



Service Investigation
Accident / Incident Report
P&WC 8114 (2020-10)

Report No.: 23-125

**Bob Ruhe AG Service LLC
Air Tractor AT-502B, N5048S
Leipsic, Ohio, USA
04 August 2023
PT6A-34AG, S/N: 56520**

Written By: [Redacted]
Service Investigation Department

Approved By: [Redacted]
Manager, Service Investigation Department

Date of Issue: 10 May 2024

Distribution: [Redacted]

NTSB Identification: ERA23LA237
TSB Identification: A23F0253
P&WC File No.: 23-125
RFA No.: 23SIE00219

[Redacted]

EXPORT CONTROL CLASSIFICATION		LOCATION	U.S. REGULATION		
			EAR	ITAR	
		U.S.	P-ECCN	9E991	P-USML NSR
		OUTSIDE U.S.	ECCN	NSR	USML NSR
			LOCAL REGULATION		
		CANADA	EIPA (ECL)	DPA (CG)	
Date of marking	2024-02-20		NSR	No	



Service Investigation

Accident / Incident Report

P&WC 8114 (2020-10)

Report No.: 23-125

Page: 2 of 26

Table of Contents

	Page No.
I ANALYSIS	
1.0 ACCIDENT SYNOPSIS	3
2.0 SUMMARY OF FINDINGS AND DISCUSSION	3
3.0 CONCLUSION	4
II FACTUAL INFORMATION	
1.0 INVESTIGATION PARTICIPANTS	5
2.0 ENGINE HISTORY	5
3.0 ENGINE EXAMINATION	5



Service Investigation

Accident / Incident Report

P&WC 8114 (2020-10)

Report No.: 23-125

Page: 3 of 26

I ANALYSIS

1.0 ACCIDENT SYNOPSIS

- 1.1 On August 4th, 2023, in Leipsic Ohio, during an aerial application flight of an Air Tractor AT-502B registration N5048S, an engine fire occurred followed by a loss of power. The pilot performed a forced landing, which resulted in substantial damage to the left wing and landing gear. The pilot was not injured.

2.0 SUMMARY OF FINDINGS AND DISCUSSION

- 2.1 The engine was received partially disassembled from a previous investigation performed at Bob Ruhe AG Service hanger by the FAA, (delegated by the NTSB), the Aircraft Owner\Operator, and a representative from Main Turbines.
- 2.2 The power turbine (PT) vane, shaft, disc, blades, shroud and containment assembly all exhibited rotational contact damage. Optical examination of the fractured PT blades and No. 3 bearing outer race fractured surfaces using a stereoscope, showed a fracture morphology indicative of overload.
- 2.3 The PT high energy event and unbalanced spool caused the No. 3 bearing to break apart. Similarly, the No. 3 bearing, PT shaft housing and cover exhibited rotational damage. One roller from the No. 3 bearing only showed deep linear scoring matching the wear observed on the PT shaft and the indentation in the 1st stage carrier sleeve. Most of the No. 3 rollers exhibited signs of axial loading.
- 2.4 The RGB 2nd stage ring gear was observed to be installed incorrectly. It was installed in front of the retaining plates instead of fixed within the dedicated slot on the ring gear. The incorrect assembly permitted the 2nd stage ring gear to migrate forward into the RGB front housing inducing a twofold effect.
- 2.4.1 The first effect was a reduction in the 2nd stage ring gear axial meshing spline engagement, to the point where the remaining contact surface could no longer sustain the ring gear load. Consequently, the small overlapping region sheared off circumferentially allowing the ring gear to spin freely. The effect of the 2nd stage ring gear free spinning resulted in the decoupling of the PT disc from the propeller shaft and potentially to an ungoverned speed increase of the PT rotor.
- 2.4.2 The second effect was an increase in radial and axial movement of the 2nd stage carrier assembly due to the reduced support by the 2nd stage ring gear. The oscillating movement of the unsupported assembly was transmitted to the 1st stage carrier sun gear, where damage was observed on the mating teeth. Additionally, the movement through the 1st stage sun gear into the PT input shaft resulted in both an excessive axial load as observed on the roller endfaces and a nonconcentric radial load on the No. 3 bearing outer ring resulting in its fracture. The loss of support from the



GO BEYOND

Service Investigation

Accident / Incident Report

P&WC 8114 (2020-10)

Report No.: 23-125

Page: 4 of 26

distress of the No.3 roller bearing resulted in the imbalance of the PT disc assembly causing the PT blades to contact into the shroud housing resulting in the PT blades fractures.

- 2.5 The “STI” prefix identification observed on the PT vane suggests that a non-P&WC approved repair was performed on it but, it is not believed that this repair was the root cause of the engine malfunction.
- 2.6 The propeller shaft key washer marks and metal deformation exhibited evidence that the RGB was previously disassembled and reassembled with non-P&WC tooling. No entry of any RGB maintenance was documented in the engine logbook images provided by the NTSB IIC.

3.0 CONCLUSION

- 3.1 The incorrect installation of the 2nd stage ring gear caused the front RGB housing splines to shear off on the entire circumference, subsequently decoupling the PT rotor from the propeller shaft and potentially causing the PT rotor to exceed the governed speed limits. Additionally, the reduced support of the 2nd stage ring gear also caused an imbalance movement in the RGB gear assembly which was transmitted to the No. 3 bearing and ultimately damaged the PT rotor assembly.

