HELICOPTER ACCIDENT REPORT AND EXECUTIVE SUMMARY

			Reference:			CA18/2/3/9955	
Aircraft Registration	**ZS-HWZ**	**Date of Accident**	17 February 2021		**Time of Accident**	0500Z	
Type of Aircraft	Bell 206B		**Type of Operation**		Private (Part 91)		
Pilot-in-command Licence Type	Private Pilot Licence		**Age**	54	**Licence Valid**	Yes	
Pilot-in-command Flying Experience	**Total Flying Hours**		1 223.1		**Hours on Type**	1 048.6	
Last Point of Departure	Ubhejane Game, Portion 21, Rhenosterhoekspruit 466 KQ, Bela-Bela						
Next Point of Intended Landing	Wonderboom Aerodrome (FAWB), Gauteng						
Damage to Helicopter	Substantial						
Location of the accident site with reference to easily defined geographical points (GPS readings if possible)							
In Wonderboom General Flying Area (GPS position: 25°28’43.20” South 028°09’58.00” East)							
Meteorological Information	Surface wind: Light and variable; Temperature: 20°C: Visibility: CAVOK						
Number of People On-board	1 + 0	**Number of People Injured**	0	**Number of People Killed**	0	**Other (On Ground)**	0
Synopsis							

On Wednesday morning, 17 February 2021, a pilot flying solo on-board the Bell 206B helicopter with registration ZS-HWZ took off on a private flight from his farm at 0415Z with the intention to land at Wonderboom Aerodrome (FAWB). While flying at a height of approximately 400 feet above ground level (AGL), he experienced an engine in-flight shut-down. The pilot immediately transmitted on the very high frequency (VHF) 124.40 megahertz (MHz): “*HWZ engine failure, going down”* as he was aware of a Robinson R44 helicopter that was flying in the area at the time. The pilot flying the Robinson R44 helicopter informed air traffic control (ATC) at FAWB of the predicament surrounding the ZS-HWZ helicopter.

The pilot stated that he identified a dirt road as a possible landing zone, but he was unable to make it as the main rotor blades had most probably impacted a tree on the side of the road, which caused the helicopter to significantly pitch up, making a successful execution of auto-rotation impossible. The helicopter sustained substantial damage as the tail boom was severed by the main rotor blades, while the main rotor assembly (main rotor head with the two main rotor blades) separated from the main rotor drive shaft. The helicopter was substantially damaged during the accident sequence. The pilot was not injured during the accident.

Probable cause

The pneumatic Scroll-to-Pc Filter Tube Assembly had fractured due to fatigue at the forward Pc filter connection. This resulted in engine in-flight shut-down (IFSD), followed by an unsuccessful forced landing (auto-rotative power off landing) on a bushy type terrain.

SRP date	13 July 2021	Publication date	21 July 2021

DESCRIPTION OF THE ACCIDENT

Reference Number	**:** CA18/2/3/9955
Name of Owner	**:** Moneyflow Sixteen (Pty) Ltd
Name of the Operator	**:** Private Flight (Part 91)
Manufacturer	**:** Bell Helicopter Textron
Model	**:** Bell 206B
Nationality	**:** South African
Registration markings	**:** ZS-HWZ
Place	**:** Wonderboom Aerodrome General Flying Area 1
Date	**:** 17 February 2021
Time	**:** 0500Z

Purpose of the Investigation:

In terms of Regulation 12.03.1 of the Civil Aviation Regulations (CAR) 2011, this report was compiled in the interest of the promotion of aviation safety and the reduction of the risk of aviation accidents or incidents and ***not to apportion blame or liability****.*

All times given in this report are Co-ordinated Universal Time (UTC) and will be denoted by (Z). South African Standard Time is UTC plus 2 hours.

Investigation Process:

The accident was notified to the Accident and Incident Investigations Division (AIID) on 17 February 2021 at about 0600Z. This was an off-site investigation. The investigator co-ordinated with all authorities by initiating the accident investigation process according to CAR Part 12 and investigation procedures. The AIID is leading the investigation as the Republic of South Africa is the State of Occurrence.

Notes:
1. Whenever the following words are mentioned in this report, they shall mean the following:

- *Accident — this investigated accident*
- *Aircraft — the Bell 206B helicopter involved in this accident*
- *Investigation — the investigation into the circumstances of this accident*
- *Pilot — the pilot involved in this accident*
- *Report — this accident report*

2. Photos and figures used in this report were taken from different sources and may have been adjusted from the original for the sole purpose of improving clarity of the report. Modifications to images used in this report were limited to cropping, magnification, file compression; or enhancement of colour, brightness, contrast; or addition of text boxes, arrows or lines.

Disclaimer:

Abbreviation	
°C	Degrees Celsius
%	Percentage
AD	Airworthiness Directive
AFM	Aircraft Flight Manual
AGL	Above Ground Level
AIID	Accident and Incident Investigations Division
AME	Aircraft Maintenance Engineer
AMO	Aircraft Maintenance Organisation
AMSL	Above Mean Sea Level
CARs	Civil Aviation Regulations
CAVOK	Ceiling and Visibility Okay
CEB-A	Commercial Engine Bulletin Alert
CSL-A	Commercial Service Letter Alert
C of A	Certificate of Airworthiness
C of R	Certificate of Registration
CTR	Control Zone
CVR	Cockpit Voice Recorder
EASA	European Aviation Safety Agency
FAWB	Wonderboom Aerodrome
FDR	Flight Data Recorder
Ft	Feet
GF 1	General Flying Area 1
hPa	Hectopascal
IFSD	In-Flight Shut-Down
ITT	Intermediate Turbine Temperature
km/h	Kilometres per hour
Kts	Knots
kW	Kilowatt
LH	Left-hand
M	metre(s)
mm	Millimetres
m/s	Metres per second
METAR	Meteorological Routine Aerodrome Report
NW	North West
OEM	Original Equipment Manufacturer
OMM	Operation and Maintenance Manual
PIC	Pilot-in-command
PN	Part Number
QNH	Barometric pressure adjusted to sea level
RH	Right-hand
RSA	Republic of South Africa
SACAA	South African Civil Aviation Authority
SAWS	South African Weather Service
SN	Serial Number
VHF	Very High Frequency
Z	Zulu (Term for Universal Coordinated Time - Zero hours Greenwich)

1. FACTUAL INFORMATION

1.1 History of Flight

1.1.1 The pilot flying solo on-board a Bell 206B helicopter took off on a private flight from his farm Portion 21, Rhenosterhoekspruit 466 KQ, located north of Zebula Lodge at 0415Z to Wonderboom Aerodrome (FAWB). The weather was good at the time of flight. While flying at a height of approximately 400 feet (ft) above ground level (AGL) in FAD 127 Pretoria General Flying Area (GFA) 1, approximately 7 kilometres (km) north-west of the FAWB control zone (CTR) the pilot experienced (an engine) in-flight shut-down (IFSD). The pilot immediately transmitted on the very high frequency (VHF) 124.40 megahertz (MHz): "*HWZ engine failure, going down"* as he was aware of a Robinson R44 helicopter that was flying in the area at the time. The "engine-out" audio warning sounded, and the engine-out light illuminated on the instrument panel. The pilot stated that when he experienced the IFSD, there was a tremendous yaw to the right. He immediately entered auto-rotation flight by lowering the collective pitch lever and applying the necessary tail rotor pedal inputs to return to a stabilised flight. Meanwhile, the pilot who was flying the Robinson R44 helicopter informed air traffic control (ATC) at FAWB of the predicament surrounding the ZS-HWZ helicopter.

1.1.2 The pilot identified a dirt road to his right and concluded that it was the only option available to him for landing the helicopter as the terrain was covered in dense bush. He stated that he banked to the right and brought the helicopter in over the dirt road straight and level, maintaining an airspeed of approximately 65 knots (kts). The road was roughly in a north-westerly direction. The pilot was able to approach over it straight and level. He consciously held back on the cyclic for the flare, but just before impact, the nose pitched up and the helicopter yawed sharply to the right. He then attempted to counter it with a forward cyclic, but the helicopter bounced and turned sharply to the left; it came to rest on its skid gear in a nose-down attitude on the side of the dirt road.

1.1.3 The pilot stated that, in retrospect, the main rotor blades must have impacted a tree on the side of the road, which caused the significant pitch up, making a successful execution of auto-rotation impossible. The helicopter sustained substantial damage as the tail boom was severed by the main rotor blades, while the main rotor assembly (main rotor head with the two main rotor blades) separated from the main rotor drive shaft. The pilot was not injured in the accident; however, the helicopter was substantially damaged.

1.1.4 The accident occurred during daylight at Global Positioning System (GPS) 25°28'43.20" South 028°09'58.00" East, at an elevation of 3 838ft.

1.2 Injuries to Persons

Injuries	Pilot	Crew	Pass.	Total On-board	Other
Fatal	-	-	-	-	-
Serious	-	-	-	-	-
Minor	-	-	-	-	-
None	1	-	-	1	-
Total	1	-	-	1	-

1.3 Damage to Aircraft

1.3.1 The helicopter sustained substantial damage during the accident sequence.

Figure 1: The helicopter as it came to rest.

1.4 Other Damage

1.4.1 None.

1.5 Personnel Information

1.5.1 Pilot-in-command (PIC)

Nationality	South African	Gender	Male	Age	54
Licence Number	**********	Licence Type	Private Pilot Licence		
Licence Valid	Yes	Type Endorsed	Yes		
Ratings	None				
Medical Expiry Date	31 August 2021 (Class 2)				
Restrictions	None				
Previous Accidents	None				

The pilot's last competency check flight was completed on 15 November 2020 with a Grade II flight instructor.

Flying Experience:

Total Hours	1 223.1
Total Past 90 Days	29.6
Total on Type Past 90 Days	29.6
Total on Type	1 048.6

1.5.2 Aircraft Maintenance Engineer (AME)

Nationality	South African	Gender	Male	Age	36
Licence Number	**********	Licence Type	Aircraft Maintenance Engineer		
Licence Valid	Yes	Type Endorsed	Yes		
Ratings	Agusta 109, A119, AB139 and AW139 Series Bell 206B Series (Airframe) Robinson R44 Engines fitted to Rotorcraft for which a CAT "A" is held				

The aircraft maintenance engineer's (AME's) details entered in the table above reflect relevant information of the person who signed off the SACAA Annual Maintenance Review Report (Helicopter) form CA 43-03 following the last maintenance inspection dated 8 December 2020. The AME also signed off the airframe and engine logbook entries for this inspection.

1.6 Aircraft Information

Airframe:

Manufacturer/Model	Bell 206B	
Serial Number	3784	
Manufacturer	Bell Helicopter Textron	
Year of Manufacture	1983	
Total Airframe Hours (at time of accident)	8 492.6	
Last MPI (hours & date)	8 471.5	8 December 2020
Hours Since Last MPI	21.1	
C of A (issue date)	14 May 1990	
C of A (expiry date)	31 May 2021	
C of R (issue date) (Present Owner)	15 November 2013	
Type of Fuel Used	Jet A1	
Previous Accident	None	

Engine:

Manufacturer/Model	Rolls Royce 250-C20J
Serial Number	CAE-270210
Hours Since New	8 484.5
Hours Since Overhaul	Modular engine

1.7 Meteorological Information

1.7.1 The weather information entered in the table below was obtained from the pilot questionnaire.

Wind Direction	150°	Wind Speed	Light	Visibility	+10km
Temperature	20°C	Cloud Cover	None	Cloud Base	None
Dew Point	10°C	QNH	1016hPa		

1.7.2 METAR for FAWB 170500Z AUTO 14014KT //// // ////// 16/10 Q1016=

The weather information was captured via an automatic weather station at FAWB.

Surface wind	-	140°M
Wind speed	-	14 kts
Temperature	-	16°C
Dew point	-	10°C
Barometric pressure	-	1016 hPa

1.8 Aids to Navigation

1.8.1 The helicopter was fitted with standard navigational equipment, which was serviceable at the time of accident.

1.9 Communication

1.9.1 The helicopter was fitted with standard communication equipment, which was serviceable at the time of accident.

1.9.2 The pilot broadcasted a distress call stating: *"HWZ engine failure, going down"* on the VHF 124.80MHz. The pilot of a Robinson R44 who was also flying in the area had informed ATC at FAWB on the VHF 118:35MHz that the ZS-HWZ helicopter had an engine failure and that the pilot had executed a forced landing.

1.10 Aerodrome Information

1.10.1 This accident did not occur at or closed to an aerodrome.

1.11 Flight Recorders

1.11.1 The helicopter was not fitted with a flight data recorder (FDR) or a cockpit voice recorder (CVR), nor was it a regulatory requirement for this helicopter type.

1.12 Wreckage and Impact Information

1.12.1 During an attempted forced landing on a dirt road, the main rotor blades struck a tree on the side of the road, which caused the helicopter to yaw and pitch nose up. During touch down on a dense bushy terrain, the main rotor blades severed the tail boom, the main rotor assembly broke off from the main rotor drive shaft and came to rest on the left of the main wreckage.

Figure 2: An aerial view of the terrain and the helicopter. (Source: Aviation Assessing Services)

Figure 3: The helicopter as it came to rest.

Figure 4: An aft view of the helicopter as it came to rest with the aft tail boom in the foreground.

Figure 5: The entire main rotor assembly had separated from the main rotor drive shaft.

1.13 Medical and Pathological Information

1.13.1 Not applicable.

1.14 Fire

1.14.1 There was no evidence of a pre- or post-impact fire.

1.15 Survival Aspects

1.15.1 The pilot was properly restrained as he had made use of the helicopter equipped four-point safety harness. Also, the cockpit/cabin area had remained intact post-accident, which rendered the accident survivable.

1.16 Tests and Research

1.16.1 The helicopter was recovered to an aircraft maintenance organisation (AMO) at Wonderboom Aerodrome (FAWB) where it was inspected on Friday, 19 February 2021. All the required persons were present during the inspection, including two AMEs from the AMO that carried out and certified the last mandatory periodic inspection (MPI) on the helicopter.

The airframe and engine logbooks were made available to the investigator, as well as the Rolls-Royce engine logbook. The work pack for the last MPI, which was signed off on 8 December 2020, was also made available to the investigator. The file (hard copy) was inspected by the investigator-in-charge (IIC), where after, the AMO scanned the documents and forwarded them to the investigator via email. All work was done under supervision by AMEs from the AMO that recovered the helicopter.

The Pc tube that was fitted to the engine had part number 63005-23051141-B (see Figure 6). This tube was fitted between the Scroll-to-Pc Filter and was found to have failed at the forward end where it attaches to the Pc filter (see Figure 7). The Pc tube was the correct part as per the requirements issued by the engine's original equipment manufacturer (OEM) in the Commercial Engine Bulletin Alert (CEB-A-1294), which was first issued on 20 July 1990, followed by Revision 2, issued on 31 October 1996.

