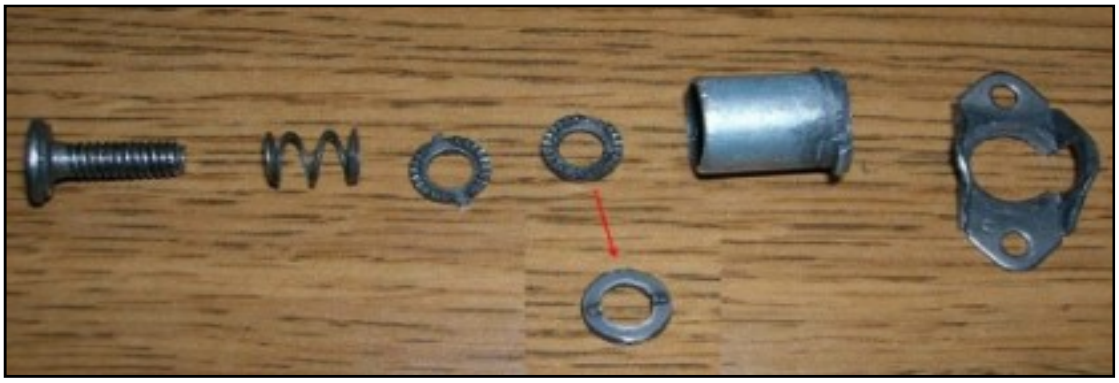
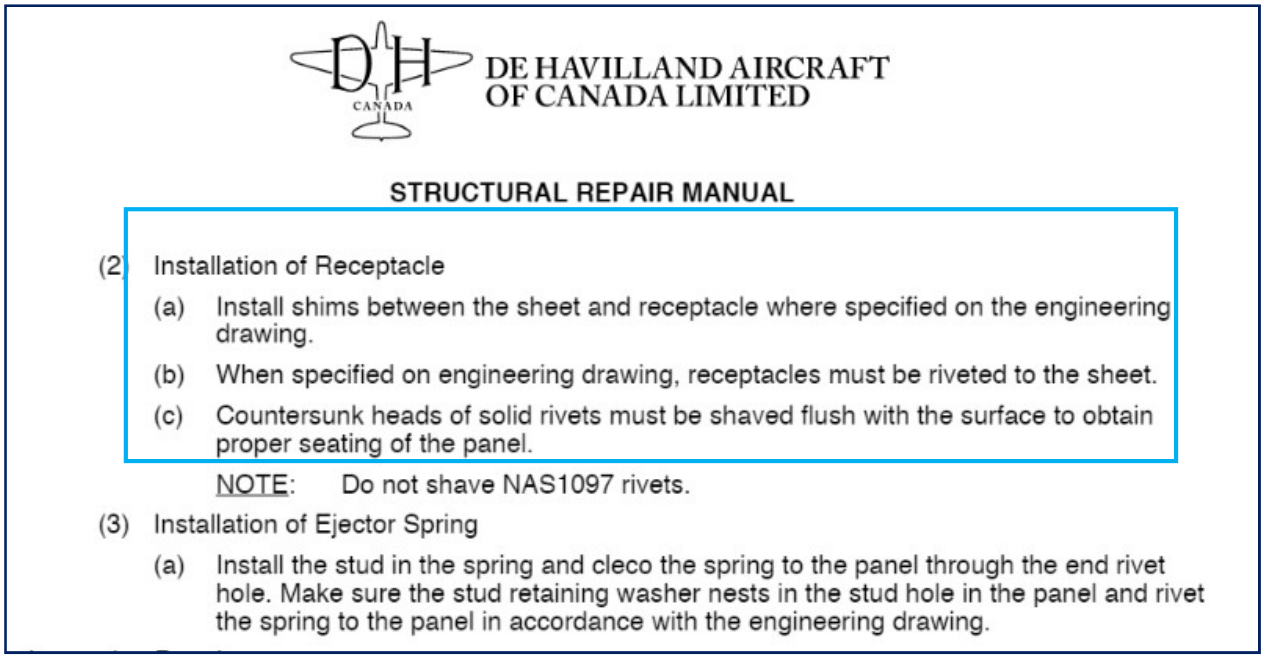


Figure 5 Exploded view of Receptacle

As per OEM's drawing specification and IPC, Shim is an optional component and if it is required to be installed, it should be installed between receptacle unit and the metal strap. Extract from the SRM is appended below:



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STRUCTURAL REPAIR MANUAL

(2) Installation of Receptacle

(a) Install shims between the sheet and receptacle where specified on the engineering drawing.

(b) When specified on engineering drawing, receptacles must be riveted to the sheet.

(c) Countersunk heads of solid rivets must be shaved flush with the surface to obtain proper seating of the panel.

NOTE: Do not shave NAS1097 rivets.

(3) Installation of Ejector Spring

(a) Install the stud in the spring and cleco the spring to the panel through the end rivet hole. Make sure the stud retaining washer nests in the stud hole in the panel and rivet the spring to the panel in accordance with the engineering drawing.

Figure 6 Extract from SRM

As per OEM's drawing specification and SRM, there is no allowance for elongated holes in the metal strap in UFC.

Further as per the SRM (54-10-05, page 101), a temporary allowance for continued operation with missing Camloc fasteners in the engine's UF Cowlings for a maximum of 250 FH, provided the following conditions are met:

- A maximum of 4 missing fastener and grommet are permitted.
- There must be at least 3 fastener installed between each missing fastener.
- The remaining fasteners shall not be loose.

1.6.3.2 Engine Upper Forward Cowl Maintenance

a) As per maintenance records, the last major/ base check was carried out on the aircraft VT-SUW in Feb 2020.

b) As per OEM's maintenance document and DGCA approved AMP, engine's upper forward cowl required to be inspected for missing or lose fastener at every 600 flight Hrs. Further as per aircraft records the last 600FH inspection was carried out on 14 Sep 2021. Further 600FH inspections carried out by the operator since Jan 2021 till incident date along with observations are given below:

Table 2: UFC 600Hrs Inspection

Date	Task	Observation made by maintenance personnel
11.01.21	1. Inspect for missing / loose fastener on Engine Fwd Cowl. 2. Install missing fastener as per SRM 3. Tighten the loose fastener as per AMM 4. Return the airplane to service (RTS).	Found 2 fasteners missing on RH side and 1 fastener missing in LH side. Same installed as per SRM. Aircraft RTS.
18.03.21		Carried out inspection for any loose/ missing fastener. Found satisfactory. Installed missing fastener as per SRM. Tightened loose fastener as per AMM. Aircraft RTS.
08.07.21		Both engine D cowl fastener inspection carried out, observed 2 qty missing and 4 qty receptacles loose. Same installed as per SRM loose fastener tightened as per AMM. A/c RTS
14.09.21		Inspected for missing / loose fastener on engine cowl. None found missing. Tightness checks C/o found satisfactory as per AMM. RTS

c) As per maintenance records, neither the RH engine's upper forward cowl nor the top metal strap was replaced by the operator since the induction of the aircraft in its fleet i.e., 01 Jun 2017.

d) As per maintenance records, On RH engine's upper forward cowling, at several instances, Camloc fasteners and receptacle had been serviced as and when required. However, it is observed that on some occasion the maintenance personnel did not capture the location of the Camloc fastener on which maintenance was done in maintenance records.

1.6.3.2.1 Tasks requiring opening of UFC.

As per maintenance data the UFC needs to be opened to perform the following tasks.

1. Engine/Propeller Hub replacement
2. HTCS servicing
3. Brush block / slip ring cleaning / inspection
4. Propeller Balancing
5. RGB MCD inspection
6. Receptacle replacement

As per maintenance records, RH engine's upper forward cowl was opened for brush block cleaning on 12 Sep 2021.

1.6.3.2.2 As per maintenance records following tasks were performed on fastener in the last six months:

Table 3: Observations

Date	Task	Relevant Observation
13.05.21	Layover Insp	Fasteners missing from RH Engine fwd Cowl. Same installed & found satisfactory.
06.07.21	Layover Insp	3 fasteners on the LH engine UFC found missing
14.08.21	Layover Insp	1 stud missing on RH engine FWD cowl at ptn B1. Same installed IAW AMM and found Satisfactory. Engine inlet FOD insp C/o and No FOD observed.
10.09.21	Pre flight	Missing fastener from RH engine FWD cowl at R4 ptn found during pre-flight is installed and founs satisfactory.
06.10.21	Transit check	2 fasteners at B2, LB7 of #2 engine cowl and also receptacles in the position which were found missing on 1st Oct was installed and found satisfactory. A/c Normalised
14.10.21	Layover Insp	Missing Fasteners of #1 Engine at RB7, B1 and #2 Engine at R4, R5 were installed and found satisfactory. Engine inlet insp carried out for FOD and found Satisfactory.
26.10.21	Layover Insp	1 Fastener at LB1 of RH engine was installed as per AMM. GVI of engine inlet C/o. found satisfactory.RTS
05.11.21	Layover Insp	2 fasteners in ptn L3, RB6 of LH engine and 2 fasteners at LB2, RB1 of RH engine were installed as per AMM. GVI of engine inlet C/o for FOD. Found satisfactory and RTS.