II FACTUAL INFORMATION

1.0 INVESTIGATION PARTICIPANTS

The powerplant investigation was performed on the 14th to the 15th of February 2024 at the Pratt & Whitney Canada (P&WC) Service Investigation Facility, Saint-Hubert, Quebec, Canada. The following individuals participated in the investigation as representatives of their respective organisations:

[REDACTED]

Air Safety Investigator
Transportation Safety Board of Canada

[REDACTED]

Air Safety Investigator
Pratt & Whitney Canada

2.0 ENGINE HISTORY

Engine Model: PT6A-34AG, **Serial No.:** 56520

Logbook Available: Yes: ☒ *No ☐

**The engine logbooks were not available at the time of the investigation.*

Time Since New (TSN): 8,274.2

Cycles Since New (CSN): N/A

Time Since Overhaul (TSO): 580

Cycles Since Overhaul (CSO): N/A

3.0 ENGINE EXAMINATION

All positional references are in relation to view from aft looking forward. Upstream and downstream references are in relation to gas path flow from the compressor inlet to the turbine exhaust.

3.1 External Condition

The engine was received assembled with tags and indications that it had been previously disassembled post accident. Engine parts sealed in plastic bags and wrapped in bubble wrap were packed underneath the engine directly on the wooden pallet (Photo No. 1 & 2). Engine components were unwrapped and placed on a work bench for evaluation (Photo No. 3). The engine data plate confirmed the engine model to be a PT6A-34AG and engine SN PC-E 56520 (Photo No. 4).



GO BEYOND

Service Investigation

Accident / Incident Report

P&WC 8114 (2020-10)

Report No.: 23-125

Page: 6 of 26

The engine had been previously inspected and partially disassembled by the FAA (delegated by the NTSB) and aircraft owner, post accident, at the Ruhe AG hanger in Leipsic Ohio. The findings were documented in a borescope report (borescope performed by Main Turbines), which the NTSB forwarded to P&WC.



Photo No. 1, Engine as Received, Right Side View



Photo No. 2, Engine as Received, Left Side View

This document is subject to the restriction contained on the cover page.



GO BEYOND

Service Investigation

Accident / Incident Report

P&WC 8114 (2020-10)

Report No.: 23-125

Page: 7 of 26



Photo No. 3, As Received Disassembled Engine Hardware

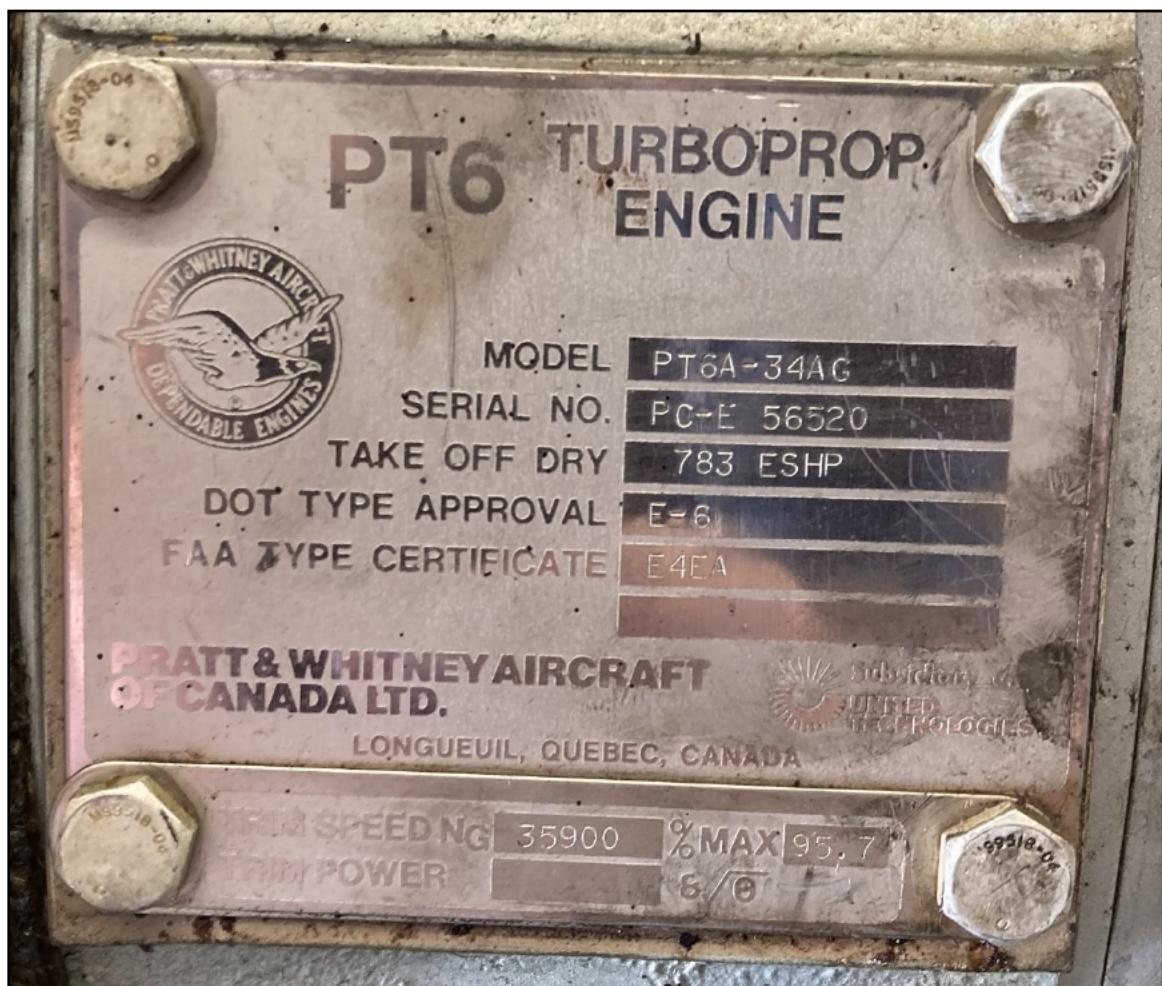


Photo No. 4, Engine Data Plate



GO BEYOND

Service Investigation

Accident / Incident Report

P&WC 8114 (2020-10)

Report No.: 23-125

Page: 8 of 26

3.1.1 External Cases

Reduction Gearbox (RGB): The RGB external exhibited no indications of operational distress.