Figure 6: The fractured Pc tube with part number 63005-23051141-B printed on it.

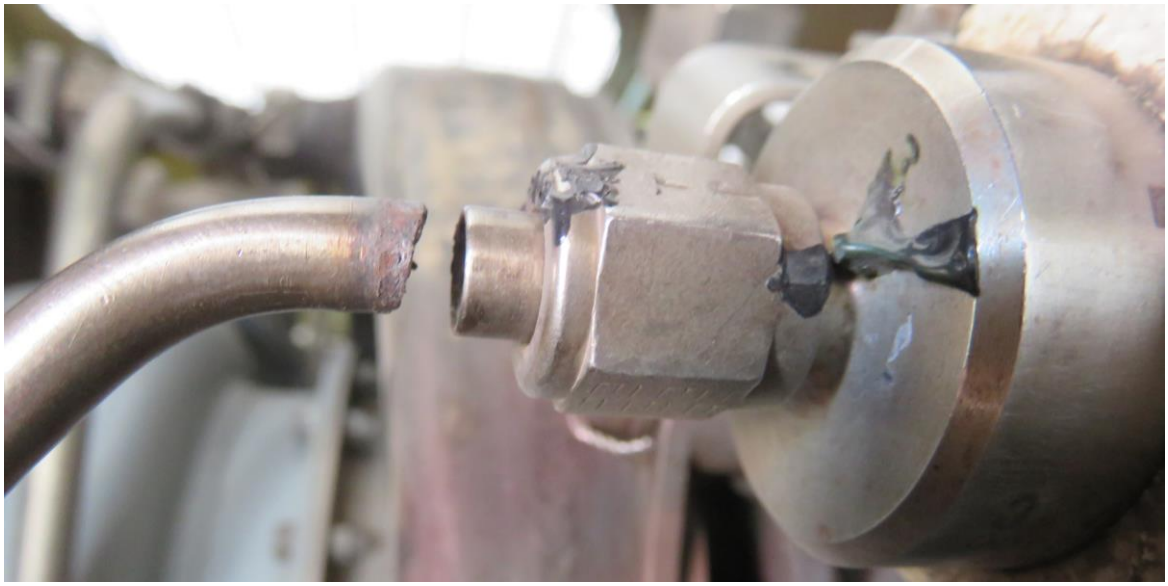


Figure 7: The fractured Pc tube (forward connection of the Pc filter) as it was found on the engine.

A new Pc tube (see Figure 9a) was made available by the AMO that recovered the helicopter. A second Bell 206B helicopter with registration ZS-BAC that was involved in an accident on 23 January 2021 near Reitz, which was recovered to the same AMO, was inspected to make a comparison between the two installations of the Pc tubes as the engine of the ZS-BAC was not damaged during the accident sequence. Figure 8 shows the Pc tube installation on the engine of ZS-BAC.

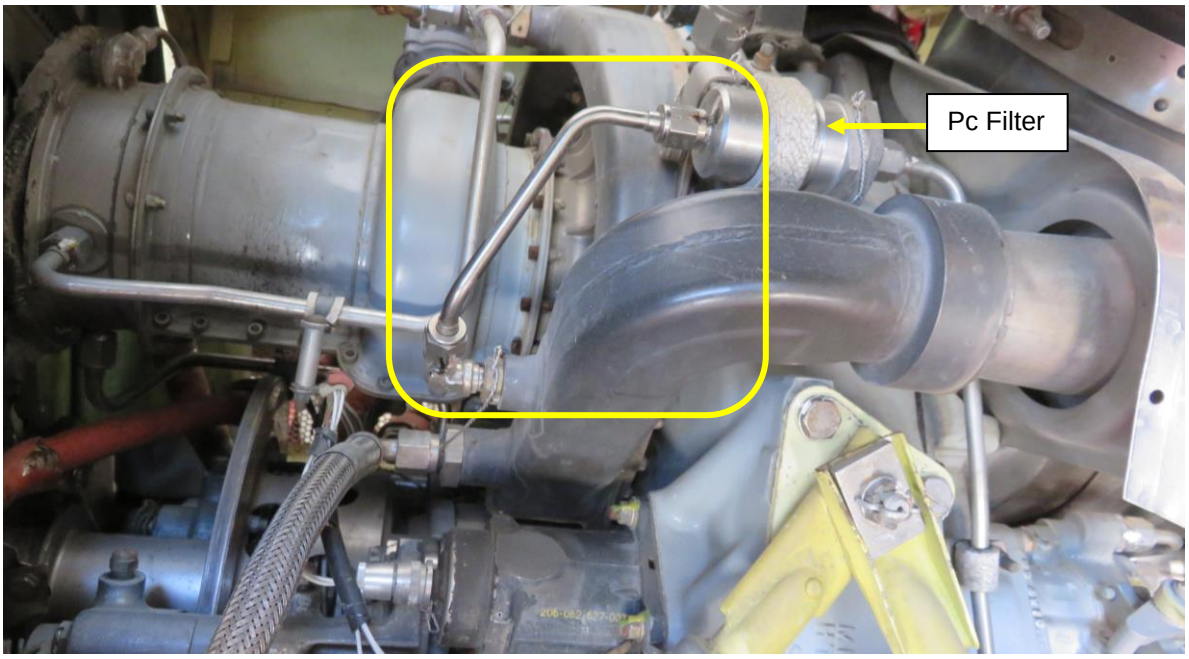


Figure 8: The Pc tube as it was installed on the engine of the ZS-BAC helicopter.

The new Pc tube with serial number 63005-23054628 was made available to the investigator by the AMO that recovered the helicopter. On the securing B-nut on the Pc filter side, the words FILTER END (see Figure 9a) are machine engraved. The Pc tube that was removed from the accident helicopter had, on the opposite end (not the side that failed), the word FILTER printed on the tube (see Figure 9b).

(a) (b)

Figure 9: (a) The new Pc tube: (b) The Pc tube removed from the accident helicopter engine.

It was evident that the Pc tube was installed incorrectly (the wrong way around) and, as a result, the Pc tube was under undue tension during operation. The fractured surface on the filter side also displayed evidence of heat exposure. The failed Pc tube was handed over to the Laboratory for Microscopy and Microanalysis at the University of Pretoria for a metallurgical analysis of the possible failure mode. The report is attached as Annexure F.

A new Pc tube was installed on the engine, and the main and tail drive transmission inputs and output shafts were disconnected from the engine; it was decided to conduct an engine ground run with the engine still secured in the airframe. The airframe was supported on a steel trolley, which was custom-made for the Bell 206 series helicopters.

A commercial type-rated pilot was called in for the ground run procedure. The engine started normally and it was allowed to settle at ground idle. It was then decided to shut down the engine and to conduct a second start.

With the second start, it was decided that one of the AMEs will disconnect the Pc tube on the filter side on instruction from the pilot. The second start was normal. The N1 was increased to 70% and the AME was instructed to loosen the Pc tube. Immediately upon loosening the Pc tube, the engine spooled down to approximately 30% N1. As the engine spooled down, the pilot noted that the intermediate turbine temperature (ITT) was increasing, he immediately shut down the engine. Both engine ground runs were captured on video by the IIC.

Figure 10 provides a comparison between the long end of the new Pc tube that was made available during the investigation process and the short end of the Pc tube that was connected to the forward Pc filter connection that failed in-flight.

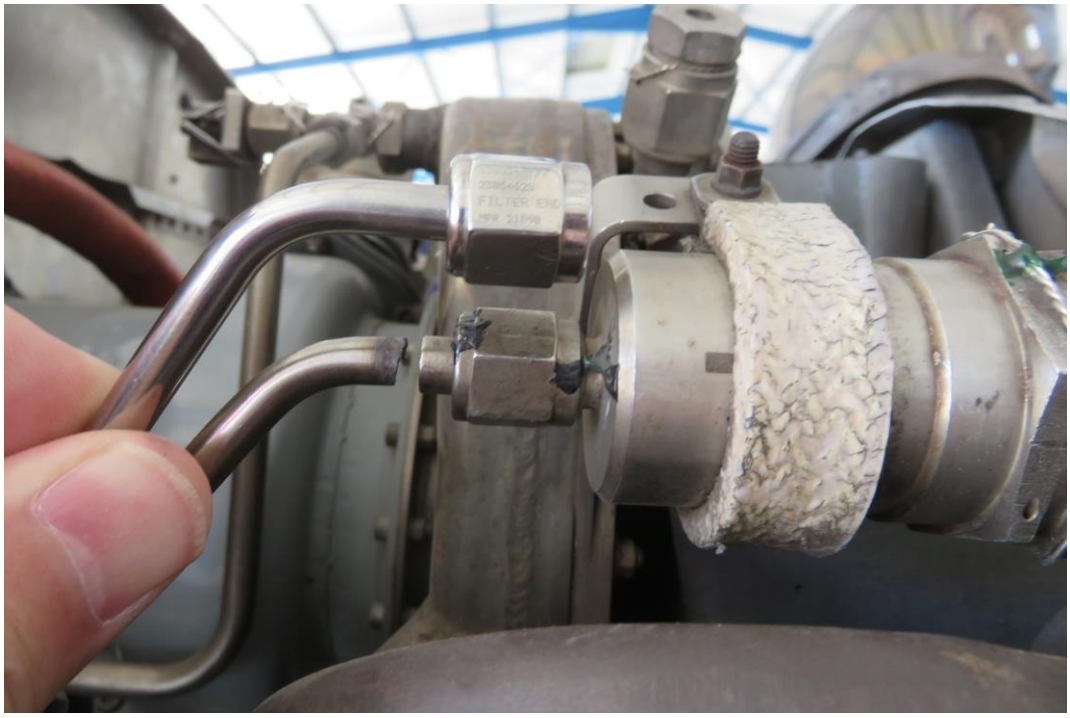


Figure 10: Comparison between the long end (new tube, top) and the short end (failed tube).

In Figure 11, the long end of the new Pc tube was connected to the compressor scroll end. This shows how the Pc tube was installed when it failed. On the picture, it is noted that the flared tube end does not meet the face of the Pc filter front connection.

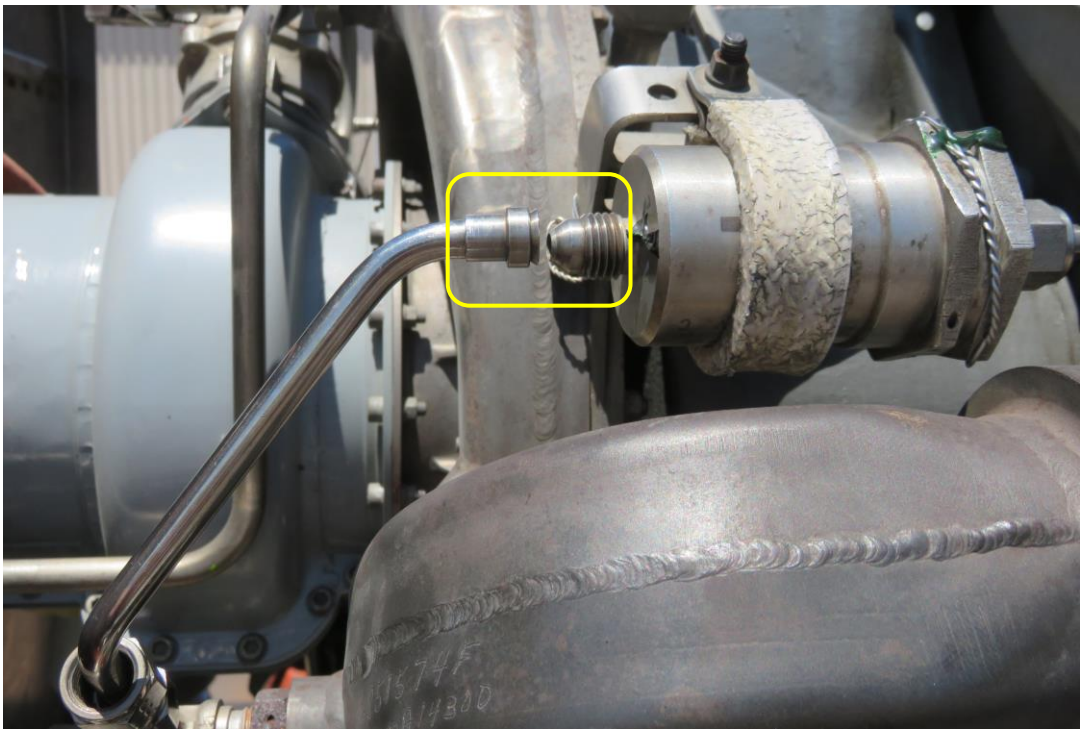


Figure 11: The new Pc tube connected to the long end of the compressor scroll.

In Figure 12, the short end of the new Pc tube was connected to the compressor scroll end. The investigator noted that the flared tube end met uniformly (in a free state) to the cone of the Pc filter front connection. The Pc tube fitted without any distortions of the tube assembly. It was also possible to turn the B-nut tightly by applying light finger pressure before the necessary torque requirements were applied.

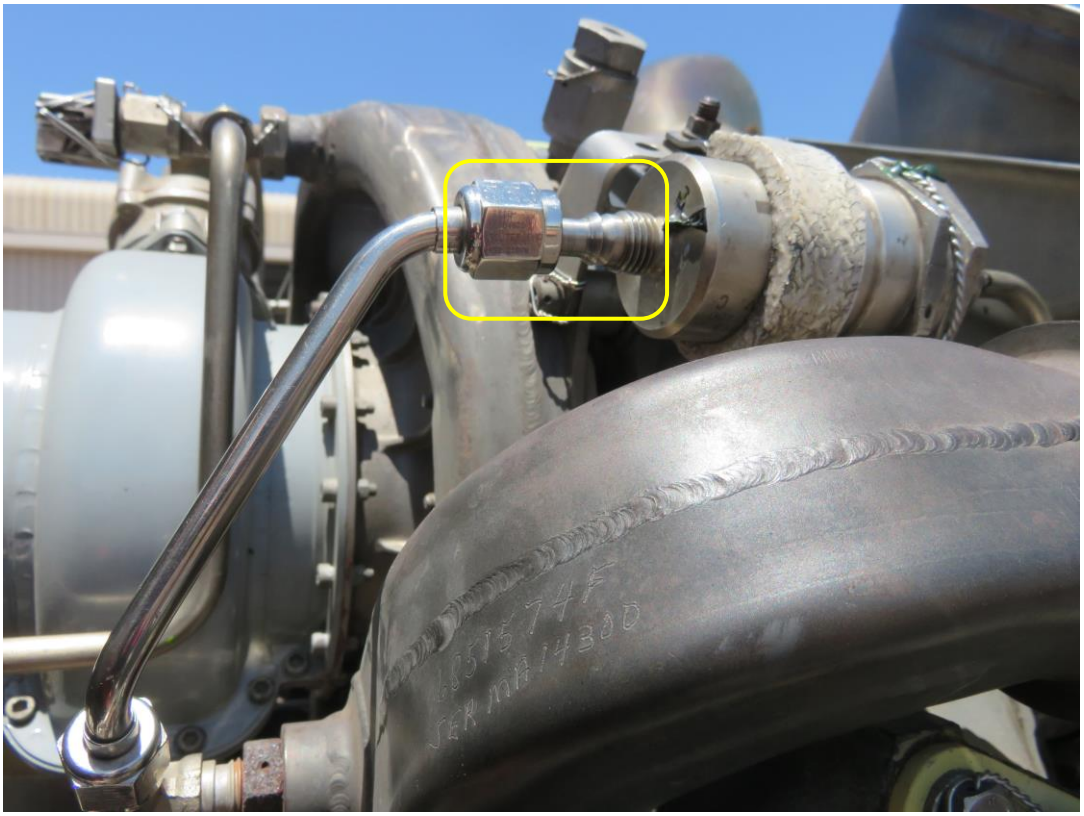


Figure 12: The new Pc tube connected with the short end to the compressor scroll.