1.6.4 Propeller

The aircraft propeller is a six bladed, constant speed, variable pitch propeller which can be feathered and used in reverse pitch. The propeller is installed on the gearbox/propeller driveshaft flange and rotates clockwise when viewed from the rear. Each blade is an all-composite aerofoil construction with a steel outer root sleeve. The aerofoil has a foam core and twin carbon fibre spars with an overall braided carbon/glass fibre shell. A polyurethane spray coat for erosion protection is applied to the complete blade surface. A nickel leading edge guard is installed for blade erosion protection.

The hub assembly has one piece aluminium hub, with 15 integral steel mounting studs and 3 location/drive dowels. The hub supports six blades and has six pairs of blade root bearings. The lower bearing is an angular contact ball race, and the upper bearing is a taper roller race. A back plate constructed of carbon fibre composite, and attached to the hub forms the aerodynamic interface between the spinner and engine nacelle.

The propeller back plate has 18 drilled holes for placing balancing weights. A dedicated ANVS (Active Noise and Vibration Suppression System) exists to monitor the propeller vibration. As per AMM's subtask 61-10-00-720-021 the balancing weights shall be added in no more than 7 holes. The total balancing weight per hole shall not exceed 51 grams including the mounting bolt and the overall balancing weight shall not exceed 350 grams.

As per AMM procedures, the ANVS system must be switched on before flight to capture the vibration levels. The system will automatically capture the data when the flight Includes a minimum five minutes of normal cruise conditions at 850 rpm with 65% torque at the typical cruise altitude.

As per AMM (subtask 61-10-00-720-021), the vibration level(s) are required to be monitored frequently in order to keep the vibration levels less than 0.13 ips (Inches per second) to avoid discomfort to passenger and damage to propeller and aircraft. AMM Subtask 05-61-00-210-004 suggests certain maintenance actions required to be done for different values of captured vibration levels.

As per maintenance records, the PBMS data was last captured on 3rd November 2021 with vibration level at 0.592 in RH engine and no data was obtained thereafter till the date of occurrence.

When the ANVS system did not capture the aircraft vibration data and indicates “no data”, there are mainly two possibilities. Either the aircraft/ANVS was not maintained in the desired configuration for desired duration or there was some technical snag in the ANVS system and ANVS system needs trouble shooting. For first reason the maintenance personnel issues a Notice to Crew (NTC) to maintain the required configuration during the next flight. Whereas for the later, as per AMM task 23-35-46-810-804, there are three possible causes for technical snag as mention below:

- Unserviceable PBMS wiring interface
- Unserviceable Active Noise Control Unit
- Unserviceable Vibration Sensor mounted on each propeller gearbox.

Following are the occasions in the last six months, when the ANVS system did not capture the aircraft vibration data and indicated “no data”. Consequently, the maintenance personnel issued the NTCs and the same are tabulated below:

Table 4: NTCs issued in last Six month

S. No.	Date of NTC issued	Date of Vibration data captured again	Days
1.	09.05.2021	16.5.2021	6 days
2.	23.07.2021	26.07.2021	2 days
3.	13.08.2021	14.08.2021	--
4.	22.08.2021	23.08.2021	--
5.	29.08.2021	29.08.2021	--
6.	08.10.2021	19.10.2021	10 days
7.	08.11.2021	16.01.2022	2 months

After 03.11.2021, PMBS values were not captured and NTCs were raised at 16 instances as tabulated below:

Table 5: NTCs issued between 08.11.2021 and 16.01.2022

S. No	Date	AFH	AFC	PBMS Status
1	08.11.21	21306:14	19406	
2	13.11.21	21346:07	19436	
3	17.11.21	21375:02	19461	
22.11.2021 date of incident				
4	23.11.21	21410:38	19489	
5	27.11.21	21443:39	19516	
6	01.12.21	21480:41	19545	
7	06.12.21	21519:32	19574	
8	09.12.21	21552:51	19603	**No Data**
9	14.12.21	21586:31	19635	
10	18.12.21	21606:15	19652	
11	21.12.21	21630:21	19668	
12	25.12.21	21661:20	19694	
13	30.12.21	21698:42	19723	
14	04.01.22	21734:27	19747	
15	08.01.22	21753:47	19761	
16	13.01.22	21783:43	19781	

As per Organization's mandatory circular dated 30 April 2015 on the subject, "***Deferred Defect Monitoring and Control procedure***". Acceptable Deferred defect (ADD) is defined as given below:

"ADD is made for systems or components which do not affect the airworthiness of the aircrafts. Defects/Deficiency observed or reported during routine inspection/maintenance may not be required to be rectified before release to service immediately but same can be rectified within a stipulated time limit as given in maintenance data and/or company policy."

Further circular also has a caution note as quoted below:

Note: "*Any Defect/Malfunction/ Un-serviceability which is covered by Respective MEL or CDL must be carried forward according to the relief provided therein".*

The PBMS was deferred 16 times as detailed in table 5. However, ANVS system was covered under operator's approved MEL. Maintenance records for invoking the MEL for the said defect were not found.

1.6.5 Post Incident Fleet Inspection

Post incident, based on operator's internal enquiry's recommendation, operator carried out one time fleet wide inspection of all fasteners and rivets of both engines on all Q400 aircraft. The major observation made during inspection is tabulated below:

Table 6: Fleet Inspection

Task	Observation made by maintenance personnel
1. Carry out inspection of both engine both forward cowls for any missing/loose and damaged fastener, Refer AMM 71-10-01-400-801 Subtask 71-10-01-210-001 2. Tighten the loose fastener (if any) as per AMM 71-10-01-400-801 and correct any damaged fastener 3. Install missing fasteners as per SRM 51-44-30-02-02. 4. Carry out inspection and security of installation of both engine forward side doors, Refer AMM 71-10-06-410-801 SJC-forward cowl & forward side doors inspection.	Found one fastener missing on each LH and RH fwd cowl. LH Eng -T4 RH Eng -T1. Tightened the loose fastener as per AMM 71-10- 01-400-801. 3). Missing fasteners to be installed as per SRM 51−44−30−02−02 AT OR before the end of the 250 flight hour Refer SRM 54-10-05-01-01 Revision 21: JUL 05/2020 4)
	Observed qty 02 stud missing on LH Engine (LOC: R3 & RB2) and qty 01 missing (LOC: R2) on RH Engine fwd upper cowl. Additionally one distorted receptacle cage (LOC: R2) on LH Engine fwd frame and qty 03 stud notches are in the damaged condition 9 LOC: R4, T4, & T2). Installed missing fasteners as per SRM 51-44-30-02-02. ADD # 5749167 raised for one missing stud/receptacle (LOC: R3) on LH Engine fwd upper cowl. Tightness checked for the fasteners as per AMM 71-10-01-400-801
	Observed qty 02 fasteners missing from L1 & T4 position of RH Engg upper fwd cowl. Missing fasteners installed as per SRM 51-44-30-02-02 REV21.
	During inspection of LH Eng forward upper cowling observed stud-grommet installed on all locations but 03 were rotating free (top location).found receptacle deteriorated, same replaced with "S" one as per SRM 51-44-30-02-02. FOR inspection of RH Eng forward upper cowling, RH Eng forward upper cowling observed stud-grommet installed on all locations but 02 were rotating free (top location).found receptacle deteriorated, same replaced with "S" one as per SRM 51-44-30-02-02.
	All fasteners found in satisfactory condition except few fasteners found loose
	Replaced fasteners as per SRM 51-44-30-02-02 as required due normal wear.
	Installed missing fasteners on RH cowl as per SRM 51-44-30-02-02. **LH Engine upper forward cowl replaced with serviceable one as per AMM** 71-10-01-000/400-801. 4)
	Tightened the loose fastener (if any) as per AMM 71-10-01-400-801 and corrected any damaged fastener
	Qty 04 fasteners installed on RH Eng upper fwd cowl & qty 02 fasteners installed on LH Eng upper fwd cowl
	Found conditions satisfactory on RH Engine. However observed qty 01 stud grommet missing on LH Fwd cowl at loc t5 and qty 02 stud grommet head condition not sat. At location T3 andT4 same installed with serviceable stud grommets as per SRM 51-44-30-02-02, found SAT. Also receptacles observed damaged at location RB6 and RB5 and stud grommet missing at location RB5 same replaced.

Note: The location motioned in the observation column is as per the diagram given in the operator's mandatory engineering circular.

Organization's mandatory engineering circular with immediate applicability was issued on 30 April 2015 on the subject, "*Upper Forward Cowl Camloc Fastener Identification*". The background of this circular was as quoted below:

"*As per SRM 54-10-05 upper Forward cowl Camloc Fastener can be missing and can be deferred for 250FH. However the fasteners in the upper forward cowl are not specifically identified during deferment or rectification of missing fasteners. Hence an identification number has been given to*

identify the specific fastener".

Further this circular also states that "*The purpose of this circular is to re-emphasize upon the certifying staff the requirement to identify and record the specific fastener as per the attached Annexure-1"* (The diagram given in the Annexure -1 is shown in fig: 7).