Exhaust Duct: The exhaust duct exhibited dimples on its exterior surface indicative of PT blade distress damage, (Photo No. 5). T-Bolts at the “C” flange were missing and a red tag was attached through one of the holes, indicating it was accessed post-accident and temporarily re-installed.

Gas Generator Case (GGC): The GGC was received stripped of the fuel nozzles, igniters, fuel, oil, air tubes and ignition leads.

Accessory Gearbox (AGB) and Inlet Case: The AGB and inlet case were in a normal in-service condition.



Photo No. 5, Exhaust Duct

3.1.2 Power Control Linkage and Reversing Linkage

The power control and reversing linkages, for the purpose of this parts review, were not examined.

3.1.3 Pneumatic Lines

Pneumatic lines, for the purpose of this parts review, were not examined.

3.1.4 Chip Detectors and Filters

Chip Detector: The RGB magnetic chip detector, which was received in a sealed plastic bag along with one of the engine igniters, had metallic debris attached to the poles (Photo No. 6).

A lock wired plug was installed at the AGB chip detector port, indicative of the engine not having one installed (Photo No. 7).

Oil Filter: The oil filter was shipped in a sealed bag. It was oil wetted and visually free of debris (Photo No. 8).

Fuel Filter: The fuel filter, for the purpose of this parts review, was not examined.



Photo No. 6, RGB Chip Detector



GO BEYOND

Service Investigation

Accident / Incident Report

P&WC 8114 (2020-10)

Report No.: 23-125

Page: 10 of 26



Photo No. 7, AGB Chip Detector Plug

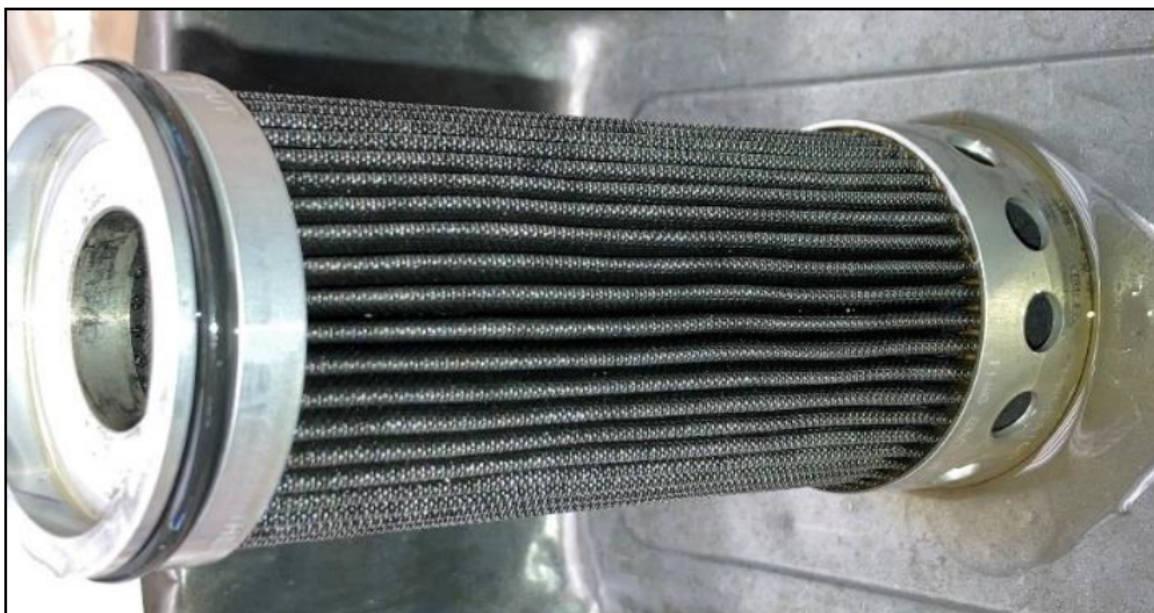


Photo No. 8, Oil Filter



GO BEYOND

Service Investigation

Accident / Incident Report

P&WC 8114 (2020-10)

Report No.: 23-125

Page: 11 of 26

3.2 Disassembly Observations

3.2.1 Compressor Turbine (CT) Section

The CT turbine showed rotational contact marks on the disc firtrees (red arrow right view of Photo No. 9), blade platforms and blade firtrees (green arrow right view of Photo No. 9). The compressor pack was free to rotate with no noticeable abnormal noise.