1.17 Organisational and Management Information

1.17.1 This was a private flight conducted under the provisions of Part 91 of the Civil Aviation Regulations of 2011 as amended. The pilot was the sole occupant on-board the helicopter.

1.17.2 The AMO that carried out the last maintenance inspection on the helicopter prior to the accident flight was issued an AMO Approval Certificate No. 0090 on 17 September 2020, with an expiry date of 30 September 2021.

1.18 Additional Information

1.18.1 Rolls-Royce Scheduled Inspection Check-sheet, Table 602

Table 602 is a 9-page document that list 51 inspection items with some subheadings that needs to be complied with during scheduled maintenance inspections on all M250-C20

series engines. During the last scheduled maintenance inspection that was certified on 8 December 2020 on this helicopter, the inspection check sheet was used, and it formed part of the AMO work pack #15736. Bullet points 5 to 8, including the NOTE between item 7 and 8, reference the Pc-Scroll-to-Pc Filter Tube Assembly. The first 2-pages of this document (not from the actual work pack) are attached as Annexure A.

1.18.2 Pc Filter – Maintenance Practices (OMM 73-20-06)

The Operation and Maintenance Manual (OMM) practices pertaining to the Pc filter are attached as Annexure B. The installation procedure is listed below.

"Installation

(1) Assemble the clamp on the filter and secure it to the filter mounting bracket with a bolt and nut. Tighten the nut to 35-40 lb in. (3.9-4.5 Nm). Make sure that the arrow on the filter is pointed rearward.

WARNING: FAILURE TO PROPERLY INSTALL, ALIGN AND TORQUE FUEL, OIL, AND AIR FITTINGS AND TUBES COULD RESULT IN AN ENGINE FAILURE.

(2) Install the Scroll-to Pc Filter Tube Assy to the compressor scroll. Torque coupling nut to 80-120 lb in. (9.0-13.6 Nm).

(3) Attach the Scroll-to-Pc Filter Tube Assy to the forward end of the Pc Filter. Attach the Pc Filter-to-Governor Tube Assy to the aft end of the filter. Hold the filter with the proper wrench at the hex flats of the filter assembly, while torqueing the coupling nuts to 80-120 lb in. (9.0-13.6 Nm).

(4) Leak check the pneumatic system following installation of the Pc Filter. (Refer to para 2.B., 73-00-00.)"

1.18.3 Commercial Service Letter Alert (CSL-A 1166)

The failure of the Pc tube in this accident was not an isolated event and the engine's OEM was aware of this. To mitigate this, the OEM had issued a Commercial Service Letter Alert (CSL-A) 1166 for the M250-C20 Series engine on 15 November 1990. On 5 February 2007, Revision 1 of this CSL-A-1166 was issued; and on 8 July 2019 Revision 2 was issued. What was of concern to the OEM were the improper alignment, clamping and torqueing of the engine tubing that could occur during installation. The OEM (through the CSL-A) further stated that practices specified in the Operation and Maintenance Manual (OMM) should be complied with as it is critical to flight safety. In the document, the OEM included a list of scenarios that could contribute or cause failure of these tube assemblies, including

pneumatic control system, fuel system and lubrication system tubes on the Model 250 engine series.

The AMO work pack #15736 relating to the maintenance inspection that was performed on the helicopter on 8 December 2020 had a copy of this CSL-A-1166, Revision 2 in it. There were two stamps from the AMO on page 1, which were signed off by two different people on two different dates. Each subheading was also initialled. This Service Letter was entered and was signed off on page 38 of the engine logbook under the heading Service Bulletins / Letters / Instructions.

EXPORT CONTROLLED

ALERT
COMMERCIAL SERVICE
LETTER

Rolls-Royce

MAINTENANCE WARNING - EXTERNAL LINES

1. Background

Rolls-Royce continues to be involved in investigations of aircraft accidents and incidents which are attributed to improper alignment, clamping, and torquing of engine tubing during installation. Instances of twisted lines, kinked lines, and split flares have resulted from installation practices contrary to those specified in the Operation and Maintenance Manual. Compliance with the manual procedures is critical to safety of flight. In most cases, the failure of the tube assemblies can be traced to one or any combination of the following causes:

A. Bent tubes which induce misalignment at the flare and result in cracked flares or fretting of the tube at the end of the ferrule.

B. Tube to fitting misalignment caused by poorly aligned fittings, which result in cracked flares or fretting of the tube at the end of the ferrule.

C. Clamps of the improper size that cause fretting wear and failure at the clamp due to stress concentration at the wear step.

D. Incorrect clamps with cushion material that causes corrosion and eventual stress corrosion failure of the tube.

E. Installation of chafe wrapping to correct a loose clamp. This chafe wrapping then causes corrosion and eventual stress corrosion failure of the tube.

F. Incorrect clamp locations that do not properly dampen tube vibrations. The vibrations then lead to fatigue failure of the tube.

G. Unauthorized clamping of other hardware to the engine tube assemblies, which induce vibratory stress that results in the tube failure.

H. Failure to properly torque tube coupling nuts can cause leakage if under torqued, which can result in fuel or oil leaks or engine power loss. Overtorqued B-nuts result in deformed and cracked flares.

See step N under Paragraph 2 “Recommendations” of this CSL, which advises the user to inspect the tubes for several conditions, one of which is corrosion. Evidence of corrosion was observed on the failed Pc tube. The AMO had signed off the work pack and the engine logbook with this CSL included.

L. Clamp the tube assemblies as shown in the appropriate Illustrated Parts Catalogs and/or Commercial Engine Bulletins.

M. Do not install unauthorized clamps, hardware, fittings, chafe material, etc., on the engine tube assemblies. See Figure 7 for a correct cushion material example.

N. Visually inspect tube assemblies before each installation for the following items: cracked flares, nicks, dents, severe fretting in the area of clamps and end ferrules, corrosion, bent or malformed tubing, correct part number, and proper clamping. Failure to meet acceptable criteria is cause for rejection of the tube assembly.

O. Perform detailed visual inspection of the tube assemblies each time the tubes are removed in the completion of maintenance procedures. For example, if the fuel control unit is removed from the engine, all tube assemblies connected to the fuel control unit should be visually inspected.

P. Assure that the tube to fitting alignment is acceptable per the appropriate Operation and Maintenance Manual. It will be the maintenance facility's responsibility to assure conformance with the proper alignment and torquing of the tubing.

Q. Maintain installation of warning placards for fuel, oil, and air tubes. Consult the Airframe Manufactures installation instructions for placard installation details. Should replacement placards P/N 23052363 be required, they can be procured from a Rolls-Royce Model 250 distributer. See Figure 8.

3. Summary

Failure of a pneumatic, lubrication, or fuel system tube assembly can cause the engine to cease operation, resulting in an in-flight shutdown or a forced landing. Properly maintained engine tubing will greatly lessen the possibility of an in-flight shutdown or forced landing.

1.18.4 Commercial Engine Bulletin Alert (CEB-A 1234)

On 23 June 1986, the engine's OEM issued a Commercial Engine Bulletin Alert (CEB-A) 1234, which pertains to fuel and air system Scroll-to-Pc Filter Tube Assembly inspection. The reason for this had been the failure of the Pc tube, which resulted in unscheduled landings or in-flight power loss. As the Pc tube must be removed to perform a compressor wash, it was found to have a higher failure rate than other similar tubes on these engines due to handling. On 15 April 1992, Revision 3 of this CEB was issued; and on 25 January 2021, Revision 4 was issued. This was after the last MPI was certified on this helicopter, but prior to the accident flight. Proper tightening of engine tubing connections is critical to flight safety. Incorrect tightening of these connections could cause cracks to the flare or the adjacent tube area. This could produce an air leak, which could cause a flameout, power loss or an overspeed condition. CEB Revision 3 is attached as Annexure D.

1.18.5 Commercial Engine Bulletin Alert (CEB-A-1294)

On 20 July 1990, the engine OEM issued a Commercial Engine Bulletin Alert (CEB-A) 1294, and on 31 October 1996 Revision 2 of this CEB was issued. Models 250-C20, 250-C20B (T63-A-720) and 250-C20J series engines were affected by this CEB. The list below references the 250-C20J model engines that were affected by this Bulletin:

Model	Serial No.
250-C20J	CAE 270001 through 270488
250-C20J	CAE 272501 through 272610

The engine that was installed in this helicopter was the 250-C20J model, with serial number CAE-270210. This CEB was, therefore, applicable to this engine.

The reason for issuance of this CEB was that the Scroll-to-Pc Filter Tube Assembly with part number (P/N) 6848641 was susceptible to maintenance manhandling damage. A new Scroll-to-Pc Filter Tube Assembly was recommended by the OEM to minimise this mishandling damage. The new Scroll-to-Pc Filter Tube Assembly with serial number 23051141 had a ticker wall and improved routing/configuration. This Pc tube with serial number 23051141 should have the letter P machine-engraved (vibropeened) on the B-nut on the filter end. *Should the engine be fitted with such a Pc tube, it would not require replacement.* The Scroll-to-Pc Tube Assembly that was fitted to this engine met the requirements as outlined in the CEB-A-1294. The caution message on the next page was contained in the CEB.

"Install the Scroll-to-Pc Tube Assembly, P/N 23051141, ("B" nut marked with a letter P) to the compressor scroll and Pc filter as follows:

CAUTION: FAILURE OF ENGINE PNEUMATIC TUBES CAN CAUSE FLAMEOUT OR POWER LOSS.

(1) Tube assemblies must fit and be aligned with the mating flare tube fittings to the degree that at both ends of the assembly the flares shall be uniformly seated in a free state on the cones of the mating fittings. The fit shall be without distortion or stretching of the tube assembly and to the degree that the nuts can be fully engaged up to the final one-half turn with light finger pressure. In the event that the tube does not align with the mating fittings, reposition the scroll fitting and/or Pc filter assembly to the degree that proper alignment may be attained."

CAUTION: THE PRACTISE OF TIGHTENING FITTING LOCK NUTS WITH TUBE ASSEMBLIES INSTALLED CAN RESULT IN DAMAGE TO THE TUBE WITH POSSIBLE FAILURE OF THE TUBE ASSEMBLY RESULTING IN A POWER LOSS."

1.18.6 European Aviation Safety Agency (EASA) Airworthiness Directive (AD)

On 15 December 2004, EASA issued an Airworthiness Directive (AD), and on 23 March 2016, Revision 4 of AD number 2004-0009R3 was issued. The AMO work pack #15736 relating to the maintenance inspection that was certified on 8 December 2020 had a copy of this AD in it. The engine logbook on page 34 under the heading Repetitive Airworthiness

Directive Compliance recorded an entry that was made on 8 December 2020 that the AD in question was complied with, as well as signed out in the logbook. The AD is attached as Annexure E.

1.18.7 Rigid Tube Inspection and Installation as per the engine Operations and Maintenance Manual (OMM)

The OMM under the heading Flared Tubes states the following:

"Tube assemblies must fit and be aligned with the mating flare tube fittings to the degree that at both ends of the assembly the flares shall be uniformly seated in a free state on the cones of the mating fittings. The fit shall be without distortion or stretching of the tube assembly and to the degree that the nuts can be fully engaged up to the final one-half turn with light finger pressure.

In the event a tube does not align with the mating fittings, reposition the mating fittings to the degree that proper alignment may be attained. Final tightening of these fittings must be accomplished before the tube assembly is connected."

This is essential information for all maintenance personnel when any task is conducted on any of the engine tubing, irrespective of whether it involves fuel, oil or pneumatic tubing.

The content as contained in the OMM with reference to this critical guidance is attached as Annexure C.

1.18.8 Engine tube failure accident in South Africa

On 5 April 2005, a Bell 206L with registration ZS-HUP was involved in a similar type of accident in South Africa when the tube located between the Power Turbine (PT) Governor and the Fuel Control Unit (FCU) fractured and separated at the FCU connection. The engine power loss occurred while the helicopter was in hover flight, off-loading maintenance personnel onto a high-tension power line tower.

1.19 Useful or Effective Investigation Techniques

1.19.1 No new methods were used in this investigation.

2. ANALYSIS

2.1 General

From the available evidence, the following analysis was made with respect to this incident. This shall not be read as apportioning blame or liability to any organisation or individual.

2.2 Analysis

2.2.1 Pilot

The pilot was the owner of the helicopter since November 2013. He had a valid Private Pilot Licence (PPL) and had flown 1 048.6 hours on the helicopter type. His last competency check flight was on 15 November 2020. The helicopter was imported to South Africa in 2008 and was operated for approximately five years in the Cape Town area before the pilot took ownership of the helicopter in 2013. Since then, the helicopter was maintained by the same AMO.

Even though the pilot had identified a dirt road as a possible landing area following engine failure, he did not keep in mind the main rotor diameter. The road surface might have been more than enough for landing the airframe, but the rotating main rotor system required a much larger area than he had anticipated. Hence, he stated that he struck a tree with the main rotor blades prior to touch down, which rendered a possible successful forced landing unsuccessful.

2.2.2 Helicopter

According to the airframe logbook, this helicopter was being maintained by the same AMO, with the first logbook entry dated 4 December 2013 at 7 632.7 airframe hours, and the last maintenance inspection being certified on 8 December 2020 at 8 471.5 airframe hours.