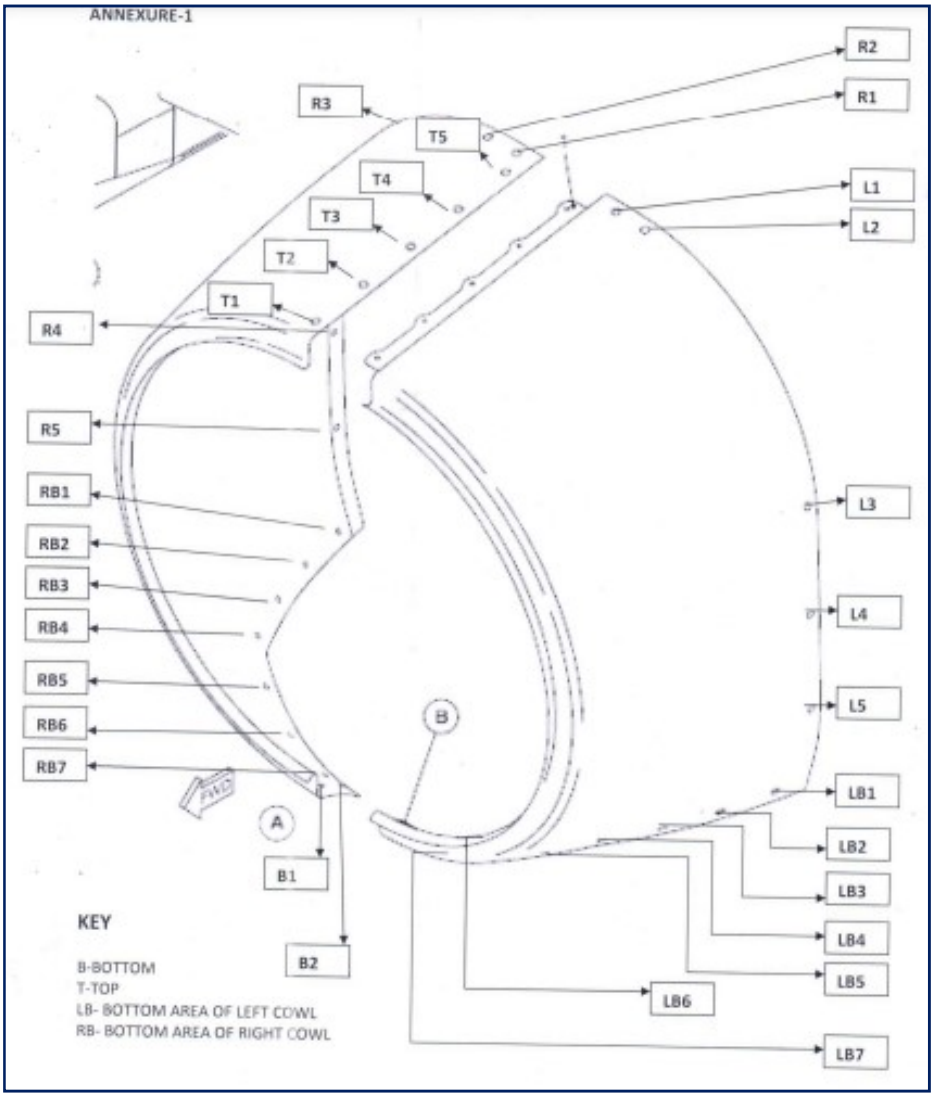

Figure 7 Fasteners Identification

1.7 METEOROLOGICAL INFORMATION

METAR recorded for runway 28, between 0930 UTC and 1100 UTC on 22 Nov 2021 at IGI Airport, New Delhi is given below:

Time (UTC)	**0930**	**1000**	**1030**	**1100**
Wind	271° /15 Kts	280°/10 Kts	260°/11 Kts	280°/09 Kts
Visibility (m)	2500	3000	3000	3200
Weather	HZ	HZ	HZ	HZ

Clouds	NSC	NSC	NSC	NSC
Temp (℃)	26	26	26	25
Dew Point (℃)	11	11	11	11
QNH (hPa)	1012	1012	1012	1012
Trend	BECMG VIS 3000m IN HZ	NOSIG	NOSIG	NOSIG

1.8 AIDS TO NAVIGATION

All Navigational aids installed at IGI Airport, New Delhi and Navigational equipment installed on the aircraft VT-SUW were serviceable. There were no navigational aids related issues or lapses.

1.9 COMMUNICATION

The aircraft was always in a positive two-way communication with relevant ATCs throughout the flight. There were no Communication related issues or lapses.

1.10 AERODROME INFORMATION

Indira Gandhi International (IGI) Airport is operated by Delhi International Airport Limited (DIAL) and AAI maintains Communication, Navigation and Surveillance (CNS) & Air Traffic Management (ATM) services at the airport. The IATA Location Identifier Code is DEL and ICAO Location Indicator Code is VIDP.

Airport Co-ordinates: - Lat: 28°34'07" N

Long: 77°06'44" E.

Elevation: 778 feet.

The detail of runway distances is as below:

Runway	TORA(M)	TODA (M)	ASDA (M)	LDA (M)	WIDTH (M)	RESA (M)
10	3813	3813	3813	3813	45	240 x150
28	3813	3813	3813	3813	45	240 x150

1.11 FLIGHT RECORDERS

Both the CVR and DFDR recordings were available for investigation. Following are the relevant information from CVR:

Time (UTC)	Information
100408 to 100411	When aircraft was descending for approach, cabin crew informed flight crew that the cabin is secured for landing
100524 to 100631	The on board AME calls flight deck to intimate that the starboard engine UFC top strap fasteners failed and the cowling had developed fracture in midsection and also requested the flight crew to exercise precautionary measure.
100638 to 100708	Flight crew requests the certifying mechanic to monitor the situation and update if the situation gets worse and gets acknowledged.
100718 to	The commander tells first officer to reduce and lock the starboard engine torque to

100746	15%. They decided not to alter the right lever and only use left engine control to avoid aerodynamic load changes on the engine cowling.
100826-50	Aircraft changes over to Delhi radar from Delhi control.
101318	Commander takes control from first officer
101340 to 101421	The flight crew conveys their situation and intentions to carry out precautionary landing and confirms no assistance required.
101434 to 101445	The flight crew gets updated that the cowling is half attached and half hanging.
101951	Aircraft changes over from radar to tower control
102035	Crew confirms that no assistance required to tower
102345 to 102354	Aircraft gets clearance to land runway 28
102510	Tower initiates runway inspection
102545	Changed over to Delhi ground
103025	Ground asked the aircraft to confirm all operations normal after parking into bay.
103224	Aircraft parked and shutdown in the assigned gate.

1.12 WRECKAGE AND IMPACT INFORMATION

1.12.1 Aircraft landed at Delhi airport and taxied on its own power to the assigned bay. After parking, when RH engine shut down was initiated, the propellers feathered. As the hanging upper forward cowl was already shifted from its secured position, propellers hit the hanging parts of outboard upper forward cowl. Consequently, few portion of upper fwd Cowl got detached and fell on the ramp. One of the pieces fell below the RH engine and the other piece got blown by the propeller wash and finally rested below the LH engine.

1.12.2 Damage occurred during incident was confined to the RH engine's forward upper cowls, propeller blades and to the propeller's back plate. The RH engine's outboard upper forward cowl had fragmented into 3 pieces (Refer fig 10 & 11) and the inboard upper forward cowling sustained a significant crack in mid section (Refer fig 9). One hole was found on the outboard UFC forward section. All propellers got minor damage in the trailing edges of blade root section (Refer fig 13) and 3 ribs of back plate in hub assembly found to have sustained damages (Refer fig 12) due to pieces of UFC pierced through them.

Fig 8: Missing outboard upper forward cowling

Fig 9: Cracked inboard upper forward cowling

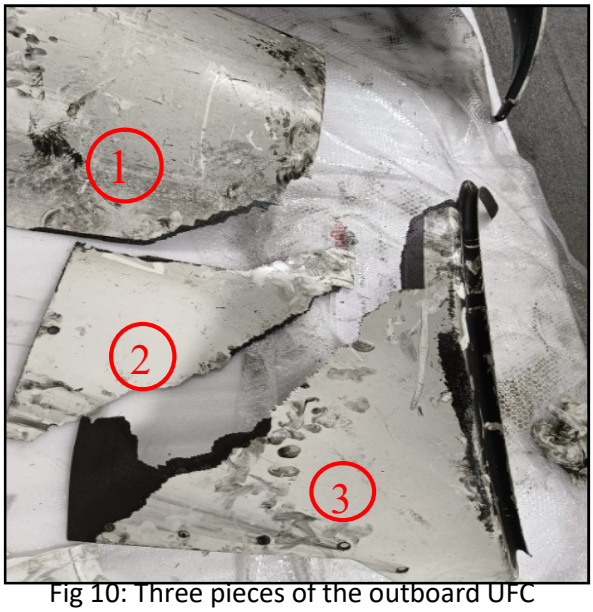

Fig 10: Three pieces of the outboard UFC

Fig 11: Inside view of the outboard UFC

Fig12: Back plate hub assembly damages

Fig13: Damages in the propeller blade

Fig 14: Wreckage part under LH engine

Fig 15: Small UFC pieces piecred into Hub Rib

Fig 16: Bottom metal strap view from inside

Fig 17: Outer view of bottom metal strap

Fig 18: Top metal strap (Top view)

1.12.3 During the wreckage examination, following observations were made:

a) All fifteen rivets, which join the top metal strap with the inboard UFC had failed. However, one sheared rivet was found attached with the composite inboard UFC.

b) All fifteen rivet holes were found elongated.

c) Top metal strap riveted to inboard UFC, was found attached with outboard UFC by three fasteners.

d) Fasteners tell tale signs found on the top metal strap and cowling indicates that out of five Camloc fasteners two fasteners were already missing i.e., prior to this incident.

e) Top metal strap was found with bend at both forward and rear end. The rear end bend was found more prominent than the forward end.

f) On top metal strap, receptacle rivet holes were found elongated, especially where shim were found used.

g) Shims were found installed on three receptacles on the RH engine UFC. On two locations shims were found attached (one at top and other on bottom metal strap). However, at other location clear signs for shim installation were found (top metal strap).

h) On bottom metal strap, one receptacle was found missing and the other receptacle was found attached with shim. From tell tale signs found on the bottom metal strap, it appears that the fastener was missing for quite some time.