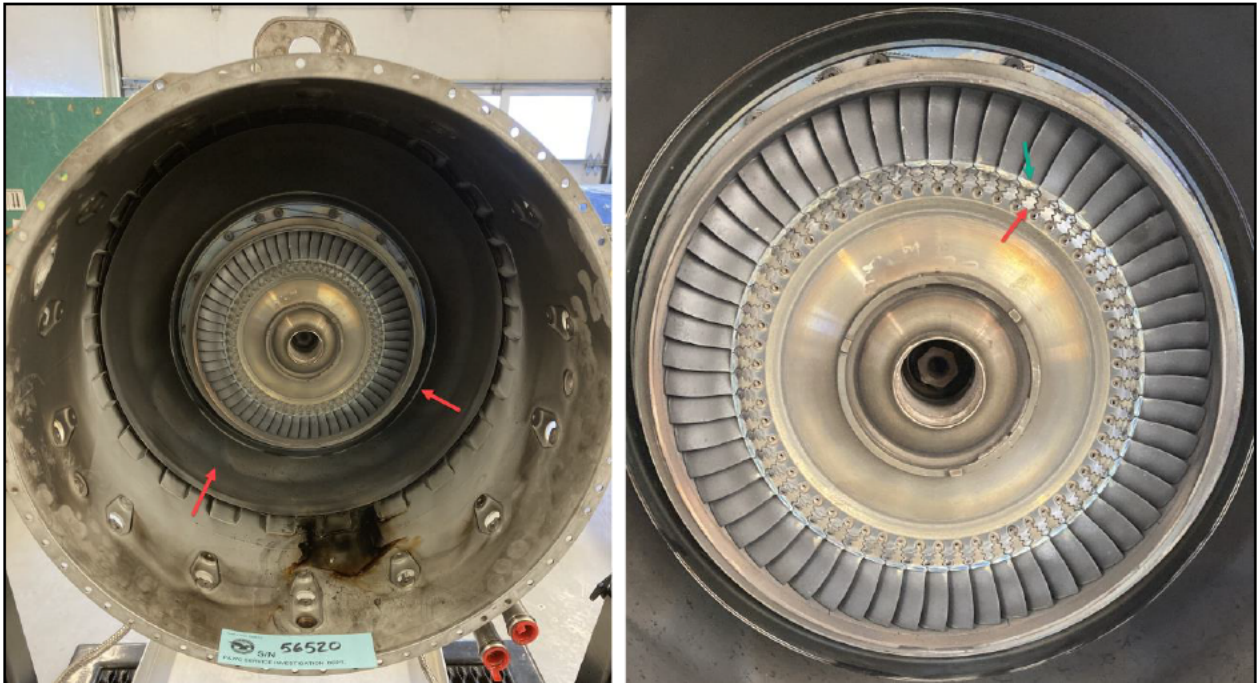


Photo No. 9, Compressor Turbine Disc

3.2.2 Combustion Section

The combustion liner was not shipped with the engine, but the small and large exit ducts were installed in the engine, (arrows in left view of Photo No. 9).

3.2.3 Power Turbine (PT) Section

The PT disc was previously disassembled and shipped with the engine in a separate sealed plastic bag. The PT disc and the PT blades showed rotational contact on the upstream face, (left image in Photo No. 10). A portion of the balancing rim, due to rotational contact, was deformed towards the disc center axis. Some PT blades exhibited liberation from just above the firtree, some above the platform and others along the blade span (Photo No. 10 to 12). Impact damage was observed to both the blade remnants and the fracture surfaces. In undamaged regions of the fracture surfaces a rough granular topography was observed.



GO BEYOND

Service Investigation

Accident / Incident Report

P&WC 8114 (2020-10)

Report No.: 23-125

Page: 12 of 26

The PT shroud ring was fractured into multiple pieces and received in several plastic bags. Not all the pieces were accounted for, however, all the shroud blade contact surfaces showed signs of circumferential contact wear, obliterating the ring shroud surface (Photo No. 13). The PT containment and reinforcement rings exhibited an oval shape suggesting two higher energy release areas (red arrows in Photo No. 14). Additionally, it was observed that the containment ring exhibited along its width, a straight and clean cut likely produced during the initial disassembly at the Operator's hangar (purple arrow in Photo No. 14)

The PT vane and baffle shown in Photo No. 15, exhibited rotational contact marks from contact with the upstream PT blades and PT disc. The PT vane was identified as a non-P&WC approved repair by Southwest Turbines (STI prefix, red circle in Photo No. 16).



Photo No. 10, Power Turbine Disc



GO BEYOND

Service Investigation

Accident / Incident Report

P&WC 8114 (2020-10)

Report No.: 23-125

Page: 13 of 26

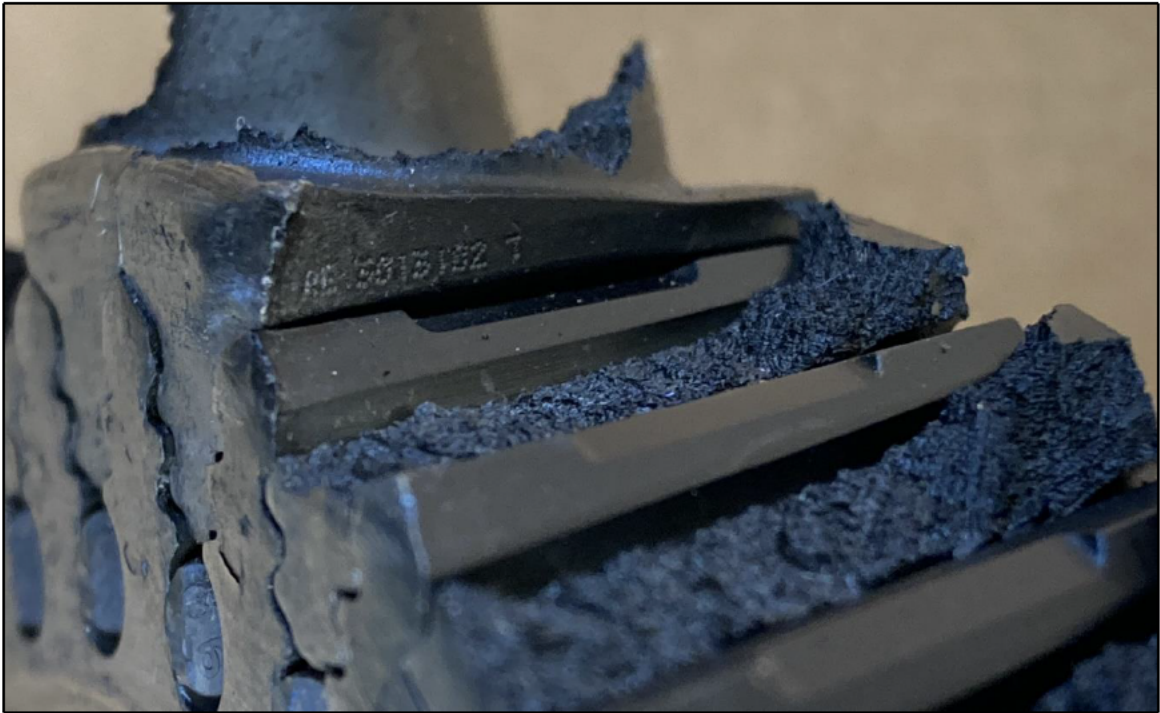


Photo No. 11, Power Turbine Blade Fractured Surfaces



Photo No. 12, Power Turbine Blade Fractured Surfaces



GO BEYOND

Service Investigation

Accident / Incident Report

P&WC 8114 (2020-10)