The airframe and engine logbooks, as well as the AMO work pack #15736 for the last maintenance inspection that was certified on 8 December 2020 prior to the accident flight were inspected. During this maintenance inspection, the engine's OEM Table 602 was followed. This was an approved scheduled maintenance inspection check sheet consisting of 9 pages. On page 2 of this inspection check sheet, bullet point 7, requests that the Scroll-to-Pc Tube Assembly be removed at both ends, and that it be inspected for cracks using 10x power glass. Tubes found to contain cracks and/or excessive fretting damage are to be replaced by a new part. The same Scroll-to-Pc Tube Assembly was required to be removed for the purpose of conducting an engine compressor wash. The compressor wash was carried out according to the work pack #15736, and an engine logbook entry entered on page 60. On page 233 of the engine OMM, the compressor wash procedure

commences; and on the next page it continues with *"bleed valve sensing tube and the scroll-to-Pc filter Pc tube by disconnecting at both ends."* At the end of this paragraph, there is a *"NOTE: Inspect the scroll-to-Pc filter tube at each end for cracks and fretting wear, especially beneath the area of the floating ferrule and at the flare ends."*

The OMM procedure with reference to: Pc Filter Maintenance Practise, states that the scroll-to-Pc Tube Assembly must be removed at both ends to inspect and clean the Pc filter. On page 202 of the OMM document, which is attached to this report as Annexure B, the installation of the Pc filter is dealt with in four steps, which include the installation of the scroll-to-Pc Tube Assembly. In the installation instructions, there is no mention of how the scroll-to-Pc tube must be installed. The OMM procedure does not state that the long end of the scroll-to-Pc tube must connect to the front end of the Pc filter and the short end, to the compressor scroll, nor does it make any mention that the word FILTER, which was stamped on the Pc tube that had failed in operation needed to fit with the end of the forward Pc filter connection. The IIC is aware that the Pc filter was not removed during the last maintenance inspection as it was required every 300 hours to be removed and cleaned, but the procedure with reference to the installation of the Pc tube, is what is of importance to this investigation.

What the engine's OEM did following several accidents and incidents that were reported with reference to the 250 Series turboshaft engines which were attributed to improper alignment, clamping and torqueing of engine tubing during installation, was to issue a Commercial Service Letter CSL-A-1166 on 15 November 1990 to provide information on how to prevent incorrect installation of fuel, oil or pneumatic tubing. This CSL-A-1166 was issued with Revision 2 on 8 July 2019. The following observations were made:

(i) The Scroll-to-Pc Tube Assembly with part number 63005-23051141-B that was fitted to the engine was an approved part as per the OEM requirements.

(ii) The Pc tube was not deformed, bent or dented in any way.

(iii) Fretting was found under the ferrule sleeves on both ends.

(iv) Corrosion was present at the tube/ferrule interface on both flange ends.

(v) The Pc tube was found to have failed due to fatigue behind the floating ferrule.

On 15 December 2004, EASA issued an AD 2004-0009, which was revised twice, with Revision 3 becoming effective on 23 March 2016. This AD was applicable to all Rolls Royce 250-C18, -C20, -C28 and -C30 Series engines and required inspection of all B-nuts of all fuel control system pipes connecting the Gas Producer Fuel Control, the Power Turbine Governor or the Compressor for indications of slipping. The AD refers to CSL-A-1166 and stipulates that instructions must be accomplished as set out in the CSL-A-1166 and that the torque value for each B-nut be recorded as set out in the OMM.

2.2.3 Environment

Fine weather conditions prevailed during the flight. The weather was not considered to have had any bearing to this accident.

The environment where the pilot executed the forced landing was hostile and should be regarded as a contributory factor for the pilot not being able to execute a successful forced landing (that is, with no damage to the helicopter).

2.2.4 Operation and Maintenance Manual (OMM)

The investigation found that the engine OMM dealing with the installation of the Scroll-to-Pc Tube Assembly was lacking critical content, which was as follows:

(i) No evidence could be found in the OMM referencing the word FILTER being printed on the Pc tube that failed when referring to the installation of the Pc tube to the engine. There must have been a valid reason why the word FILTER was printed on the Pc tube, otherwise the vendor would not have done it. However, the supporting documentation does not make mention to it, nor does it provide clear guidance to maintenance personnel on how the installation of the tube should be carried out if and when the word FILTER was printed on it. In this accident, the Pc tube was found to have been an approved part and had the word FILTER printed on it.

During the investigation process, a new Pc tube with P/N 23054628 was compared to the one that was in service; and on that tube, the word FILTER END was found machine-engraved (vibropeened) on one of the B-nuts. Once again, the OMM was silent on the installation of the newer Pc tube assembly.

One, therefore, must conclude that with the word FILTER either printed on the Pc tube or machine-engraved on the B-nut, maintenance personnel, if they make the observation, should fit this end to the Pc filter forward connection. If one fails to observe the word FILTER, one cannot regard it as non-compliance as the OMM is silent on this matter.

(ii) The OMM was also silent about the Pc tube elbow lengths with reference to installing the Scroll-to-Pc filter tube onto the engine. One of the Pc tube elbow sections was designed slightly longer than the other side (see Figure 8). Although the OMM does not make any reference to this, it had become an industry norm that the longer end of the Pc tube is attached to the Pc filter forward connection.

(iii) The OMM (72-00-00, pages 328 and 329) does provide maintenance personnel with clear guidance on the installation of all pneumatic, fuel and oil tubing on the engine.

"Tube assemblies must fit and be aligned with the mating flare tube fittings to the degree that at both ends of the assembly the flares shall be uniformly seated in a free state on the cones of the mating fittings. The fit shall be without distortion or stretching of the tube assembly."

2.2.5 Conclusion

The installation guidance material contained in the OMM and all other relevant supporting documentation mentioned in this report (i.e., CEBs, CSL and AD) allow room for error with reference to the installation of the Scroll-to-Pc tube.

What has transpired in this accident is the Scroll-to-Pc tube installation did allow for normal engine operation from the time it was installed until the Pc tube failed. What is not known is whether this Scroll-to-Pc tube was installed the same way during previous maintenance inspections where the helicopter was flown without any failure of the Pc tube from one maintenance inspection to the next.

No reference to the word FILTER, printed or engraved on the Pc tube, was found on any of the documents referred to in paragraph one under this sub-heading.

The fact that one end of the Pc tube was slightly longer than the other end, and that the longer end should have been connected to the Pc filter forward connection is also not mentioned on any of the documents referred to in paragraph one under this sub-heading.

What the investigation found in all these documents are the words *CAUTION / WARNING NOTES,* which state that if the pneumatic, fuel and oil tubing is not installed correctly, it could result in loss of engine power, flameout, engine stoppage / failure, with the potential of an unforeseen landing.

When referencing CSL-A-1166, which was issued for the first time on 15 November 1990, it was noted that the engine OEM was aware of potential failures with regard to engine tubing, which could be attributed to improper alignment, clamping and torqueing of the engine tubing during installation. The OEM also presented a list of eight potential scenarios which could contribute to such a failure, or any combination thereof. With reference to the Pc tube failure in question, sub-heading B was found to be applicable for this accident *"Tube to fitting misalignment caused by poorly aligned fittings, which result in cracked flares or fretting of the tube at the end of the ferrule."*

The installation, as it was found, did allow for the Pc tube to have been under undue tension due to misalignment during installation, which resulted in fatigue failure, thereof, and a subsequent engine in-flight shut-down with substantial damage to the helicopter. What was of concern was the presence of corrosion on the Pc tube. Reference document

issued by the engine OEM, CSL-A-1166, under paragraph 2, “Recommendations”, step N states: *“Visually inspect tube assemblies before each installation for the following items: cracked flares, nicks, dents, severe fretting in the area of clamps and end ferrules, corrosion, bent or malformed tubing, correct part number, and proper clamping. Failure to meet acceptable criteria is cause for rejection of the tube assembly.”* The corrosion observed on the failed Pc tube could not have occurred in the 21 operating hours since the last maintenance inspection was performed. It is most likely that it was present prior to inspection. The presence of corrosion should have prompted the replacement of the Pc tube by maintenance personnel as it was an on-condition part.

3. CONCLUSION

3.1 General

From the available evidence, the following findings, causes and contributing factors were made with respect to this incident. These shall not be read as apportioning blame or liability to any organisation or individual.

To serve the objective of this investigation, the following sections are included in the conclusion heading:

- **Findings —** are statements of all significant conditions, events or circumstances in this accident. The findings are significant steps in this incident sequence, but they are not always causal or indicate deficiencies.
- **Causes —** are actions, omissions, events, conditions or a combination thereof, which led to this accident.
- **Contributing factors —** are actions, omissions, events, conditions or a combination thereof, which, if eliminated, avoided or absent, would have reduced the probability of the incident occurring, or would have mitigated the severity of the consequences of the accident. The identification of contributing factors does not imply the assignment of fault or the determination of administrative, civil or criminal liability.

3.2 Findings

Pilot

3.2.1 The pilot had a valid Private Pilot Licence (PPL) which was initially issued on 5 May 2008. He had the helicopter type endorsed on his licence and had accumulated a total of 1 223.1 flight hours, of which 1 048.6 were on the helicopter type.

3.2.2 The pilot had a valid aviation medical certificate (Class 2) that was issued on 4 August 2020 with an expiry date of 31 August 2021.

3.2.3 The flight was conducted under visual flight rules (VFR) by day.

3.2.4 The pilot's last competency check flight was on 15 November 2020 with a Grade II flight instructor.

3.2.5 The pilot broadcasted a distress call on the VHF 124.80MHz, which was relayed to ATC at FAWB tower by another helicopter pilot flying in the area at the time.

The Helicopter

3.2.6 The helicopter was issued a Certificate of Airworthiness on 14 May 1990 with an expiry date of 31 May 2021.

3.2.7 The Certificate of Registration for this helicopter was issued on 15 November 2013.

3.2.8 The last maintenance inspection that was carried out on the helicopter prior to the accident flight was certified on 8 December 2020 at 8 471.5 airframe hours. Subsequent to the inspection, a further 21.1 hours were flown.

3.2.9 The helicopter was issued a Certificate of Release to Service on 8 December 2020, with an expiry date of 7 December 2021 or at 8 571.5 airframe hours, whichever comes first.

3.2.10 According to the OEM Table 602 maintenance inspection sheet which formed part of the work pack #15736, the Scroll-to-Pc tube was removed during the last maintenance inspection on the helicopter. It was also required to be removed for an engine compressor wash, which was accordingly signed out in the engine logbook.

3.2.11 The Scroll-to-Pc tube was found to have been installed the wrong way around (following the compressor wash).

3.2.12 The Pc tube with part number 63005-23051141-B that was installed on the helicopter was an approved part for this engine series, according to CEB-A-1294.

3.2.13 The Pc tube that failed had the word FILTER printed on the one end (that is, not the end that failed).

3.2.14 It was possible to install the Scroll-to-Pc filter tube the "wrong way around" and still obtain optimal engine performance.

3.2.15 A post-maintenance acceptance flight, which included operational checks of all systems was conducted on 8 December 2020, and all parameters and systems were found to be within operating limits.

3.2.16 EASA had issued an AD number 2004-0009R3 with reference: Engine Fuel & Control - Engine Fuel System Pipes - Installation on all Rolls-Royce 250-C18, -C20, -C28 and -C30 engines to prevent a possible Pc tube failure. This AD was signed off in the engine logbook and the AMO work pack as being complied with.

3.2.17 In the documents CEB-A-1234, CSL-A-1166 as well as the applicable OMM procedures (referred to in this report), the engine OEM had issued several warnings that if the pneumatic, fuel and oil tubing are not properly installed, aligned and torqued, an engine power loss in-flight could occur, or an engine failure could result in an unforeseen landing / accident.

3.2.18 Although the word FILTER was printed on the scroll-to-Pc filter tube assembly, no reference was made in the engine OMM stating the purpose of the word FILTER being printed on the tube assembly, nor was any installation guidance provided in this regard.

3.2.19 The operating environment for this helicopter prior to it being imported to South Africa in 1990 is unknown. The helicopter had operated in Cape Town for several years before moving inland in 2013.

3.2.20 The Scroll-to-Pc tube displayed evidence of corrosion, which was regarded as a significant contributory factor to the failure of the tube assembly.

3.3 Probable Cause

3.3.1 The pneumatic scroll-to-Pc filter tube assembly fractured due to fatigue at the forward Pc filter connection. This resulted in an engine in-flight shut-down (IFSD), followed by an unsuccessful forced landing (auto-rotative power off landing) on a bushy type terrain.

3.4 Contributory Factors

3.4.1 The Pc tube displayed evidence of corrosion and fretting on the tube/floating ferrule interface on both ends, which manifested over an undetermined period. The AMO had signed off the work pack and the engine logbook with CSL-A-1166 included.

3.4.2 The manner in which the Pc tube was installed allowed for an applied tensile stress component during flight (vibration to be induced during operation).

3.4.3 Although the word FILTER was printed on the Pc tube, there was no engine OMM guidance material for maintenance personnel during installation of the Pc tube that made reference to this word, nor did any of the CSL or CEBs that were issued highlighted this information.

3.4.4 The engine OMM did not make any reference that, when installing the Scroll-to-Pc tube, the longer end of the tube should be attached to the Pc filter.

4. SAFETY RECOMMENDATIONS

4.1 General

The safety recommendations listed in this report are proposed according to paragraph 6.8 of Annex 13 to the Convention on International Civil Aviation and are based on the conclusions listed in heading 3 of this report. The AIID expects that all safety issues identified by the investigation are addressed by the receiving States and organisations.

4.2 Safety Recommendations

4.2.1 The safety recommendations are raised on the basis that it is highly possible that the Pc tube might be installed incorrectly on these helicopters, therefore, this needs to be corrected to avoid a recurrence of the accident or even loss of life. Therefore, my recommendations are to the Director of Civil Aviation to consider the following:

a) Issuance of mandatory maintenance notice (MMN) for all helicopters fitted with the same kind of Pc tube (as the accident helicopter) to be inspected for correct installation before the next flight from the date of issue of the MMN.

b) The Director of Civil Aviation to consider issuing an RSA Airworthiness Directive for the replacement of the old Pc tubes with the new Pc tubes that are clearly marked to prevent incorrect installation.

4.2.2 The recommendation below is forthcoming from the Laboratory for Microscopy and Microanalysis at the University of Pretoria following their analysis of the failure.

It is recommended that the Pc tube be inspected for the **presence of corrosion damage** at the Scroll-to-Pc Filter Tube/Floating Ferrule interface, in particular the vertically fitted end, should be included in the maintenance schedule/checklist.

IMPORTANT: This should be a reoccurring AD.
NOTE: With reference to the safety recommendations in 4.2.1 and 4.2.2, a memo was drafted 30-days after the accident occurred to the Director for Civil Aviation for her consideration and approval.