1.13 MEDICAL AND PATHOLOGICAL INFORMATION

Both the flight crew had signed the undertaking for non consumption of alcohol and other psychoactive substances as per prevailing DGCA regulation on the date in presence of medical personnel during reporting for flight duty at Delhi.

1.14 FIRE

Nil

1.15 SURVIVAL ASPECTS

This serious incident was survivable.

1.16 TESTS AND RESEARCH

The both inboard and outboard UFC halves of RH engine were sent to DGCA laboratory for failure analysis.

Note:

1. The inboard and outboard UFC halves are interchangeably referred as LH and RH UFC respectively in the following Lab Report.

2. The fasteners and rivets of metal straps are numbered from the rear to fore end in the following Lab Report.

3. The term Clamp washer may be read as shim in the following Lab Report.

1.16.1 DGCA Laboratory Observations:

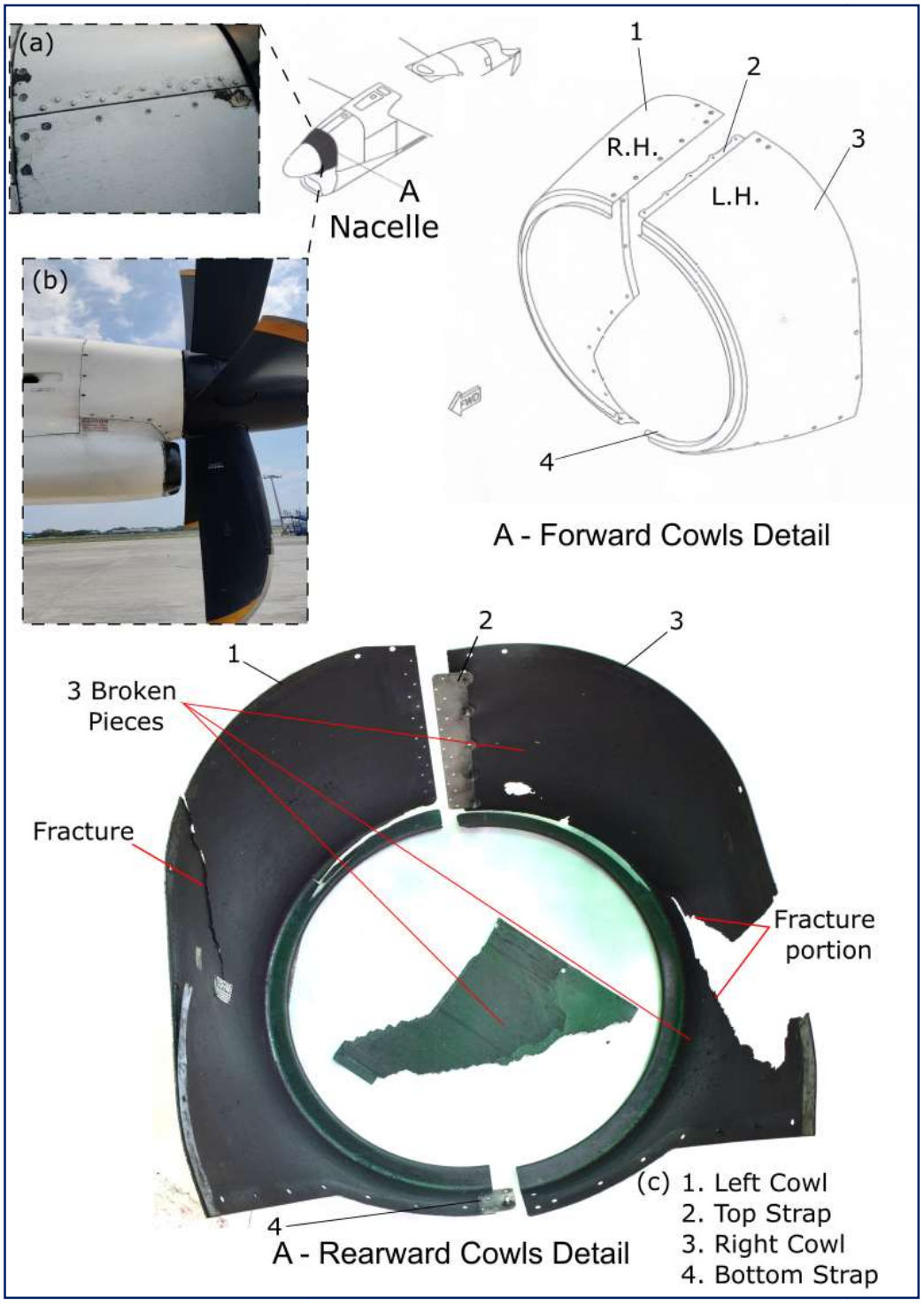

Fig 19: Schematic view, installation position and visual examination of upper forward cowling

Upper Forward Cowl:

i. During the visual inspection, the left cowl (L.H.) and right cowl (R.H.) were found fractured, as shown in Fig. 19 (c).

ii. The R.H. side UFC composite panel was found broken into 3 pieces at various locations, whereas L.H. side found with fracture on the composite panel, as shown in Fig. 19(c). The strike damages were also observed on R.H. and L.H. side UFC, as shown in Fig. 20 (c – 1, 2 & 3).

iii. At the top fitting of the upper forward cowling, two fasteners (F_1 and F_3) and fourteen rivets (R_1 to R_{14}) were found missing, as shown in Fig. 20 (a).

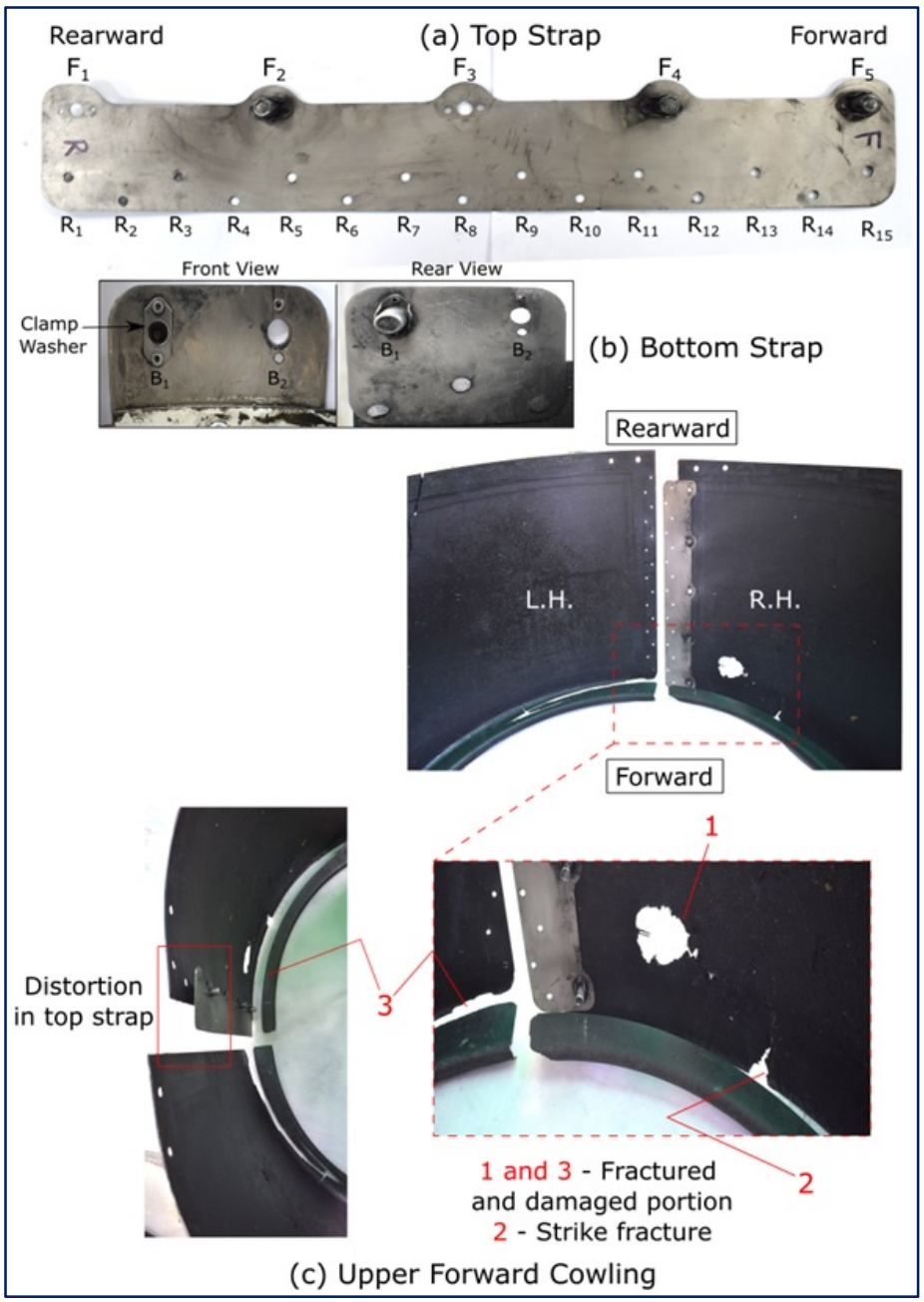

Fig. 20: Visual examination of upper forward cowling, top & bottom strap

Bottom and Top metal Strap:

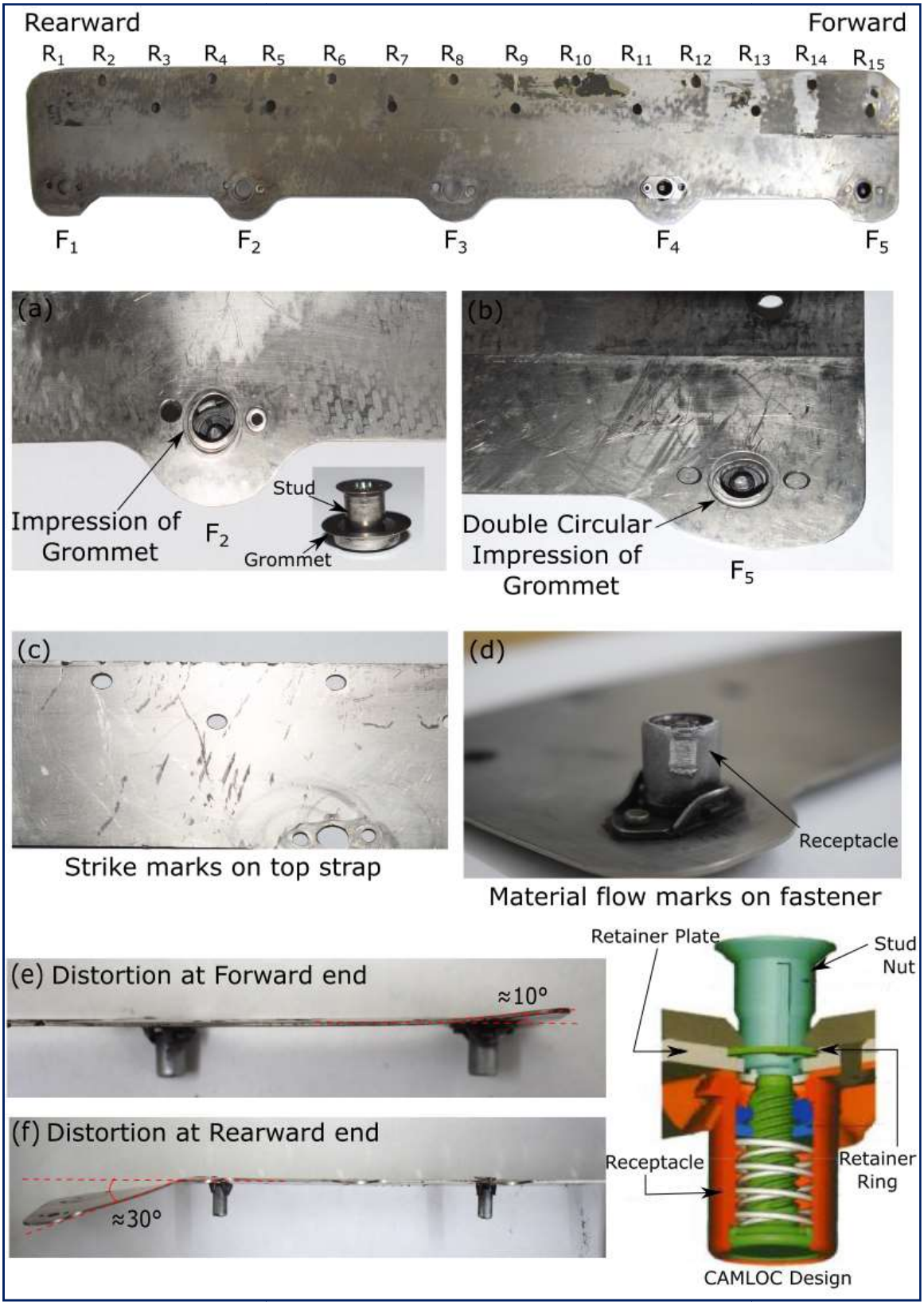

Fig. 21: Visual examination of top strap.

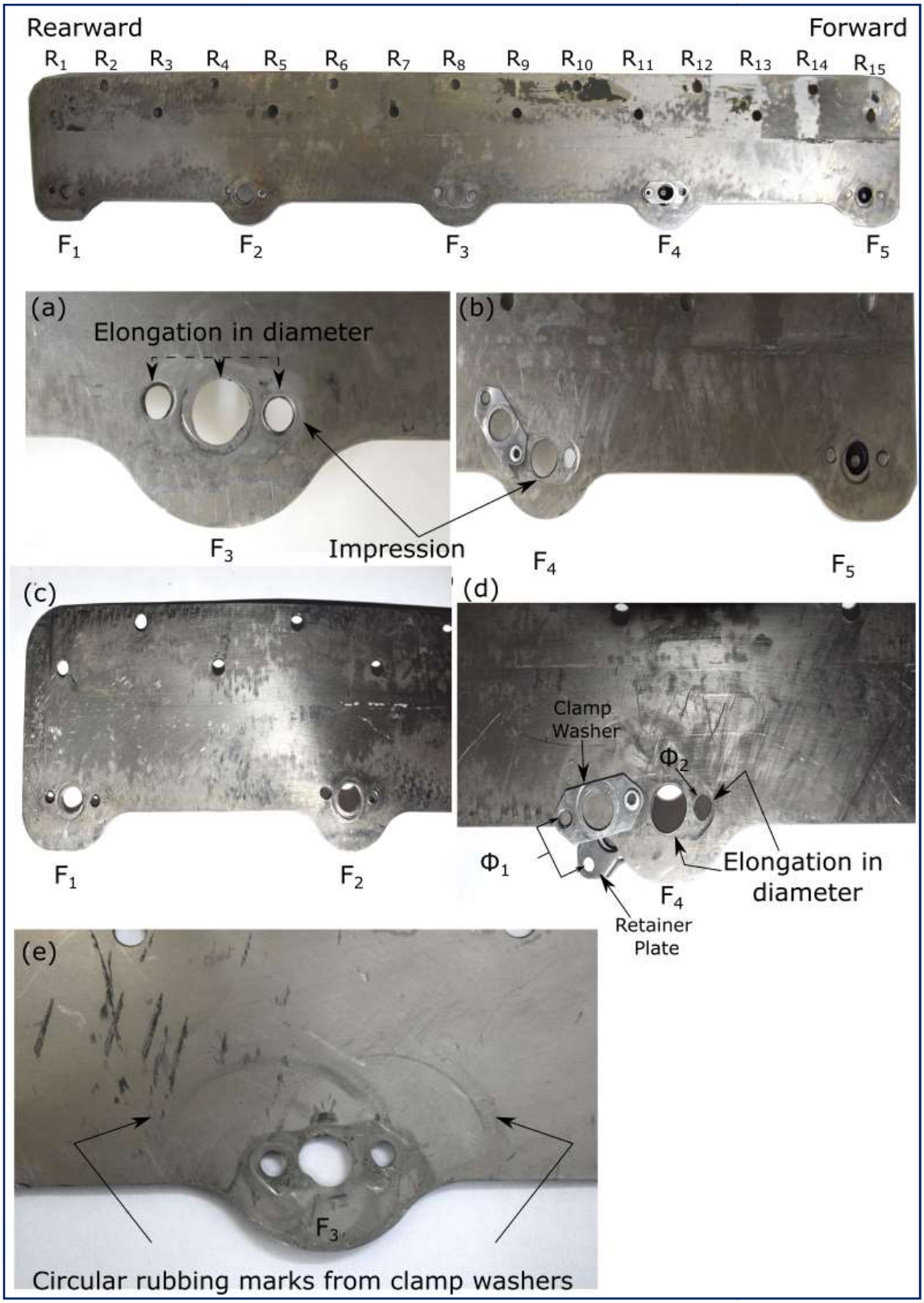

Fig. 22: Visual examination of top strap and drilled holes.

i. One fastener, B_2 found missing at the bottom strap, while the fastener and riveted joints at B_1 were under intact condition, as shown in Fig. 20 (b). The clamp washer was also found on fastener B_1, as marked in Fig. 20 (b).

ii. At all five fastener locations on the top strap plate multiple impressions of grommets were observed, as shown in Fig. 21 (a) & (b).

iii. The strike marks were also observed on the top strap, as shown in Fig. 21 (c).

iv. The top strap was also found to have distortion at the forward and rearward end, as shown in Fig 20 (c) and Fig. 21 (e) & (f). The forward end bent at approximately 10°angle and the rearward end at about30°, as shown in Fig. 21 (e) & (f), respectively.

v. The ovality was observed on all five fastener holes (F_1 to F_5, oval) and on all fifteen rivet holes of top strap, as shown in Fig. 22.

vi. The two circular arcs of rubbing marks about the two rivet axes were found at F_3, as shown in Fig. 22 (e).