Report No.: 23-125

Page: 14 of 26



Photo No. 13, Power Turbine Shroud Ring

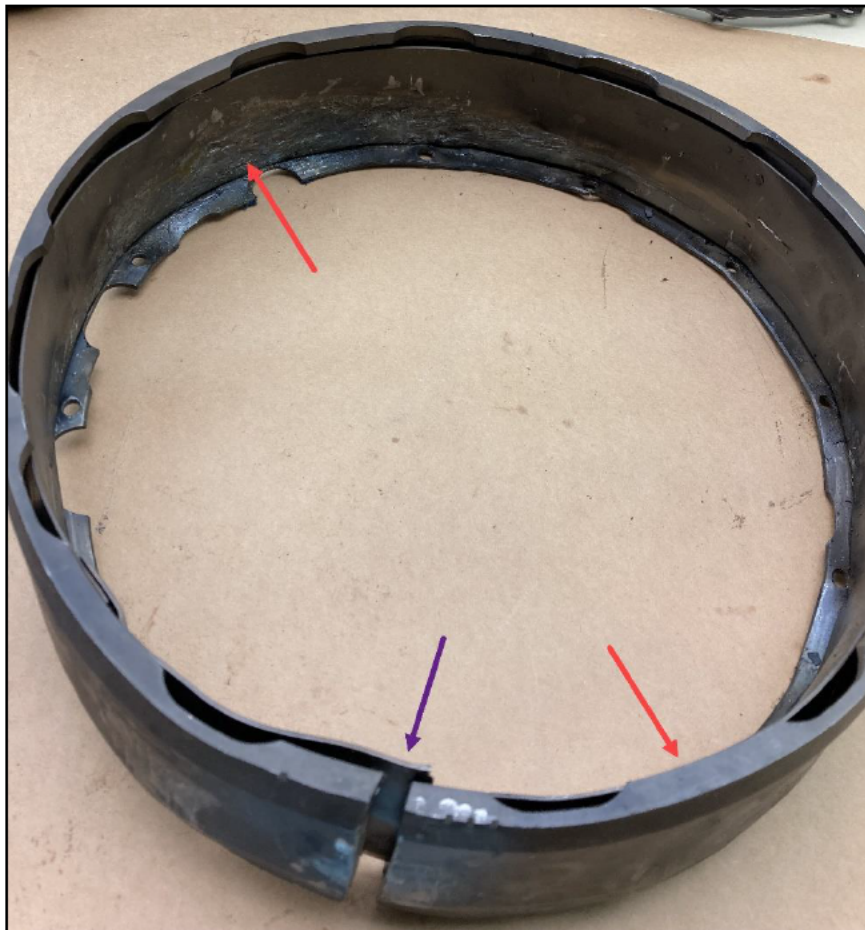


Photo No. 14, PT Containment and Reinforcement Ring



GO BEYOND

Service Investigation

Accident / Incident Report

P&WC 8114 (2020-10)

Report No.: 23-125

Page: 15 of 26

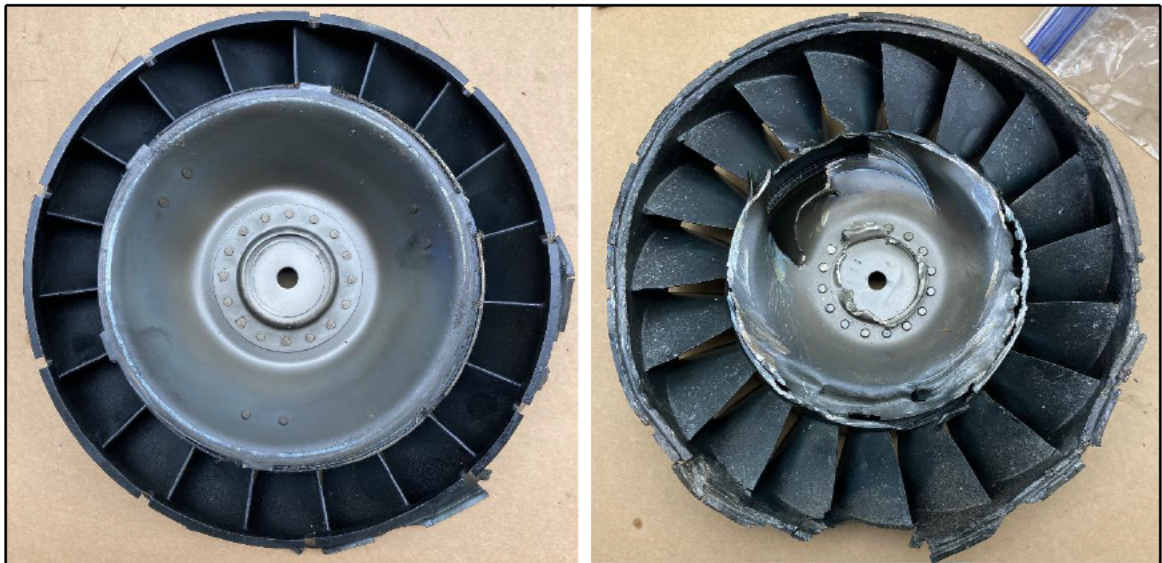


Photo No. 15, Power Turbine Vane



Photo No. 16, Power Turbine Vane Identification



GO BEYOND

Service Investigation

Accident / Incident Report

P&WC 8114 (2020-10)