4.2.3 It is recommended that Rolls-Royce revised the OMM procedure for the installation of the Scroll-to-Pc Filter Tube Assembly on all M250-C20 Series engines. The OMM was found to be lacking detailed information on the installation of the Pc tube as it does not make any

reference to the word FILTER being printed on the Pc tube with serial number 23051141, nor does it refer to the newer Pc tube with part number 23054628 that has the words FILTER END machine-engraved on the B-nut that should connect to the Pc filter forward connection. (See Figures 8a and 8b on page 14 of this report.) There is also no reference in the OMM that this Pc tube has a longer end and a shorter end; and that the longer end of the Pc tube should be attached to the Pc filter forward connection.

4.2.4 It is recommended that Rolls-Royce re-issue CSL-A-1166 to include this occurrence as an example and add information regarding various tubes that can possibly be installed in either orientation.

4.2.5 It is recommended that Rolls-Royce consider replacing the Scroll-to-Pc tube assembly with a flexible tube that could provide proper heat resistance in order to transfer the air in the tube. The writer is aware that the air being transferred in the Pc tube must withstand a temperature of approximately 315°C (600°F), however, a flexible Pc tube will eliminate the possibility that the Pc tube assembly could be installed incorrectly.

5. APPENDICES

5.1 Annexure A (Rolls-Royce Table 602 scheduled inspection check sheet, page 1 and 2)
5.2 Annexure B (Rolls-Royce M250-C20 Operation and Maintenance – Pc Filter Maintenance Practices)
5.3 Annexure C (Rolls-Royce M250-C20 Operation and Maintenance – Rigid Tube Inspection and Installation)
5.4 Annexure D (CEB-A-1234, Revision 3, Engine – Fuel and Air System, Pc Scroll to Pc Filter Tube Assembly - Inspection)
5.5 Annexure E (EASA Airworthiness Directive No. 2004-0009R3, Revision 3)
5.6 Annexure F (Report from the Laboratory of Microscopic and Microanalysis University of Pretoria on the Pc tube failure).

This report is issued by:
Accident and Incident Investigations Division
South African Civil Aviation Authority
Republic of South Africa

PARA 1. (contd)

B. Scheduled Inspections

Scheduled inspections are made at periodic intervals in an effort to prevent engine malfunction and serve in the role of preventative maintenance for the engine. The component to be inspected, the nature of the inspection, and the elapsed time after which the inspection is to be performed are given in the Inspection Checksheet, Table 602. The inspection times are hours of engine operation.

Table 602
Scheduled Inspections

Inspection Checksheet

Owner_____ Date _____

A/C Make/Model_____ S/N _____ Reg. No. _____ TSN _____

Engine S/N_____ TSN_____ TSO _____

This inspection checksheet is to be used when performing scheduled inspections. This form can be locally reproduced and/or expanded to reflect the aircraft operating environment. Keep the completed sheets as a permanent part of the aircraft engine records. Detailed information regarding each inspection item is contained in the referenced Operation and Maintenance Manual paragraphs.

CAUTION: BEFORE UNDERTAKING ANY INSPECTION OR MAINTENANCE ACTION, CONSULT THE REFERENCED PARAGRAPHS OF THE OPERATION AND MAINTENANCE MANUAL. FAILURE TO FOLLOW THE RECOMMENDED INSTRUCTIONS IN THE MANUAL COULD RESULT IN EQUIPMENT DAMAGE OR DESTRUCTION, POSSIBLY RESULTING IN PERSONNEL DEATH OR INJURY.

Item	Inspection/Maintenance Action	REF PARA	✓	Initial
	100 Hour Inspection			
1	Inspect the entire engine for loose or missing bolts, broken or loose connections, security of mounting accessory and broken or missing lockwire. Check accessible areas for obvious damage and evidence of fuel or oil leakage.	N/A		
2	Inspect all "B" nuts for application and alignment of torque paint. If missing, loosen "B" nut, retighten, and apply torque paint.	PARA 9.B., 72-00-00, Engine-Servicing		
3	Check mounting and support bolts to be sure they are tight, lockwired and in good condition. Check security of screws and rivets. Remove all foreign material which might be drawn into the compressor inlet.	N/A		
4	Check accessible fuel system components, lines, and connections for security, damage or leakage. Accomplish with the boost pump on, if available. Remove, visually inspect and clean if visual condition dictates.	PARA 2., 73-00-00		

Table 602 (cont)
Scheduled Inspections

Item	Inspection/Maintenance Action	REF PARA	✓	Initial
	100 Hour Inspection (cont)			
5	Inspect P_c filter for proper clamping.	73-20-06		
6	Until CEB-A-1233 is complied with, inspect P_c filter assembly as follows: Without disassembly or removal of the P_c filter assembly from the mounting bracket, inspect using a 10x magnification glass and a bright light to detect any signs of cracks, paying particular attention to both of the end fittings at their junction with the end walls. If cracks are detected, remove assembly and comply with CEB-A-1233.	N/A		
7	Remove the Scroll-to-P_c Filter Tube Assembly at both ends and inspect for cracks using 10x power glass. Pay particular attention to the flared ends of the tube for cracks, and to the areas beneath the floating ferrules for fretting damage. Tubes-found to contain cracks and/or excessive fretting damage are to be replaced by new parts of the same part number as removed.	N/A		
	NOTE: Excessive fretting is present when the ferrule has chafed the tube sufficiently to wear a step in the tube that can be felt with a thumbnail or other inspection aid.			
8	With the Scroll-to-P_c Tube Assembly still removed and using a 10x power glass, inspect the elbow in the compressor scroll for distress/cracks/proper alignment. No cracks are permissible.	N/A		
9	Check fuel control and power turbine governor linkage for freedom of operation, full travel and proper rigging. Check security of linkage for loose or worn linkage and linkage bolts.	PARA 3.C., 73-20-02, 3.B., 73-20-03, 3.C., 73-20-04 and PARA 2.C., 73-20-01		
10	Inspect compressor inlet guide vanes and visible blades and vanes for foreign object damage.	N/A		
11	Clean compressor with chemical wash solution as required if operating in a smoggy area, conditions with airborn pollutants or with water alcohol.	PARA 6., 72-30-00		
12	Visually inspect the water-alcohol nozzles for build-up of contaminants which could restrict flow or alter the spray pattern. Ultrasonic clean nozzles if equipment is available.	N/A		
13	Clean the 200 mesh screen (if equipped with water-alcohol injection kit).	N/A		

P_C FILTER - MAINTENANCE PRACTICES

1. General

   Remove, clean and install the P_c filter, which is bracket mounted to the gearbox. (See Figure 202 or 203, 73-00-00.)

2. Replacement

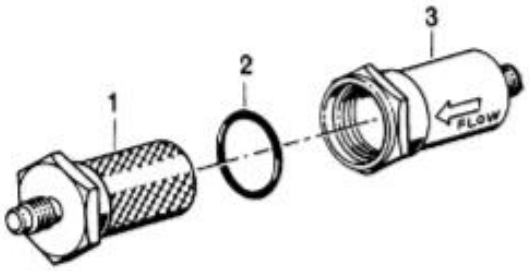
   A. Removal

      (1) Remove the scroll-to-P_c filter P_c tube by disconnecting the tube at both ends. Hold the filter assembly by placing the proper size wrench on the large hex flats of the housing or filter element while loosening the coupling nut.

      (2) Disconnect the P_c air tube from the aft end of the filter. Hold the filter assembly as outlined above while loosening the coupling nut.

      WARNING: FAILURE TO PROPERLY REMOVE OR INSTALL PC AIR LINES MAY DAMAGE LINES, FITTINGS, AND/OR FILTER ASSEMBLY WHICH CAN RESULT IN SUDDEN UNINTENDED ENGINE POWER LOSS.

      (3) Remove the nut and bolt securing the filter clamp to filter mounting bracket. Remove the filter and separate the clamp from the filter.



ADH043XD

1. Filter element
2. Packing
3. Filter housing

P_c Filter Assembly
Figure 201

B. Installation

(1) Assemble the clamp on the filter and secure it to the filter mounting bracket with a bolt and nut. Tighten the nut to 35-40 lb in. (3.9-4.5 N·m). Make sure that the arrow on the filter is pointed rearward.

WARNING: FAILURE TO PROPERLY INSTALL, ALIGN, AND TORQUE FUEL, OIL, AND AIR FITTINGS AND TUBES COULD RESULT IN AN ENGINE FAILURE.

(2) Install the Scroll-to P_c Filter Tube Assy to the compressor scroll. Torque coupling nut to 80-120 lb in. (9.0-13.6 N·m).

(3) Attach the Scroll-to-P_c Filter Tube Assy to the forward end of the P_c Filter. Attach the P_c Filter-to-Governor Tube Assy to the aft end of the filter. Hold the filter with the proper wrench at the hex flats of the filter assembly, while torquing the coupling nuts to 80-120 lb in. (9.0-13.6 N·m).

(4) Leak check the pneumatic system following installation of the P_c Filter. (Refer to para 2.B., 73-00-00.)

3. Cleaning and Inspection

A. Disassembly

(1) Remove the lockwire and separate the filter element and packing from the filter housing. (See Figure 201, this section.)

(2) When a vise is used, place the element hex (1) in the vise and use a wrench on the hex of the housing (3).

B. Cleaning the Element

Clean the filter element ultrasonically if equipment is available. If ultrasonic equipment is not available, use either of the following alternate cleaning methods.

(1) Solvent and brush method.

(a) Cap the outlet fitting of the element with a clean metal cap (AN 820-4 or equivalent).

(b) Wash the element with solvent and a soft bristle brush.

(c) Remove the cap and blow dry the element. Use clean, dry low-pressure air, 100-120 psig (689-827 kPag), in a reverse flow direction (through the outlet fitting).

(2) Sodium hydroxide soak method.

WARNING: SODIUM HYDROXIDE CAN CAUSE SEVERE BURNS. DO NOT GET IN EYES, ON SKIN OR ON CLOTHING. IN THE EVENT OF CONTACT WITH SODIUM HYDROXIDE, IMMEDIATELY FLOOD EXPOSED SKIN OR CLOTHING WITH WATER. FOR EYES, FLUSH HEAVILY WITH WATER AND OBTAIN IMMEDIATE MEDICAL ATTENTION.

WARNING: POTASSIUM PERMANGANATE CAN BE VERY DANGEROUS IF IMPROPERLY HANDLED. CONTACT WITH ORGANIC MATERIALS (OIL, GREASE) CAN CAUSE FIRE.

(a) Soak the filter element in a sodium hydroxide solution at 102-107°C (215-225°F) for a maximum of one hour.

NOTE: A typical solution is 13.5 oz (399 milliliters) sodium hydroxide and 4 oz (118 milliliters) potassium permanganate in one gallon (3.8 liter) deionized water.

(b) Thoroughly rinse the element in cold running water.

9. Rigid Tube Inspection and Installation

CAUTION: TORQUE PAINT (SLIPPAGE MARKS) MUST BE APPLIED TO ALL THE RIGID TUBE B-NUTS IN ACCORDANCE WITH THE RIGID TUBE INSTALLATION PROCEDURES. THE TORQUE PAINT MUST BE REMOVED AND REAPPLIED EACH TIME THE B-NUT IS LOOSENED AND TIGHTENED. DAMAGE TO THE ENGINE CAN OCCUR.

When a component to which rigid tube assemblies are attached is replaced, remove all interfering tube assemblies to permit easy removal and reinstallation of the component. This precaution will prevent subsequent damage to the tube assemblies. Tube-to-fitting alignment should be checked for proper fit, as described in Flared Tubes and Flanged Tubes, para 9.B. and 9.C., this section, anytime such a component is installed.

A. Inspection

Inspect fuel, control air, and oil tubes as follows:

(1) Inspect tubes for dents, chafing or cracks.

(2) Reject tubes with cracks (FPI) in all areas.

(3) Reject tubes having dents or chafing on the flared ends or on the retention clamps.

(4) Reject tubes with dents exceeding 0.125 in. (3 mm) depth or having a sharp radius.

B. Flared Tubes

WARNING: PROPER TIGHTENING OF ENGINE TUBING CONNECTIONS IS CRITICAL TO FLIGHT SAFETY. CORRECT TORQUE VALUES MUST BE USED AT ALL TIMES. EXCESSIVE TORQUE ON PNEUMATIC SENSING SYSTEM CONNECTIONS RESULTS IN CRACKING OF THE FLARE OR ADJACENT TUBE AREA IN CONTACT WITH THE FERRULE. THIS PRODUCES AN AIR LEAK WHICH CAN CAUSE FLAMEOUT, POWER LOSS, OR OVERSPEED.

CAUTION: FAILURE OF ENGINE PNEUMATIC OR FUEL TUBES DUE TO FAULTY MAINTENANCE PRACTICE COULD CAUSE FLAMEOUT, POWER LOSS, OR OVERSPEED.

Tube assemblies must fit and be aligned with the mating flare tube fittings to the degree that at both ends of the assembly the flares shall be uniformly seated in a free state on the cones of the mating fittings. The fit shall be without distortion or stretching of the tube assembly and to the degree that the nuts can be fully engaged up to the final one-half turn with light finger pressure.

CAUTION: THE PRACTICE OF TIGHTENING FITTING LOCK NUTS WITH TUBE ASSEMBLIES INSTALLED CAN RESULT IN DAMAGE TO THE TUBE WITH POSSIBLE FAILURE OF THE TUBE ASSEMBLY.

In the event a tube does not align with the mating fittings, reposition the mating fittings to the degree that proper alignment may be attained. Final tightening of these fittings must be accomplished before the tube assembly is connected.

CAUTION: EXTREME CAUTION MUST BE OBSERVED WHILE HAND BENDING PREVIOUSLY FORMED TUBES TO PREVENT EXCESSIVE FLATTENING OF TUBES AT THE BEND RADIUS.

If proper alignment cannot be attained by repositioning mating flare tube fittings, bend the tube sufficiently to provide alignment in the free state as specified. Accomplish all bending with the tube removed from the engine. Adjustment of the fit may be accomplished by bending by hand at principal bends. In the event the tube cannot be bent by hand, the tube must be clamped in a fixture or device which will not scratch, indent, crimp, or mark the surface of the tube during the bending operation. The flattened effect of the cross section of the tube as a result of the reforming operation must not exceed 15 percent of the tube OD.

CAUTION: MAKE SURE NO LOOSE PARTICLES OF TORQUE PAINT ARE ALLOWED TO ENTER THE CONTROL SYSTEM TUBES OR FITTINGS.