Fasteners and Rivets

Fig 23: Stereoscopic examination of faying surfaces of rivet holes on top strap.

a. The material flow was found on all receptacles of fasteners, as shown in Fig. 21 (d).

b. One clamp washer was found at F_4 during the visual inspection, as shown in Fig. 22.

c. The impression of clamp washers were also observed on F_3 and F_4, as shown in Fig. 22 (a) & (b), and there was no significant presence of clamp washers impression on F_1, F_2, and F_5, as shown in Fig. 22 (b) & (c).

d. The Camloc receptacle rivet hole at F_4 on top strap was found over-sized ($\Phi_2 > \Phi_1$) compared to corresponding drilled holes on the clamp washer and retainer plate, as shown in Fig. 22 (d).

e. The faying surfaces and drilled holes (R_1 to R_{15}) on the top strap were examined under the stereo-microscope and all drilled holes (R_1 to R_{15}) were found oval in shape with damages at their circumferences, as shown in Fig. 23.

f. The stud nut and fasteners grommet were thoroughly examined from the composite installation panel and the dent was observed on the F_2 grommet.

1.16.2 DGCA Laboratory Conclusion:

The fasteners and rivet joints failed due to overload.

1.17 ORGANIZATIONAL AND MANAGEMENT INFORMATION

1.17.1 General

M/s Spice jet Ltd. is a scheduled airline with a fleet of 36 Boeing 737 and 13 B737 -8 (Max) aircraft and 32 Bombardier Q-400 aircraft operating flights on domestic and international sectors. The Airlines Head Quarter is located at New Delhi. The Air operator permit of the Airlines is valid till 16.05.2023. M/s SpiceJet Ltd is holding a valid DGCA approval for carrying out maintenance activities under CAR 145. The company is headed by Chief Executive Officer assisted by a team of professional of various departments. The Flight Safety Department is headed by Chief of Flight Safety approved by DGCA. The Chief of Safety is senior management official who reports directly to the CEO. M/s SpiceJet has an established Operations training facility for the pilots. The training facility for both Boeing pilots and Q-400 pilots is setup at Delhi. The training facilities are headed by the senior vice president Operations who reports to Chairman directly. The Engineering training facility is established at Delhi for B737 aircraft and Hyderabad for Q-400 aircrafts.

1.18 ADDITIONAL INFORMATION

Nil

1.19 USEFUL OR EFFECTIVE INVESTIGATION TECHNIQUE

Nil

2. ANALYSIS

2.1 SERVICEABILITY OF THE AIRCRAFT

2.1.1 Aircraft general:

The aircraft was manufactured in the year 2011 and was inducted by the operator in its fleet on 01 Jun 2017. Aircraft's C of R, C of A, ARC and aero mobile license were valid and current as per applicable DGCA requirements. Weight Schedule was dully approved by the DGCA. Load and trim was prepared for the sector and was within the safe limits. On the day of incident, there were 13 open deferred defects (under ADD) and one MEL pending for action. Out of 13 ADD one was related to the RH engine propeller re-torque and rest is not relevant to this incident. Fueling panel instruction placard was deferred under the Acceptable deferred defects on 30 Oct 2021 and was not rectified within the time frame of 90days due to non availability of spares and was extended by further 30 days with the approval of PHCA as per Organization deferment Policy. However, same was carried out on 09 Mar 2022.

2.1.2 RH Upper Forward Cowl:

History: As per aircraft maintenance records, the RH upper forward Cowl involved in the incident was found installed since the aircraft came to operator's fleet. Thereafter it was never replaced till the date of incident.

During the investigation, maintenance records were examined and following observations were made.

a) The RH engine upper forward cowls were opened to perform maintenance task of brush block cleaning on 12 Sep 2021.
b) Last 600 Hr inspection was carried out on 14 Sep 2021 at 20840:07 hrs to identify missing and loose fasteners. However, no abnormalities were observed on RH UFC during last 600hrs inspection.
c) As per maintenance data, layover inspection is required to be carried out within 48 FH. The missing fasteners was last captured and installed during layover inspection carried out on

05 Nov 2021 at 21277:50 hrs. However, the missing fasteners captured during the layover inspection were from lower section of the UFC. Thereafter, layover inspection was carried out as and when was due. But no entries for missing fasteners from RH engine UFC were found during these subsequent layover inspections.

Aircraft records were examined and as per aircraft records, fasteners were also found missing in preceding last six months on seven occasion which includes layover inspection, Pre flight inspection and Transit inspection. Few maintenance personnel indicate the location of the missing/installed fasteners as per operator's Engineering circular (Refer fig: 7), whereas on some occasion maintenance personnel did not indicate the location of the missing/installed fasteners. Consequently, records are insufficient to identify the locations of missing fasteners.

Post incident operator had ordered one time fleet inspection to identify the condition of the fasteners installed on the engine upper forward cowl such as missing or loose fasteners in light of this incident. Aircraft maintenance records reveals, during those inspections, fasteners were also found missing/loose on other aircraft. However, the location of the missing/lose/installed fasteners were not capture and recorded appropriately in the maintenance records as per operator's Engineering circular.

Therefore the exact date of defect/maintenance done on the RH engine UFC fasteners with location could not be established. Further during fleet inspection, one upper forward cowling was replaced with serviceable one but the reason for replacement was not recorded. **This indicates non adherence to the documented organization's policy and procedure. This also reflects lack of supervisions.**

2.1.2.1 Top metal strap:

History: As per aircraft maintenance records, the top metal strap installed on RH forward upper Cowl's involved in the incident was found installed since the aircraft came to operator's fleet. Thereafter it was never replaced till date of incident.

During the investigation following observations were made:

a) During investigation, the rivet holes diameter (on T2 & T3 location as per organization's engineering circular) found on the metal strap was quite larger than the rivet holes diameter of receptacle unit. (Refer fig 24 & 25). **This is a tell tale sign, which confirms that the elongation found on the rivet hole of the metal strap are pre exiting to this incident.** The same is confirmed in the DGCA laboratory report.