Report No.: 23-125

Page: 16 of 26

The bolts retaining the PT shaft housing to the RGB rear housing were all fractured (Photo No. 17). The PT shaft housing and the No. 3 bearing cover exhibited rotational contact damage (Photo No. 18). The PT shaft exhibited signs of heat tinting and rotational scoring on the midsection surface (Photo No. 19). The No. 3 bearing flanged outer ring was fractured into two halves (Photo No. 20). The bearing inner ring raceway exhibited signs of overheating similar to the PT shaft in color. The No. 3 bearing cage was deformed in an oval shape (Photo No. 20). The bearing rollers (Photo No. 20), which were all released from the cage, were found in the No. 4 bearing housing region (Photo No. 21). The No. 4 bearing did not show any signs of distress.



Photo No. 17, Reduction Gear Box Rear Housing

Service Investigation Accident / Incident Report

P&WC 8114 (2020-10)

Report No.: 23-125
Page: 17 of 26



Photo No. 18, PT Shaft Housing (Left) and No. 3 Bearing Cover (Right)

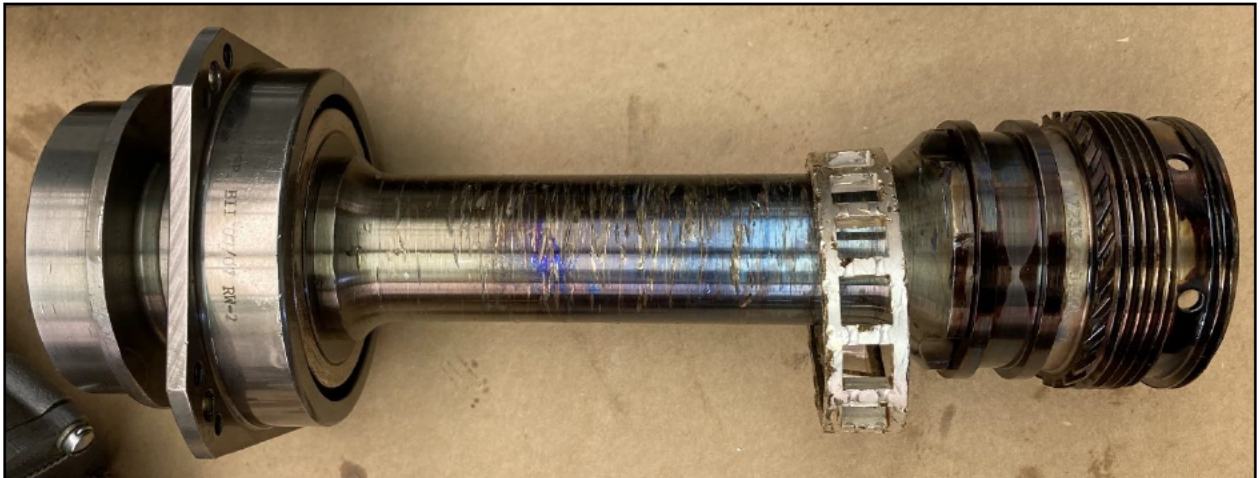


Photo No. 19, Power Turbine Shaft



GO BEYOND

Service Investigation

Accident / Incident Report

P&WC 8114 (2020-10)

Report No.: 23-125

Page: 18 of 26



Photo No. 20, No. 3 Roller Bearing



GO BEYOND

Service Investigation

Accident / Incident Report

P&WC 8114 (2020-10)

Report No.: 23-125

Page: 19 of 26



Photo No. 21, No. 3 Bearing Rollers Next to No. 4 Bearing



Service Investigation

Accident / Incident Report

P&WC 8114 (2020-10)

Report No.: 23-125

Page: 20 of 26

3.2.4 Compressor Section

The compressor section was free to rotate by hand without any abnormal sound. The borescope report provided by the NTSB did not identify any anomalies and as a result for the purpose of this investigation it was not disassembled.

3.2.5 Reduction Gearbox (RGB)

The RGB rear housing “A” flange, as shown in Photo No. 22, with the exception of metallic debris, did not exhibit visible distress. The RGB rear housing “B” flange, interfacing with the PT shaft housing flange, exhibited rotational contact distress (red arrows). The “B” flange retaining bolts were all fractured (white arrows, Photo No. 23).

The 1st stage sun gear and planet gear mating teeth shown in Photo No. 24 & 25, exhibited signs of distress resulting in material loss.

No visual anomaly was observed on the exterior surfaces of the RGB front housing (Photo No. 26). The 2nd stage carrier and planet gears visually exhibited normal in-service condition (Photo No. 27). It was observed that the 2nd stage ring gear was incorrectly assembled. The ring gear retaining slot was located forward of the three retaining plates and as a result was found capable of moving freely axially within the RGB housing splines (Photo No. 28). All three 2nd stage ring gear retaining plates and respective RGB housing mounting holes did not show signs of distress.

Removal of the 2nd stage ring gear revealed distress over the full circumference of the front RGB housing mating splines that resulted in material loss of the spline teeth forward ends (green arrows in Photo No. 29). Matching contact/wear marks were observed on the 2nd stage ring gear spline teeth ends (Photo No. 30). The 2nd stage ring gear was also found to have contacted the RGB front housing surfaces adjacent to the housing splines machining these regions flat, shown by the red arrow in Photo No. 29.

The propeller shaft assembly exhibited no evidence of distress. However, the propeller shaft retaining nut and key washer exhibited tool marks and localized damage indicative of previous removal (red arrows in top right image of Photo No. 31). Tool marks were observed on the key washer swaged section that were not consistent with the condition left when using the dedicated P&WC tooling red arrow in bottom right image of Photo No. 31.