WARNING: TUBING B-NUTS USED IN INSTALLATIONS EXPOSED TO A HIGH DEGREE OF VIBRATION AND PRESSURE SURGES ARE SUBJECT TO TORQUE RELAXATION WHEN IMPROPERLY TIGHTENED.

WARNING: USE ACCEPTABLE TECHNIQUES AND PRACTICES TO PREVENT TORQUE PAINT OR TORQUE PAINT REMOVER FROM CONTACTING RUBBER OR PLASTIC MATERIALS OR ENTERING EXPOSED AREAS.

When proper free state alignment is attained, complete tubing installation by simultaneously securing the coupling nuts. After all B-nuts are properly tightened to the correct torque values, apply a slippage mark (torque paint) of contrasting color approximately 0.063 inch (1.60 mm) wide minimum. The mark shall extend down the side of the B-nut and onto the mating fitting. Install necessary clamping. (Refer to M250-C20 Series Parts Catalog, Pub. No. 10W4, for clamping requirements.)

B-nuts shall be inspected for indications of slippage at 100 hour maintenance intervals.

Old slippage marks (torque paint) shall be completely removed, using torque paint remover, and reapplied each time the B-nut is tightened.

C. Flanged Tubes

WARNING: PROPER TIGHTENING OF ENGINE TUBING CONNECTIONS IS CRITICAL TO FLIGHT SAFETY. CORRECT TORQUE VALUES MUST BE USED AT ALL TIME. EXCESSIVE TORQUE ON PNEUMATIC SENSING SYSTEM CONNECTIONS RESULTS IN CRACKING OF THE FLARE OR ADJACENT TUBE AREA IN CONTACT WITH THE FERRULE. THIS PRODUCES AN AIR LEAK WHICH CAN CAUSE FLAMEOUT, POWER LOSS, OR OVERSPEED.

The alignment of tube fittings with mating sealing surfaces and the securing of tube clips must conform to the following:

(1) Nut and Nipple Joints. With one end hand tightened, it must be possible to locate the nipple at the free end in its conical seating, by flexing the tube by hand, without effecting a permanent set to the assembly. The alignment of the joint must be such that the nut readily engages with its mating thread.

(2) Setscrew Retained Flanged Adapters. The clearance and parallelism between flange and mating surface, with the opposite end secured, must be such that the total flange area contact can be achieved by flexing the tube by hand, without effecting a permanent set to the assembly. Flange clearance holes must line up with tapped holes, so that bolts can be fitted without subjecting the tube to a torsional load.

(3) Clipping Points. Locate clips to securing points such that the setscrews can be fitted by flexing the tube by hand, without effecting a permanent set to the assembly. Tubes which fail to meet this requirement may be removed from the engine and reformed as follows:

(a) Tubes must be clamped in a fixture which will not scratch, indent, crimp or mark the surface of the tube during the bending operation.

(b) Retention of the tube during bending should be made in a manner which does not permit bending or torsional loads across welded or brazed areas.

(c) Tubes which can be corrected for fit only by submitting welded areas to bending or torsional loads, must be reinspected by X-ray or Fluorescent Penetrant Inspection (FPI) for evidence of weld or braze fracture prior to reinstallation on the engine.

(d) Reformed tubes must meet the requirements of steps (1) and (2).

ALERT

COMMERCIAL ENGINE BULLETIN

Allison Engine Company

ENGINE - FUEL AND AIR SYSTEM -
Pc SCROLL TO Pc FILTER TUBE ASSY - INSPECTION

1. PLANNING INFORMATION:

A. Effectivity:

All Pc Scroll to Pc Filter Tube Assy's, Pc Scroll Fittings, and Pc Filter Fittings installed in 250 Series Engines. Inspect and comply as defined herein.

B. Reason:

A recent incident involving the failure of a Pc tube resulted in an unscheduled aircraft landing. The Pc tube between the compressor scroll and the Pc filter failed at the flared end. The tube was found to have cracked 360° around the flared filter attachment end. Since this Pc tube is removed to perform compressor washing (but not compressor rinsing), it is susceptible to a higher failure rate than other similar tubes due to handling. As a result, inspection of these tubes is to be accomplished as defined in the "Accomplishment Instructions" herein.

C. Description:

The Pc Tube between the Compressor Scroll and the Pc Filter, the Pc Filter flared fittings, and the Pc Scroll fitting are inspected for cracks using a 10x magnifying glass.

D. Compliance:

1. Inspection using 10x magnifying glass is to be accomplished within the next 100 hours of operation after receipt of this bulletin, but no later than July 31, 1986.

2. Inspect when the tube is removed for compressor washing, also when the PC filter is cleaned.

NOTE: The tube should not be removed when performing the daily water rinse.

June 23, 1986
Revision No. 3
April 15, 1992

250-C18 Series (T63-A-700)
250-C20 Series (T63-A-720)
250-C28 Series
250-C30 Series
250-B15 Series
250-B17 Series

CEB A-247
CEB A-1234
CEB A-73-2030
CEB A-73-3032
TP CEB A-118
TP CEB A-1194

1. PLANNING INFORMATION: (Continued)

E. Approval: Technical Aspects are FAA Approved.

F. Material Availability:

When defective parts are found by inspection, they are to be scrapped locally and replaced by new parts as applicable in the appropriate Illustrated Parts Catalog.

G. Tooling: None.

H. Weight and Balance: None.

I. Electrical Load Data: Not affected.

J. Other Publications Affected:

(1) 5W2 Operation and Maintenance Manual 250-C18

(2) 5W4 Illustrated Parts Catalog 250-C18

(3) 10W2 Operation and Maintenance Manual 250-C20

(4) 10W25 Operation and Maintenance Manual 250-C20S

(5) 10W4 Illustrated Parts Catalog 250-C20

(6) 6W2 Operation and Maintenance Manual 250-B15

(7) 6W4 Illustrated Parts Catalog 250-B15

(8) 11W2 Operation and Maintenance Manual 250-B17

(9) 11W4 Illustrated Parts Catalog 250-B17

(10) 16W2 Operation and Maintenance Manual 250-C28

(11) 16W4 Illustrated Parts Catalog 250-C28

(12) 14W2 Operation and Maintenance Manual 250-C30

(13) 14W2PM Operation and Maintenance Manual 250-C30P, 250-C30M

(14) 14W4 Illustrated Parts Catalog 250-C30

K. Prerequisites: None.

2. ACCOMPLISHMENT INSTRUCTIONS:

NOTE: Manuals listed in Section 1.J. herein provide applicable disassembly, cleaning, inspection, repair, reassembly, and testing instructions, and are to be used when required during the accomplishment of this bulletin.

A. Pc Scroll to Pc Filter Tube Assy's are to be inspected in accordance with the instructions herein:

(1) Remove the Pc Scroll to Pc Filter Tube and inspect for cracks using a 10x magnifying glass. Pay particular attention to the flared ends of the tube for cracks, and to the areas beneath the floating ferrules for excessive fretting damage. Tubes found to contain cracks and/or fretting damage are to be replaced by new parts of the same part number as removed.

NOTE: Excessive fretting is present when the ferrule has chafed the tube sufficiently to wear a step in the tube that can be felt with a thumbnail or other inspection aid.

B. The Pc Fitting (I.E. elbow) on the Scroll and Flare Fittings on the Pc Filter are to be inspected as follows:

(1) Using a 10x magnifying glass, inspect the condition of the Pc filter end fittings for distress/cracks, and the elbow in the scroll for distress/cracks/proper alignment. No cracks are permissable in either the Pc Filter or the compressor scroll elbow.

NOTE: All maintenance personnel should be aware of and comply with the recommendations provided in the Operations and Maintenance Manual concerning the removal, installation, and torque procedures for rigid tubing prior to performing any maintenance action on the Pc system. Proper torque of the Pc tube coupling nuts is 80-120 lb. in. Tightening above this range is to be avoided as tube damage may occur.

WARNING: PROPER TIGHTENING OF ENGINE TUBING CONNECTION IS CRITICAL TO FLIGHT SAFETY. CORRECT TORQUE VALUES MUST BE USED AT ALL TIMES. EXCESSIVE TORQUE ON PNEUMATIC SENSING SYSTEM CONNECTIONS RESULTS IN CRACKING OF THE FLARE OR ADJACENT TUBE AREA IN CONTACT WITH THE FERRULE. THIS PRODUCES AN AIR LEAK WHICH CAN CAUSE FLAMEOUT, POWER LOSS, OR OVERSPEED.

2. ACCOMPLISHMENT INSTRUCTIONS: (Continued)

C. Record compliance in the Engine Log Book, Compressor Assembly (blue pages), Inspection-Maintenance-Overhaul Record Part IV, as applicable with the following bulletins:

250-C18 Series	(T63-A-700)		CEB A-247
250-C20 Series	(T63-A-720)		CEB A-1234
250-C28 Series			CEB A-73-2030
250-C30 Series			CEB A-73-3032
250-B15 Series		TP	CEB A-118
250-B17 Series		TP	CEB A-1194

3. MATERIAL INFORMATION:

A. Instructions/Disposition Notes:

(1) Inspect removed parts as outlined in the Accomplishment Instructions herein. Parts found to be free of cracks/defects and otherwise serviceable may be reinstalled. Parts found to contain cracks/defects are to be scrapped locally and replaced by new parts as applicable in the appropriate parts catalog.

CUSTOMER SUPPORT

Allison Engine Company

ANNEXURE E

Airworthiness Directive

AD No.: **2004-0009R3**

Issued: **23 March 2016**

Note: This Airworthiness Directive (AD) is issued by EASA, acting in accordance with Regulation (EC) 216/2008 on behalf of the European Union, its Member States and of the European third countries that participate in the activities of EASA under Article 66 of that Regulation.

This AD is issued in accordance with Regulation (EU) 748/2012, Part 21.A.3B. In accordance with Regulation (EU) 1321/2014 Annex I, Part M.A.301, the continuing airworthiness of an aircraft shall be ensured by accomplishing any applicable ADs. Consequently, no person may operate an aircraft to which an AD applies, except in accordance with the requirements of that AD, unless otherwise specified by the Agency [Regulation (EU) 1321/2014 Annex I, Part M.A.303] or agreed with the Authority of the State of Registry [Regulation (EC) 216/2008, Article 14(4) exemption].

Design Approval Holder's Name:	Type/Model designation(s):
ROLLS-ROYCE CORPORATION	250-C18, -C20, -C28 and -C30 engines

Effective Date:	Revision 3: 30 March 2016 Original issue, Revision 1 and Revision 2: 15 December 2004
TCDS Number(s):	EASA.IM.E.052 and EASA.IM.E.109
Foreign AD:	None
Revision:	This AD revises EASA AD 2004-0009R2 dated 25 November 2005. The original issue of this AD superseded United Kingdom (UK) Civil Aviation Authority (CAA) AD 010-12-92 Revision 2, effective date 03 March 1995.

ATA 73 – Engine Fuel & Control – Engine Fuel System Pipes – Inspection

Manufacturer(s):
Rolls-Royce Corporation (RRC), formerly Allison Engine Company, Allison Gas Turbine Division, Detroit Diesel Allison

Applicability:
Models 250-C18, 250-C18A, 250-C20, 250-C20B, 250-C20F, 250-C20J, 250-C20R, 250-C20R/1, 250-C20R/2, 250-C20R/4, 250-C20S, 250-C20W, 250-C28B, 250-C28C, 250-C30, 250-C30G, 250-C30G/2, 250-C30M, 250-C30P and 250-C30S turboshaft engines, all serial numbers.

These engines are installed in single- and twin-engined helicopters.

Reason:
Accidents and incidents were reported concerning RRC 250 series turboshaft engines, which were attributed to improper alignment, clamping, and torquing of engine tubing during installation. Instances of twisted lines, kinked lines and split flares resulted from installation practices contrary to those specified in the Operation and Maintenance Manual.

This condition, if not detected and corrected, could lead to engine in-flight shut-down (IFSD), possibly resulting in a forced landing and consequent damage to the helicopter and injury to occupants.

To address this potential unsafe condition, RRC issued Alert Commercial Service Letter (CSL) A-169, A-1166, A-2113, A-3117 and A-4036 (single document, hereafter referred to as 'the CSL' in this AD) to provide information on how to prevent incorrect installation of fuel control system pipes. The CSL also describes the various failure modes of the tube assemblies, which can be traced to one or any combination of the causes listed in the CSL.

Prompted by these findings and actions, in 1991, CAA UK issued 'additional' AD 010-12-92 (later revised twice) to require repetitive inspections of the 'B' nuts of all fuel control system pipes connecting the Gas Producer Fuel Control, the Power Turbine Governor, or the Compressor for indication of slippage and, depending on findings, accomplishment of applicable corrective action(s), as described in the CSL for engines installed on UK-registered helicopters.

In December 2004, upon request of the CAA UK, EASA issued AD 2004-0009 (later corrected, and revised twice), retaining the requirements of CAA UK AD 010-12-92 Rev.2, which was superseded, making these actions valid for all engines installed on helicopters registered in EASA Member States.

Since AD 2004-0009R2 was issued, it became apparent that, despite the fact that the AD explicitly applied to "engines installed in single- and twin-engined helicopters", the AD also included a reference to USA TCDS E10CE (250-B15 and -B17 turboprop engines) which has caused confusion. The same CSL (TP CSL A-101, A-1121 and A-2019) also applies to those turboprop engines, but this AD does not. In addition, feedback from operators indicated that the not-to-exceed 100 flight hours (FH) inspection interval was deemed too 'inflexible' for maintenance planning purposes.

For the reasons described above, this AD is revised to delete the reference to USA TCDS E10CE, to explicitly list the affected turboshaft engine models (at this time, the Models 250-C18B, 250-C18C, 250-C20C, 250-C28, 250-C30R, 250-C30R/1, 250-C30R/3, 250-C30R/3M and 250-C30U are not validated in Europe), to extend the inspection interval, and to introduce some editorial changes to meet current AD writing standards, without changing the requirements.

Required Action(s) and Compliance Time(s):
Required as indicated, unless accomplished previously:

(1) Within 100 FH after 15 December 2004 [the effective date of the original issue of this AD], and, thereafter, at intervals not to exceed 110 FH, inspect the 'B' nuts of all fuel control system pipes connecting the Gas Producer Fuel Control, the Power Turbine Governor, or the Compressor (Pc, Py, Pr, Pg, Po, P1 and P2 pipelines) for indication of slippage.

(2) During each engine maintenance after 15 December 2004 [the effective date of the original issue of this AD] which involves disturbing any fuel control system pipes connecting the Gas Producer Fuel Control, the Power Turbine Governor, or the Compressor (Pc, Py, Pr, Pg, Po, P1, and P2 pipelines), comply with paragraphs (2.A) and (2.B) of this AD.