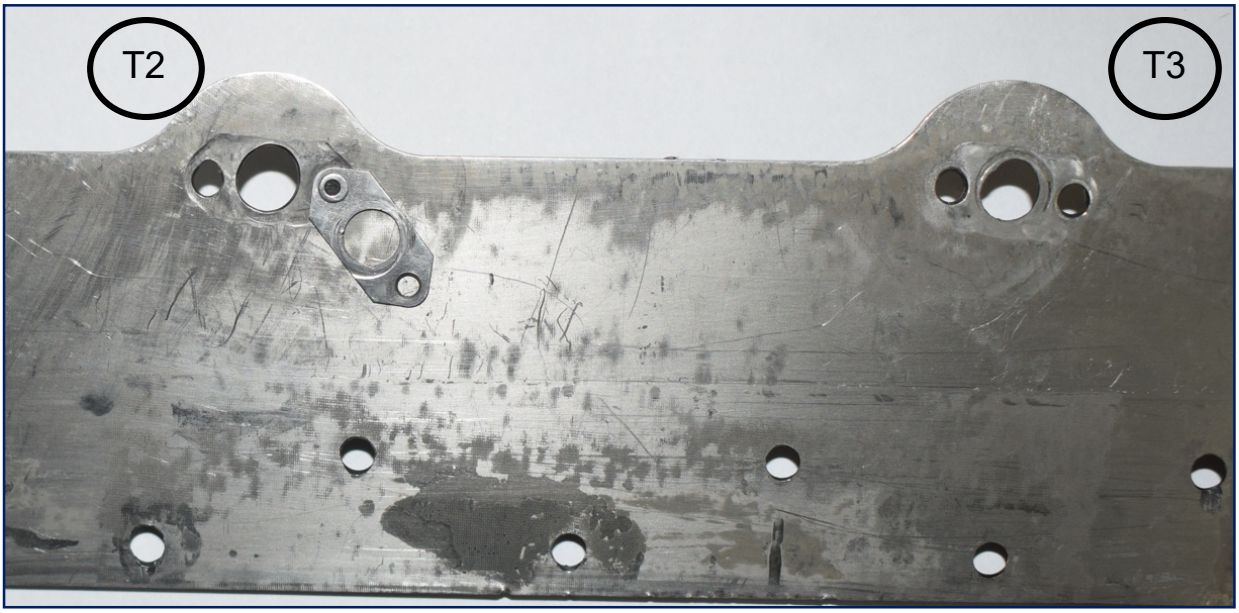

Fig 24 : Metal strap viewed from top

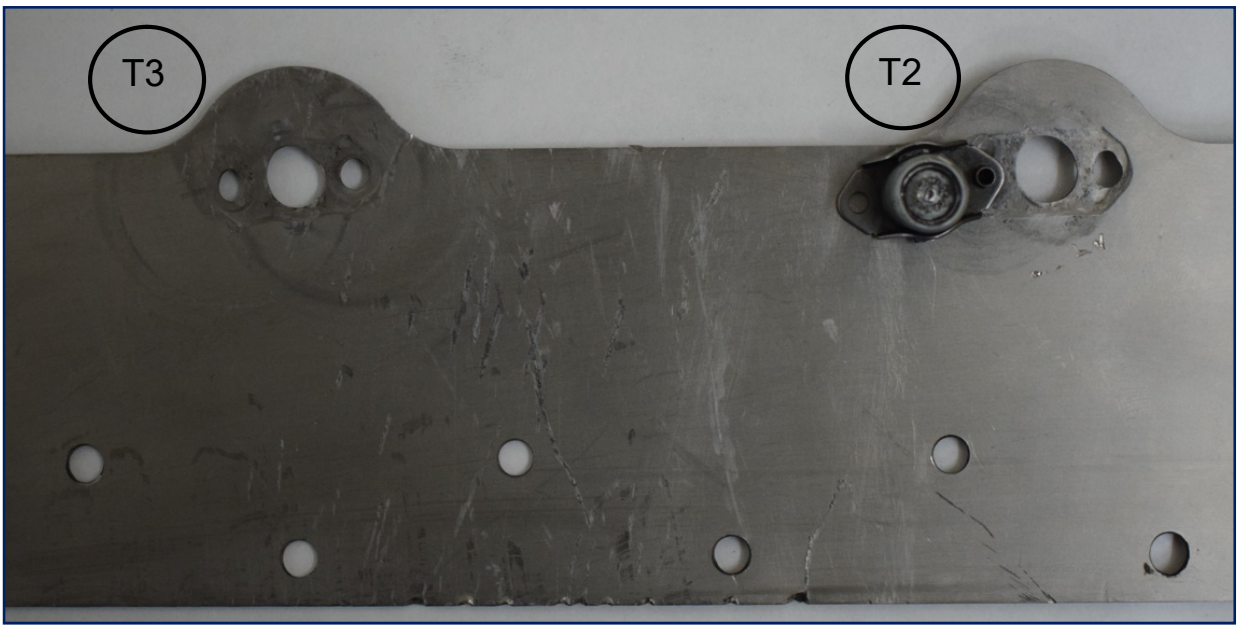

Fig 25 : Metal strap viewed from beneath

b) Shims were found installed inappropriately over the metal strap instead of using between the metal strap and the receptacle unit/ housing as given in OEM maintenance data. Maintenance personnel were found not capturing the observation/ rectification action as required by the organization's engineering circular. This will hamper the follow up action and lead to lack of traceability of the work carried out. Therefore, the exact reason and date/place of maintenance/installation of the shim on the metal strap could not be traced from the maintenance records. In the installation shown in the photograph, the shim is installed over the metal strap. As per OEM data the shim is an optional component to ensure proper grip length of the chosen rivets i.e., to accommodate different type of rivets lengths.

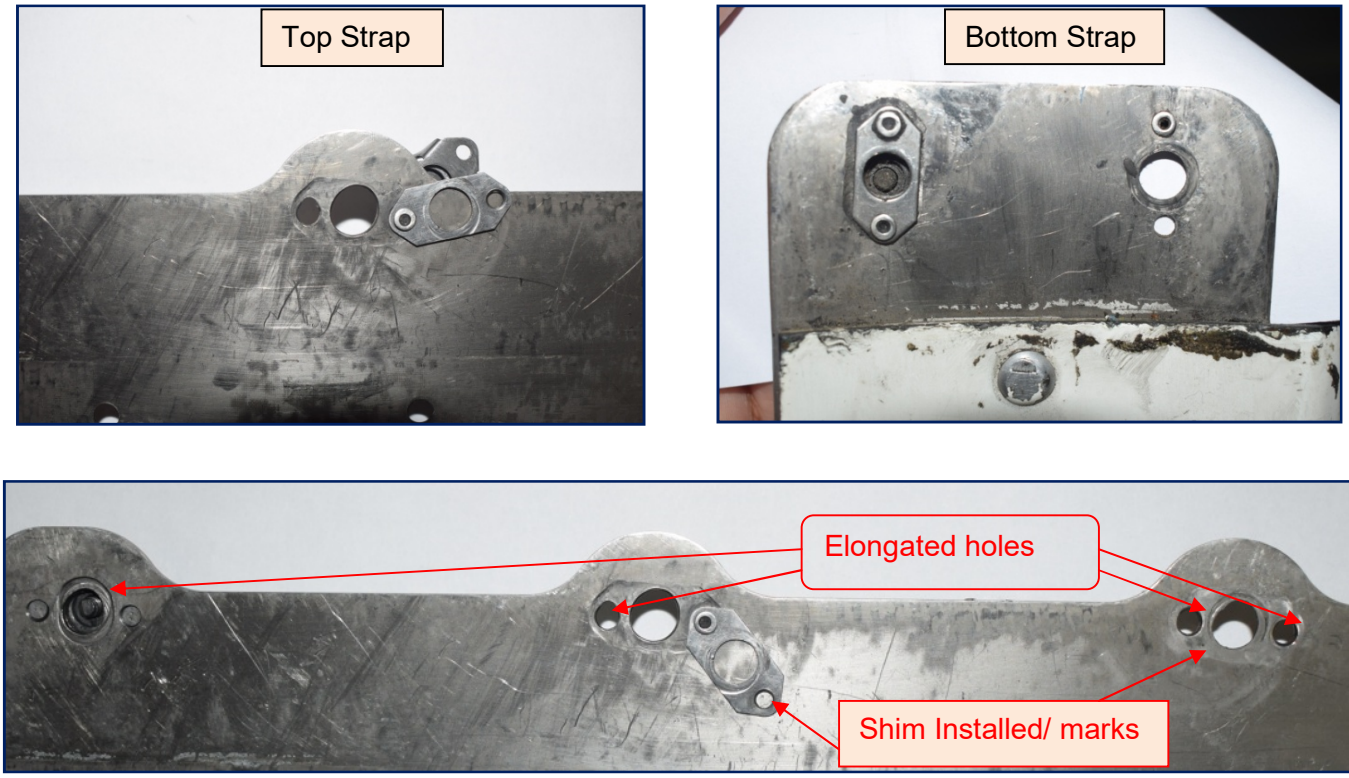

Fig 26: Shims installed over elongated rivet holes.

c) During investigation, Shim marks found on the metal strap indicates that the shims were used at multiple locations against the OEM design requirements for shim. The shims were used as back plates in order to rivet the receptacle with elongated metal strap rivets holes, **which is a non adherence to the maintenance procedures/data as given in SRM**. Same is confirmed in the DGCA laboratory report. This infers that instead of discarding the metal strap with elongated rivet holes as required by the SRM, organization has installed shims as back plates to fix the receptacles with elongated holes. This inappropriate installation would interfere with mating part creating a gapping condition and will interfere with the normal operation of the Camloc fasteners installed on the UFC.

As a result of inappropriate Shim installation, the Stud nut will not be able to engage completely with the receptacle. Consequently the Camloc fasteners installed with shims will not be able to carry the designed loads and this will redistribute and increases the stress concentration on the remaining fasteners and rivets. With this configuration, when UFC was subjected to the vibrations caused due to rotating propeller blades and the vibration created by the other rotating components of the engine in addition to the severe conditions of exposure to aerodynamic buffeting due to propeller wash eddies may accelerates the failures of Camloc fasteners and rivets.

d) Impression of grommets were observed on the top metal strap at multiple Camloc fastener locations i.e., Grommet was found damaging the metal strap. Grommet impression on the metal strap indicates improper installation (tooling/techniques).

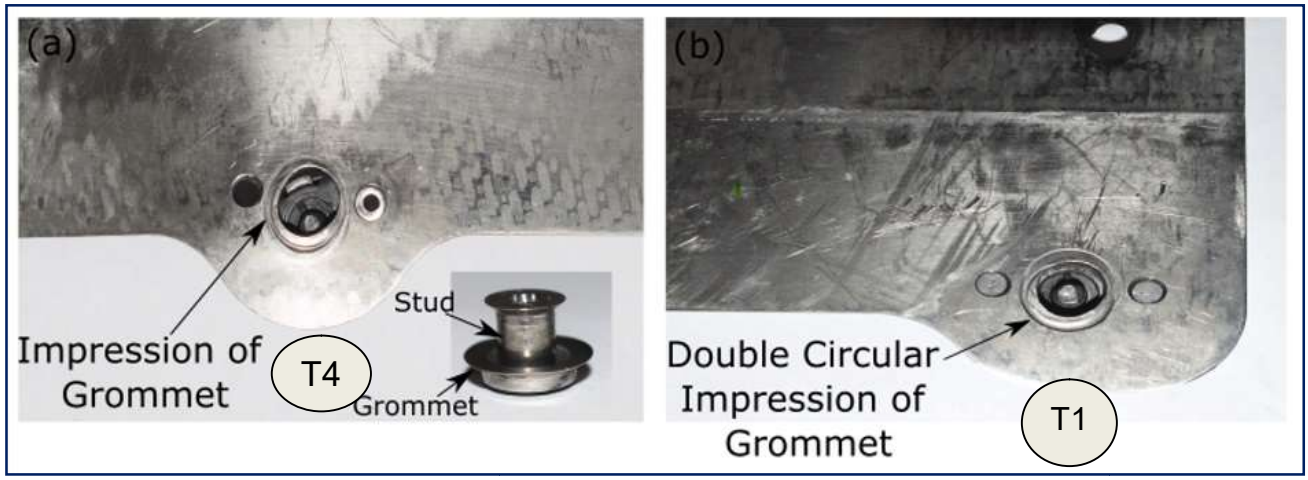

Fig 27: Grommet Impression on metal strap

As per OEM design data, the cowling attachment loads are considered low. The burst duct critical analysis data shows maximum load of 47 lbs for rivets and 141 lbs for Camloc fasteners. The load shared by the Camloc fasteners and rivets installed on the top metal strap in the UFC are as given below:

5 x 141 = 705 lbs (Camloc load)
15 x 47 = 705 lbs (Rivet load)

This indicates that load shared by the fasteners installed on the metal strap are exactly 3 times more than the load carried by the rivets install on the metal strap. Therefore, if one fastener fails, it rearranges the stress distribution and also increases the load on remaining fasteners and rivets.