GO BEYOND

Service Investigation

Accident / Incident Report

P&WC 8114 (2020-10)

Report No.: 23-125

Page: 21 of 26



Photo No. 22, RGB Rear Housing Front RGB Housing Interface



Photo No. 23, RGB Rear Housing PT Shaft Housing Interface



GO BEYOND

Service Investigation

Accident / Incident Report

P&WC 8114 (2020-10)

Report No.: 23-125

Page: 22 of 26



Photo No. 24, RGB PT Shaft, 1st Stage Sun Gear

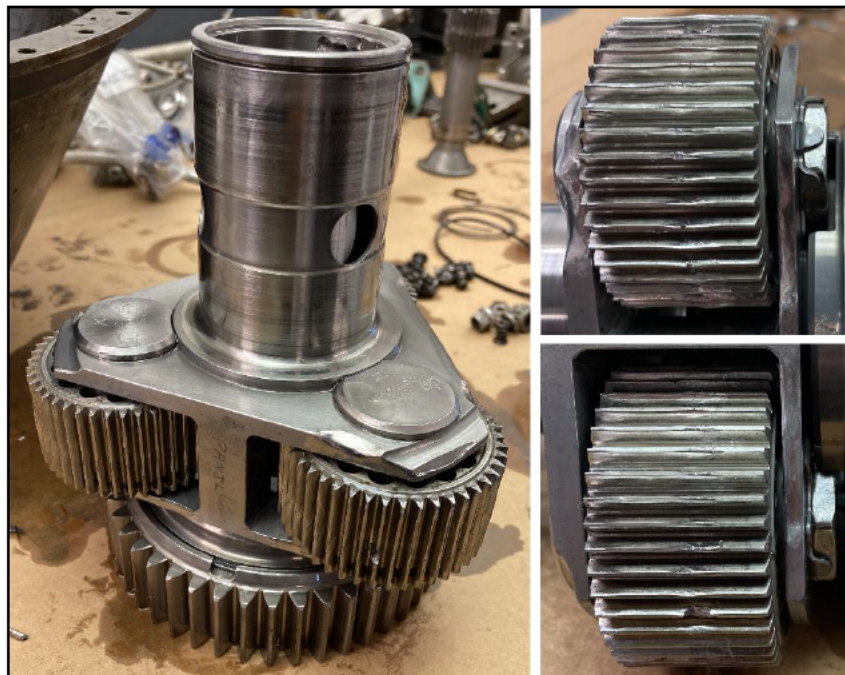


Photo No. 25, RGB 1st Stage Carrier and Planet Gears, 2nd Stage Sun Gear



GO BEYOND

Service Investigation

Accident / Incident Report

P&WC 8114 (2020-10)

Report No.: 23-125

Page: 23 of 26

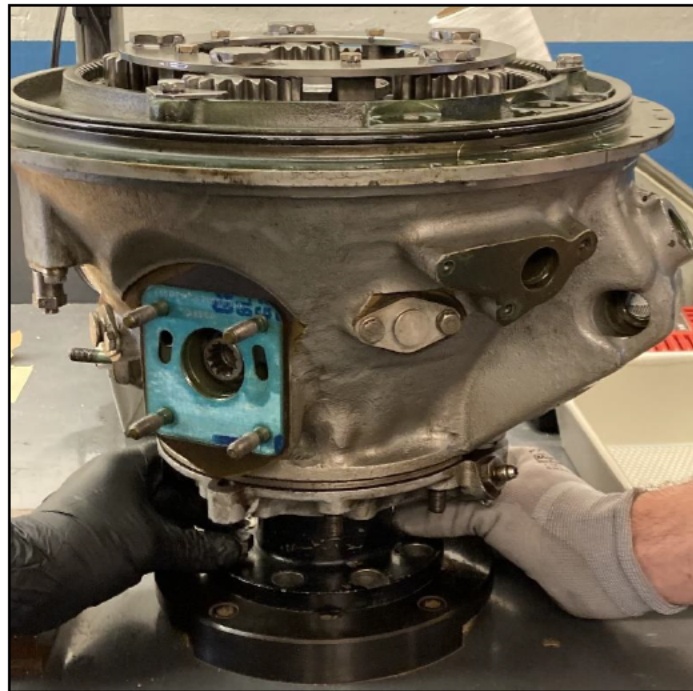


Photo No. 26, RGB Front Housing

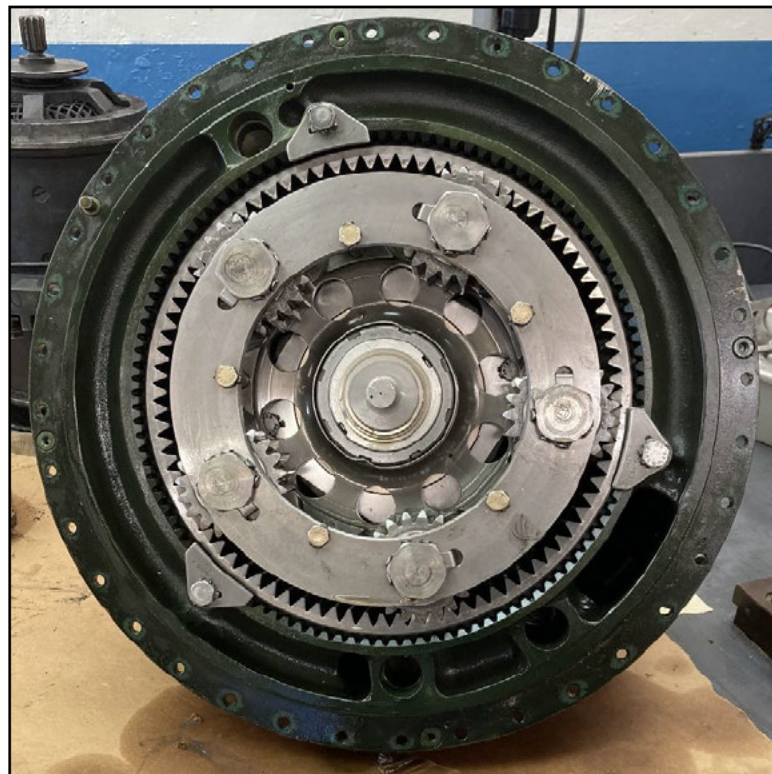


Photo No. 27, RGB Front Housing and 2nd Stage Carrier Assembly



GO BEYOND

Service Investigation

Accident / Incident Report

P&WC 8114 (2020-10)