(2.A) Accomplish the instructions of the CSL original issue, Section Recommendations, all paragraphs, except 1 and 10, or the CSL at Revision 1, Section 2 Recommendations, all paragraphs, except A and J.

(2.B) Record the torque value of each 'B' nut in the applicable engine maintenance record(s).

(3) If, during any inspection as required by paragraph (1) of this AD, discrepancies are detected, before next flight, accomplish the applicable corrective action(s) in accordance with the instructions of the engine's applicable Operation and Maintenance Manual.

(4) If, during any maintenance action as required by paragraph (2.A) of this AD, discrepancies are detected, before release to service of the engine, accomplish the applicable corrective action(s) in accordance with the instructions of the engine's applicable Operation and Maintenance Manual.

(5) Accomplishment of corrective actions on an engine, as required by paragraph (3) or (4) of this AD, as applicable, does not constitute terminating action for the repetitive actions required by paragraphs (1) and (2) of this AD for that engine.

Ref. Publications:

Rolls-Royce Corporation Alert CSL A-169, A-1166, A-2113, A-3117 and A-4036 (single document), original issue dated 15 November 1990, or Revision 1 dated 5 February 2007.

Remarks:

1. If requested and appropriately substantiated, EASA can approve Alternative Methods of Compliance for this AD.

2. Based on the required actions and the compliance time, EASA have decided to issue a Final AD with Request for Comments, postponing the public consultation process until after publication.

3. Enquiries regarding this AD should be referred to the EASA Safety Information Section, Certification Directorate. E-mail: ADs@easa.europa.eu.

4. For any question concerning the technical content of the requirements in this AD, please contact Rolls-Royce Corporation, 450 South Meridian Street, Indianapolis, Indiana 46225-1103, United States of America, Telephone: 888-255-4766 or +1 317-230-2720, E-mail: helicoptercustsupp@rolls-royce.com, Internet: www.rolls-royce.com.

ANNEXURE F

COMPILED BY:	LABORATORY FOR MICROSCOPY & MICROANALYSIS	PAGE 1 OF 12
	FAILURE ANALYSIS REPORT: Scroll-to Pc Filter Tube Assembly, Bell 206B Jet Ranger III, ZS-HWZ	DOCUMENT NUMBER FA-010-02-21
COMPILED FOR: AIID (SACAA)		DATE 2021-02-22 / ISSUE 1

ITEM: **Scroll-to Pc Filter Tube Assembly, Bell 206B Jet Ranger III, ZS-HWZ**

1. BACKGROUND INFORMATION

1.1. The fractured Scroll-to Pc Filter Tube Assembly (Photo 2), part number 63005-23051141-B, originating from a Bell 206B Jet Ranger III, aircraft number ZS-HWZ (Photo 1), was submitted to determine the most probable failure mode/s and possible causational factor/s thereto.

Photo 1: Bell 206B Jet ranger III, ZS-HWZ[1]

Photo 2: Supplied component (Digital)

1.2. This report is divided into the following sections:

[1] Courtesy Flickr

2. APPLICABLE DOCUMENTS

(a) Rolls-Royce M250-C20 Series Operation and Maintenance Schedules Inspections Table 602.
(b) Allison Rolls-Royce CEB-A-1294.

3. DEFINITIONS

(a)	OEM	Original Equipment Manufacturer
(b)	SEM	Scanning Electron-microscope
(c)	NDT	Non-Destructive Testing
(d)	IPC	Illustrated Parts Catalogue
(e)	EDS	Energy Dispersive X-ray Spectroscopy

4. PERSONNEL

(a) The investigative member and compiler of this report is Mr C.J.C. Snyman, ID number 6406105057080. Mr Snyman is a qualified Physical Metallurgist (H.N.Dip. Metallurgical Engineering, Tech. PTA, ECSA Registration: Prof. Eng. Tech. No 201670194), Radiation Protection Officer (RPO, NNR, No 281) and Aircraft Accident Investigator (SCSI).

5. APPARATUS AND METHODOLOGY

(a) The methodology included visual inspection, sectioning and preparing samples for Light-, Stereo-, EDS and Electron-microscopy.

6. INVESTIGATION RESULTS

6.1. Inspection Results

6.1.1. On-Site Inspection

The on-site visual inspection of the Scroll-to P_C Filter Tube assembly (Photo 3) revealed a fracture that initiated underneath the floating ferrule, P_C Filter end (Photo 4, red arrow).

The inspection showed the *short end* of the tube was fitted to the P_C Filter as found (Photo 4, red circle). This is in contradiction to reference units (Photo's 7 and 8, red circles) as well as the "Filter" inscription on the fractured Tube (Photo 6, red dashed square). *The latter inscription was found partially obscured by the applied torque securing compound.*

6.1.2. Laboratory Inspection

Following teardown and sectioning of the as-found flanged Tube end fitted unto the P_C Filter revealed extensive corrosion damages with a clear disparity in severity when compared to the opposite flanged Tube end (Photo 5, yellow dashed square). When fitted correctly the short Tube end will by facing vertically down (Photo 7) allowing for moisture to accumulate in the cavity between the floating ferrule and the Tube line itself inducing crevice corrosion over a period of exposure time. Considering that the relevant area is also prone to fretting damages (Extract 2) that will induce the breakdown of the Tube base metal protective layer (Stainless

Steel – EDS Result 1), the added presence of a corrosive environment will enhance the formation of corrosion pitting.

6.1.3. Microscopy

The stereo-microscope inspection revealed clear indications of corrosion induced pitting (Stereo 1, yellow arrows) at the Tube/Floating Ferrule interface. Indications of fatigue mode fracture progression were noted (red dashed squares). These dark colored sections depict selected areas where the tube wall was breached during operation. The general fracture surface geometry and selected features compare favorably with historic failures of the thin-walled Scroll-to Pc Filter Tube, part no 6890581 (Extract 1).

The SEM inspection confirmed the presence of corrosion pitting with a typical V-shape geometry extending from the floating ferrule/tube line interface towards the inner surface (Fractographs 1, 2 and 3; red dashed circles).

From these corrosions pits multiple fatigue fractures initiated while progressing within various planes (Fractograph 4). Corrosion- and foreign deposits on the fracture surface suggest progression over an undetermined period of operational time until final fracture (Fractograph 5).

Inspection of the Tube outer surface at the location of the Tube/Floating Ferrule interface confirms the presence of corrosion products (EDS Result 2) with high Oxygen percentages as well as extensive pitting (Fractograph 7) when compared to the as manufactured outer Tube surface (Fractograph 6).

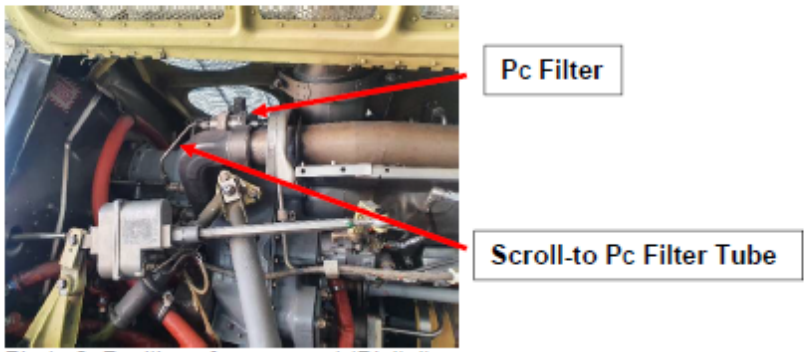


Photo 3: Position of component (Digital)

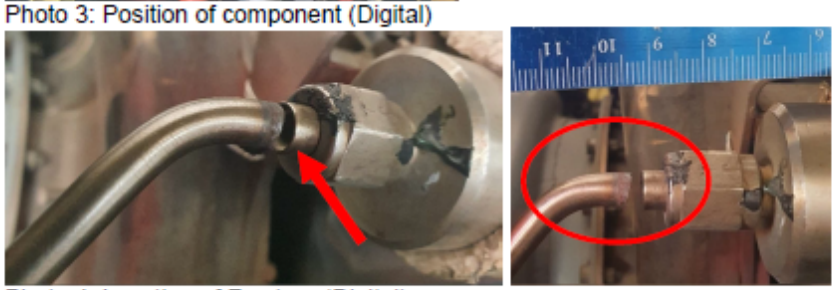


Photo 4: Location of Fracture (Digital)

Photo 5: Tube opposing ends showing corrosion damages (Digital)

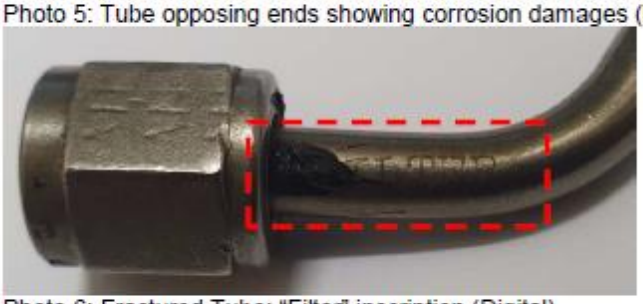


Photo 6: Fractured Tube: "Filter" inscription (Digital)

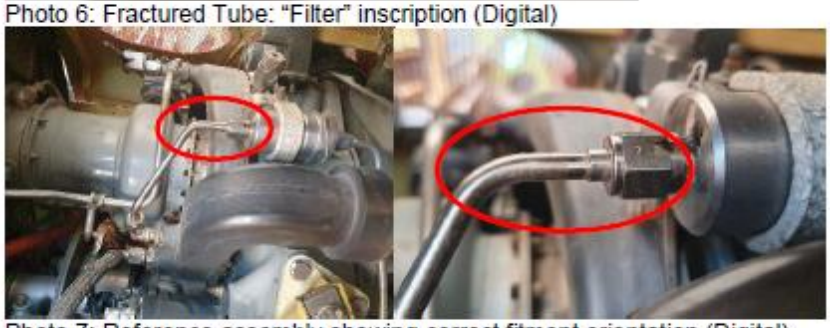


Photo 7: Reference assembly showing correct fitment orientation (Digital)

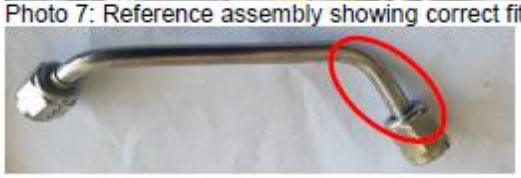
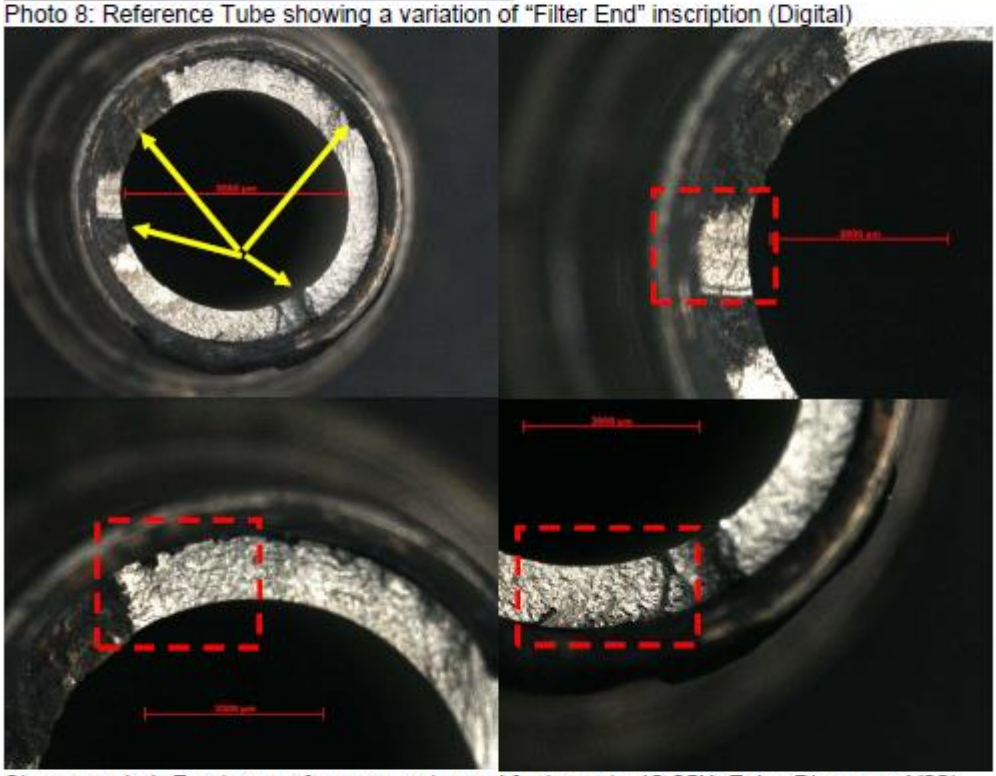


Photo 8: Reference Tube showing a variation of "Filter End" inscription (Digital)



Stereograph 1: Fracture surface geometry and features (+-10-25X, Zeiss Discovery V20)

Extract 1: Historic Scroll-to P_C Filter Tube fracture surface geometry and features[2]

[2] Courtesy RR Corporation

EXPORT CONTROLLED

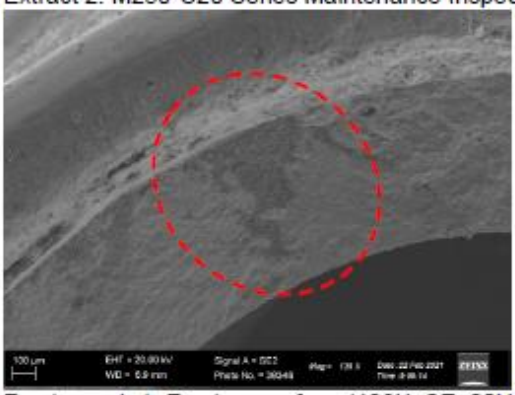
Rolls-Royce

M250-C20 SERIES OPERATION AND MAINTENANCE

Table 602 (cont)
Scheduled Inspections

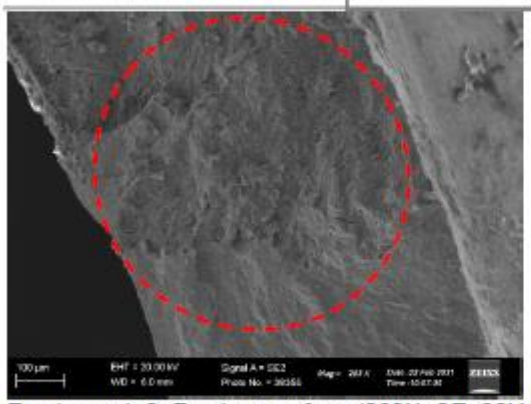
Item	Inspection/Maintenance Action	REF PARA	✓	Initial
	100 Hour Inspection (cont)			
5	Inspect P_c filter for proper clamping.	73-20-06		
6	Until CEB-A-1233 is complied with, inspect P_c filter assembly as follows: Without disassembly or removal of the P_c filter assembly from the mounting bracket, inspect using a 10x magnification glass and a bright light to detect any signs of cracks, paying particular attention to both of the end fittings at their junction with the end walls. If cracks are detected, remove assembly and comply with CEB-A-1233.	N/A		
7	Remove the Scroll-to-P_c Filter Tube Assembly at both ends and inspect for cracks using 10x power glass. Pay particular attention to the flared ends of the tube for cracks, and to the areas beneath the floating ferrules for fretting damage. Tubes found to contain cracks and/or excessive fretting damage are to be replaced by new parts of the same part number as removed.	N/A		
	NOTE: Excessive fretting is present when the ferrule has chafed the tube sufficiently to wear a step in the tube that can be felt with a thumbnail or other inspection aid.			