During the investigation, there were tell tale signs which indicates that 02 (T3 and T5) out of 05 fasteners installed on the top metal strap were missing prior to this incident. Therefore the metal strap fasteners were under increased stress/load. Which can explains the bend found on the top metal strap, which is more pronounced in the rear side than the bend found on the forward side of the top metal strap. **Therefore, it is concluded that the RH UFC failure started from the rear end of metal strap.**

Fig 28: Top metal strap bend

As per above discussion, it is evident that the maintenance practices adopted by the organization is one of the major contributory factor for this incident.

1.2.3 Propeller

Rotating propeller blades are one of the major sources of vibration that a UFC can experience. In order to keep vibration with a specified limits for safe operation. Propeller's vibration data needs to be monitored within OEM's specified interval. However, during investigation it was found that the last vibration data captured on the aircraft was on 03 Nov 2021 at 21264:57 hrs and was 0.592.ips. As per AMM, if vibration levels at cruise are higher than 0.23 ips but less than or equal 0.6 ips, rectification action for vibration control required to be performed within next 400 hrs.

On 08 Nov 2021 at 21306:14 hrs, organization had issued NTC due to "No Data" captured during PBMS monitoring. The organization deferred the same multiple times under ADD. However, ANVS is covered under approved MEL. **This is a non-adherence to the Organization Policy and procedures.** Further Organization instead of going for trouble shooting, it kept on issuing NTCs only. The trouble shooting for "No Data" was initiated on 31 Dec 2021 and accelerometer was suspected faulty. However, NTCs were found issued during subsequent occasions also. On the date of incident organization did not have propeller vibration data. The trouble shooting was completed on 16 Jan 2022 and sensors were found faulty and same were replaced. Post trouble shooting, on 16 Jan 2022, at 21798:52 hrs, the vibration data was obtained and vibration level recorded for RH propeller was 0.298 ips. As per work order issued on 23 Nov 2021 at 21410:38 hrs, post incident, all the six propeller blades, propeller Hub and both inboard & outboard forward upper cowl were replaced on the RH engine. As per AMM, post installation of propeller blades, re-torque within 20 FH, followed by functional check within 100 FH are required to be carried out. However, the same was accomplished on 16 Jan 2022 and at 391:06 Hrs elapsed after propeller blade change.

As per the maintenance records, it is evident that after vibration reading of 0.592 ips obtained on 03 Nov 2021, the vibration control actions and the trouble shooting of PBMS system for no data has not been effectively carried out. **Therefore, it is concluded that the failure to obtain PBMS (propeller's vibration) data and inappropriate action to control vibration levels was one of the contributory factor.**

2.2 CREW HANDLING

Both the operating crew were appropriately licensed, qualified and authorized to undertake the flight. AME onboard was also holding a valid company authorization. Further when onboard AME apprised the flight crew about the condition of RH upper forward cowling, crew discussed the situation and took the precautionary action as required. Therefore, it is concluded that the crew handling was not a contributory factor to this serious incident.

2.3 CIRCUMSTANCES LEADING TO THE INCIDENT

The 600hrs inspection, to examine the condition of fasteners installed on RH engine UFC was last carried out on 14 Sep 2021 and was found satisfactory. Subsequently, on 06 Oct 2021, two receptacles were found missing and same were installed on 06 Oct 2021. Thereafter, top section of UFC was not accessed for inspection/maintenance. Hence the missing fasteners on the top section of UFC were not mapped during preceding routine inspections. However, fasteners installed on the bottom and side of the UFC, which were visible from the ground were mapped and installed subsequently on 14 Oct 2021, 26 Oct 2021 and 05 Nov 2021. Thereafter, weekly & layover inspection were found to be carried out, however, no observation was found recorded regarding RH engine's UFC missing fasteners.

The PBMS value was last recorded on 3rd November as 0.592ips. After which there was no data and hence the level of vibration reached during the incident flight is not known.

With few inappropriately installed and missing UFC fasteners, and unchecked vibration level, on 22 Nov 2021, the top metal strap rivets started failing due to the significant uneven load distributions which lead to stress concentration on the rivets. This stress build up caused the compressive failure of titanium strap by elongation of strap holes and rivet shank got sheared. This triggered the failure of rivet joint. After all the 15 UFC rivets failed, starting from rear to fore end, cowling opened in the mid air and both halves of UFC started fluttering. This unusual fluttering was observed from the cabin. The propeller rotation is clockwise (viewed from rear) hence when the cowling halves opened in mid air the cork screw propeller wash was aiding the inboard cowling to cling onto the structure with flutter but the out board cowling half was blown further which lead to severe flutter and bending of outboard cowling. Further as the fasteners in the sides of cowling are spaced far from top row of fasteners the cowling bending force lead to fracture due to severe flutter. Post landing, the cowling made contact with all six propeller rear root end. Small piece of outboard UFC separated due to propeller contact and was found pierced into the ribs of the propeller hub. When the RH engine was shutdown at the parking bay, the fractured pieces of the outboard UFC got detached and fell on the tarmac.

3. CONCLUSIONS

3.1 FINDINGS

1. The aircraft was holding a valid C of R, C of A and ARC.

2. Both the operating crew were appropriately licensed, qualified and authorized to undertake the flight. AME onboard was also holding a valid company authorization.

3. On the day of incident, there were 13 open deferred defects (under ADD) and one MEL pending for action. Out of 13 ADD, one was related to the RH engine propeller re-torque and rest was not relevant to this incident.

4. Both inboard and outboard UFC along with metal straps were never replaced since the induction of the aircraft into the operator's fleet.

5. The last 600 hrs inspection for fasteners & rivets was carried out on 14 Sep 2021 at 20840:07 hrs and no abnormalities were observed on RH UFC.

6. The last layover inspection during which, missing fasteners were captured and installed was carried out on 05 Nov 2021 at 21277:50 hrs. However, the missing fasteners captured during the layover inspection were from lower section of the UFC. Thereafter, there is no records pertaining to missing fasteners from RH engine UFC.

7. On 29 Oct 2021 at 21235:45 hrs, after re-torque of RH engine's propeller blade no 3, 4 & 5, a functional test was required to be performed within 100 hrs. However, same was found carried on 16 Jan 2022 at 21798:52 hrs.

8. Maintenance records reveal that the maintenance personnel are not adhering to the Organization's Engineering Circular to capture the location of the missing/lose/installed fasteners in the records. Therefore the exact date of defect/maintenance done on the RH engine UFC fasteners with location could not be established.

9. Similarly, the exact reason and date/place of maintenance of the fasteners/shim/rivets installation on the metal strap could not be traced from the maintenance records.

10. Shim marks found on the top metal strap indicates that the shims were used at inappropriate location at multiple instances against the design requirement as mentioned in OEM data

11. Instead of discarding the metal strap with elongated rivet holes as required, organization has inappropriately installed shims, as back plates to fix the receptacles with elongated holes.

12. The last vibration reading of 0.592 ips was obtained on 03 Nov 2021, the vibration control actions and the trouble shooting of PBMS system for no data has not been effectively carried out.

13. Non exhaustive (simple) trouble shooting of PBMS was not initiated and NTC were raised multiple times for over 70 days which indicates unhealthy troubleshooting practices.

14. Post incident, operator had ordered one time fleet inspection to identify the condition of the fasteners installed on the engine forward cowl, one of upper forward cowl was replaced with serviceable one.

3.2 PROBABLE CAUSE AND CONTRIBUTORY FACTORS

"The probable cause of this serious incident could be attributed to the non adherence to maintenance data requirements while carrying out the maintenance".

"*The contributory factors to this serious incident could be attributed to the unchecked vibration levels of the propeller"*

4. RECOMMENDATIONS

4.1 It is recommended that DGCA may carry out an audit to ensure compliance of CAR 145 approvals and also look into the practices adopted by the organization in context of acceptable deferred defect (ADD) policy and procedures.

4.2 It is recommended that operator should sensitize its maintenance personnel to meticulously adhere the organization policy and procedure notwithstanding only to the engineering circular and deferred defect procedure.

4.3 It is recommended that operator should sensitize its maintenance personnel to adhere the requirements of OEM's maintenance data.

4.4 It is recommended that operator should carryout detailed inspection during next major maintenance of every aircraft to capture and mitigate the non standard maintenance (like shim installed in this aircraft but notwithstanding only to this particular non standard maintenance practice) existing in the fleet.

Amit Kumar
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K.S.Muthukrishnan
Investigator

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Place: New Delhi