Extract 2: M250-C20 Series Maintenance Inspection Checklist[3]

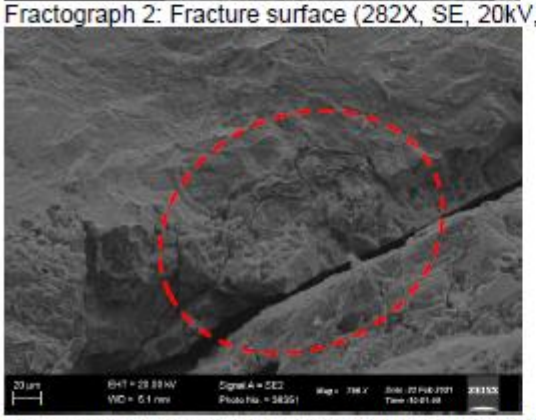


Fractograph 1: Fracture surface (138X, SE, 20kV, FEGSEM)

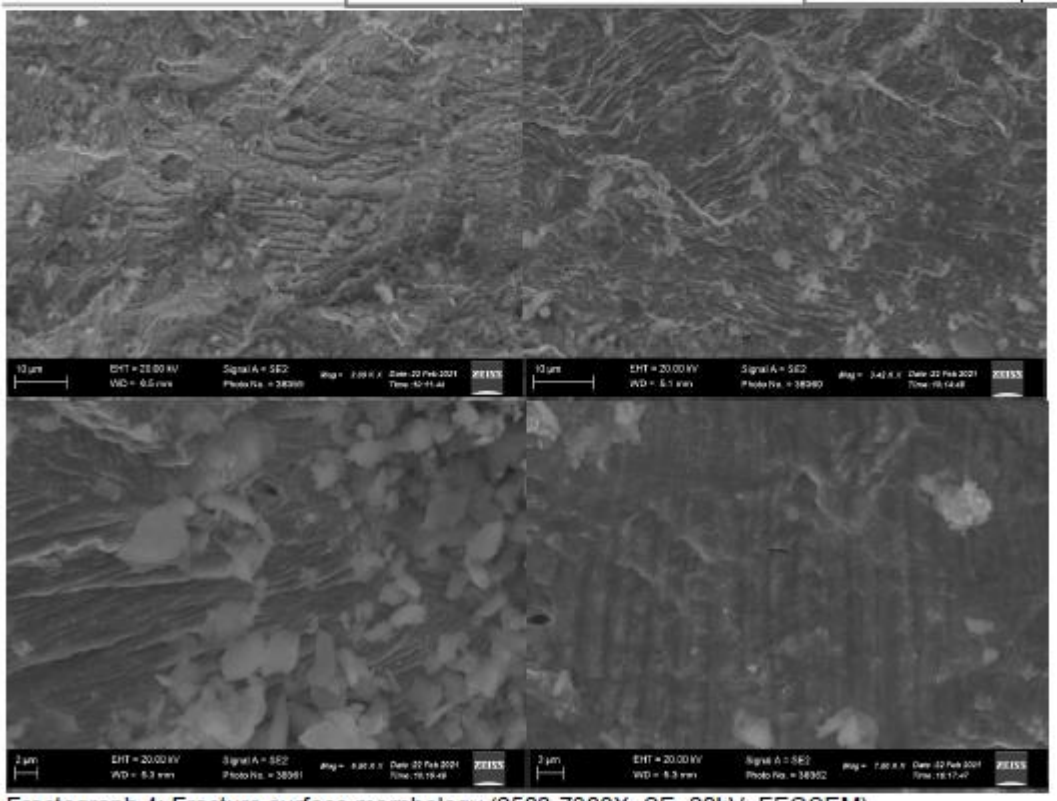
[3] Courtesy RR



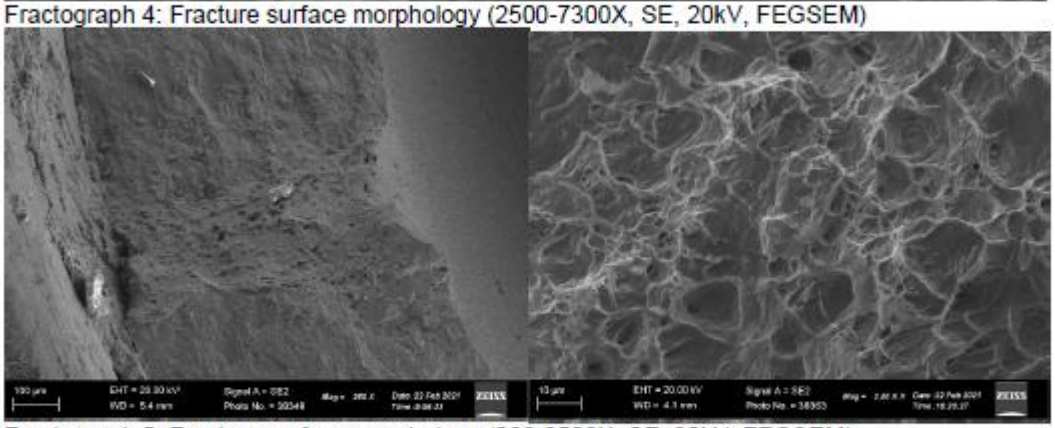
Fractograph 2: Fracture surface (282X, SE, 20kV, FEGSEM)



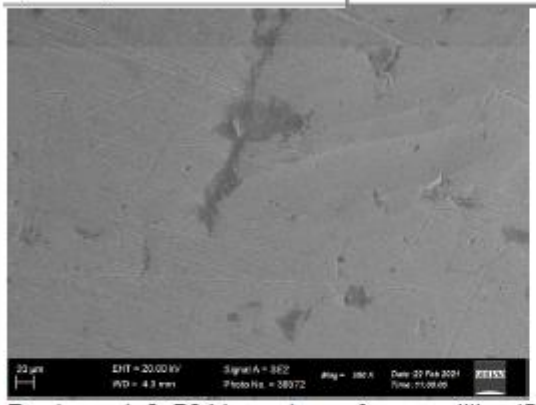
Fractograph 3: Fracture surface (799X, SE, 20kV, FEGSEM)



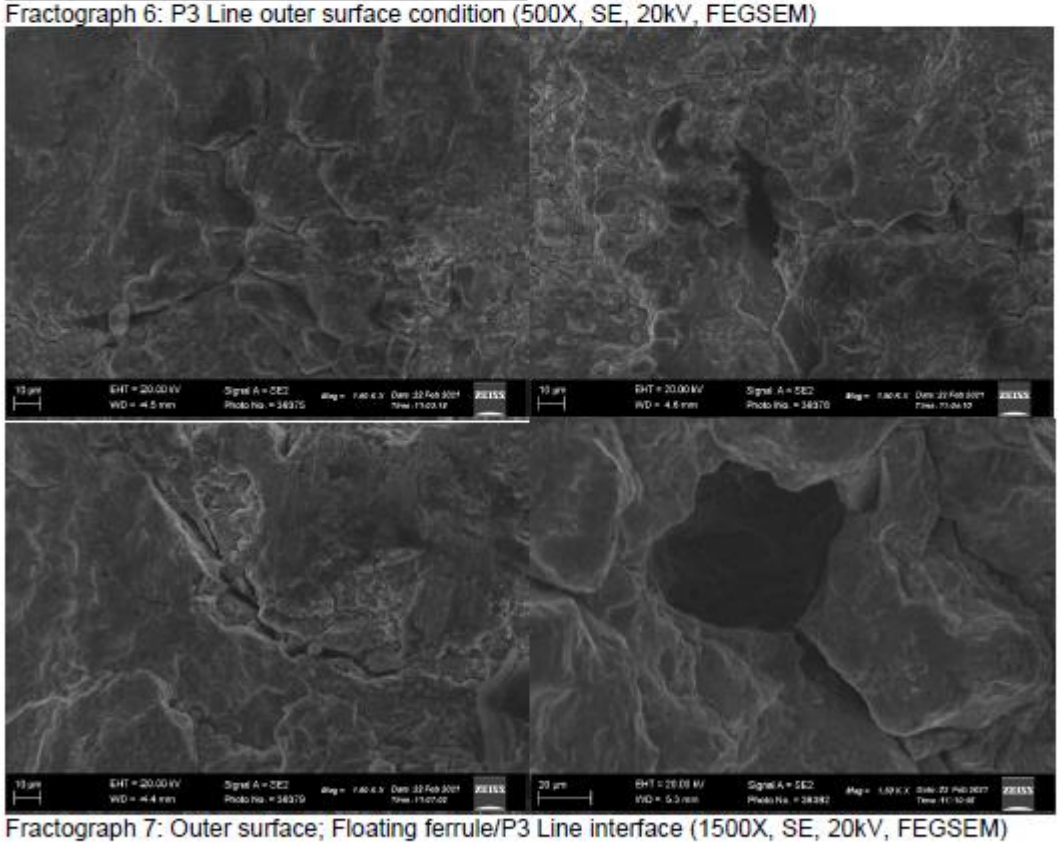
Fractograph 4: Fracture surface morphology (2500-7300X, SE, 20kV, FEGSEM)



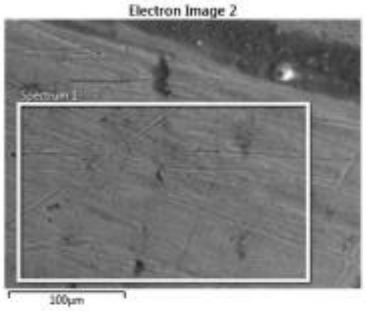
Fractograph 5: Fracture surface morphology (260-2500X, SE, 20kV, FEGSEM)

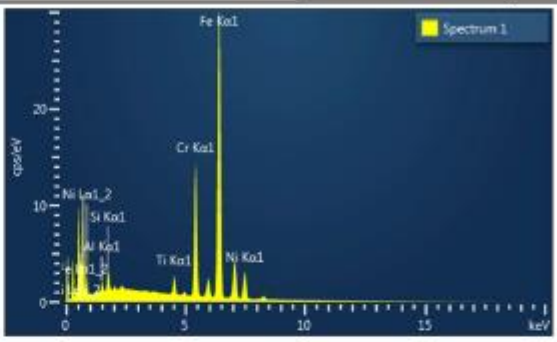


Fractograph 6: P3 Line outer surface condition (500X, SE, 20kV, FEGSEM)



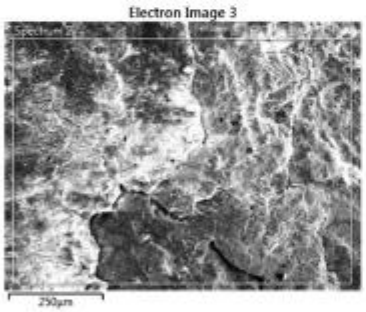
Fractograph 7: Outer surface; Floating ferrule/P3 Line interface (1500X, SE, 20kV, FEGSEM)

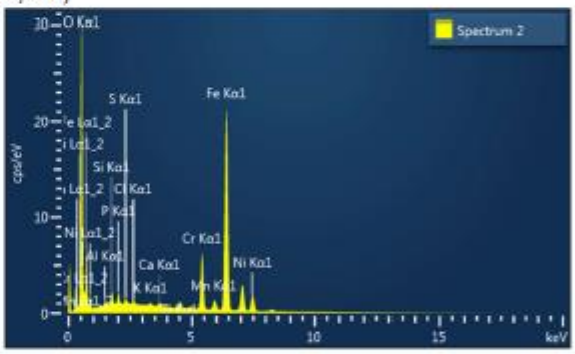




Element	Wt%	Wt% Sigma
Al	0.84	0.04
Si	1.45	0.04
Ti	1.99	0.04
Cr	19.06	0.08
Fe	66.89	0.12
Ni	9.77	0.10
Total:	100.00	

EDS result 1: Tube Base Material (Oxford, 15kV, SE)





Element	Wt%	Wt% Sigma
O	27.74	0.14
Al	0.57	0.04
Si	1.00	0.03
P	0.91	0.03
S	0.37	0.03
Cl	0.33	0.03
K	0.24	0.03
Ca	0.37	0.03
Ti	0.81	0.04
Cr	8.95	0.07
Mn	0.81	0.06
Fe	51.79	0.15
Ni	6.12	0.10
Total:	100.00	

EDS result 2: Corrosion - Base Material (Oxford, 15kV, SE)

7. DISCUSSION AND CONCLUSIONS

Note 1: *The conclusions are based on the investigation results obtained from the supplied parts/components and information only. All information supplied to this investigation from other parties are considered factual.*

7.1. The investigation results showed that the Scroll-to P_C Filter Tube was **fitted erroneously** allowing for an applied tensile stress to be induced during operation.

7.2. **Corrosion damages** were noted at the Tube/Floating Ferrule interfaces on both flanged ends. However, considering the proneness towards corrosion- and fretting damages during operation, the disparity in severity between the opposite flanged ends suggest that the Scroll-to P_C Filter Tube was fitted correctly for a period of operational time prior to final failure.

7.3. The primary failure mode proved to be **fatigue**. Fatigue fracture initiation requires surface stress raisers, in this case brought about by corrosion pitting, and an applied and fluctuating tensile stress again brought about by the incorrect fitment of the Scroll-to P_C Filter Tube Assembly.

8. RECOMMENDATIONS

8.1. The **correct fitment** of the Scroll-to P_C Filter Tube Assembly as per OEM specifications should be adhered to (also refer to Allison Rolls-Royce CEB-A-1294).

8.2. Inspection in order to determine the **presence of corrosion** at the of the Scroll-to P_C Filter Tube/Floating Ferrule interface, in particular the vertically fitted end, should be included in the maintenance schedule/checklists.

9. DECLARATION

9.1. All digital images have been acquired by the author, unless otherwise stated, and displayed in an un-tampered manner.