Report No.: 23-125

Page: 24 of 26

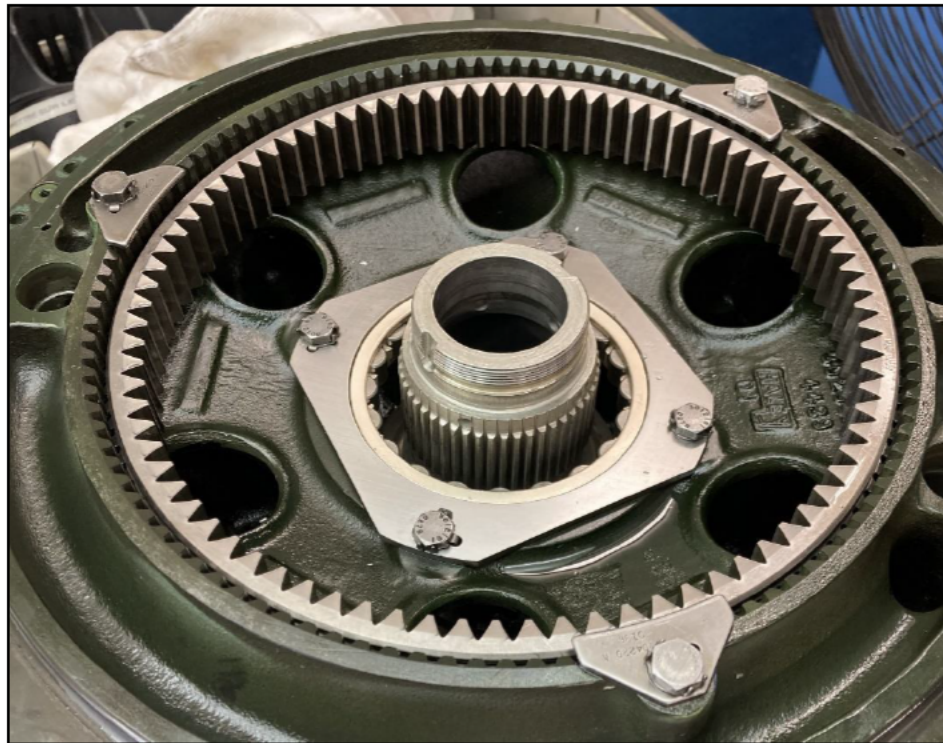


Photo No. 28, RGB 2nd Stage Ring Gear and Retaining Brackets

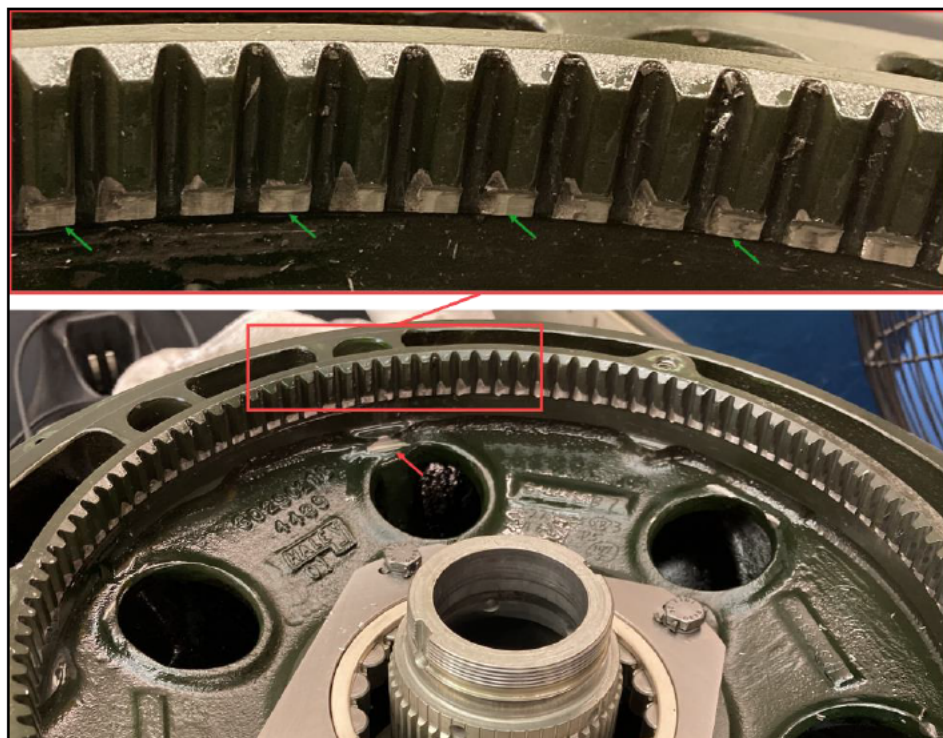


Photo No. 29, RGB Front Housing 2nd Stage Ring Gear Splines



GO BEYOND

Service Investigation

Accident / Incident Report

P&WC 8114 (2020-10)

Report No.: 23-125

Page: 25 of 26

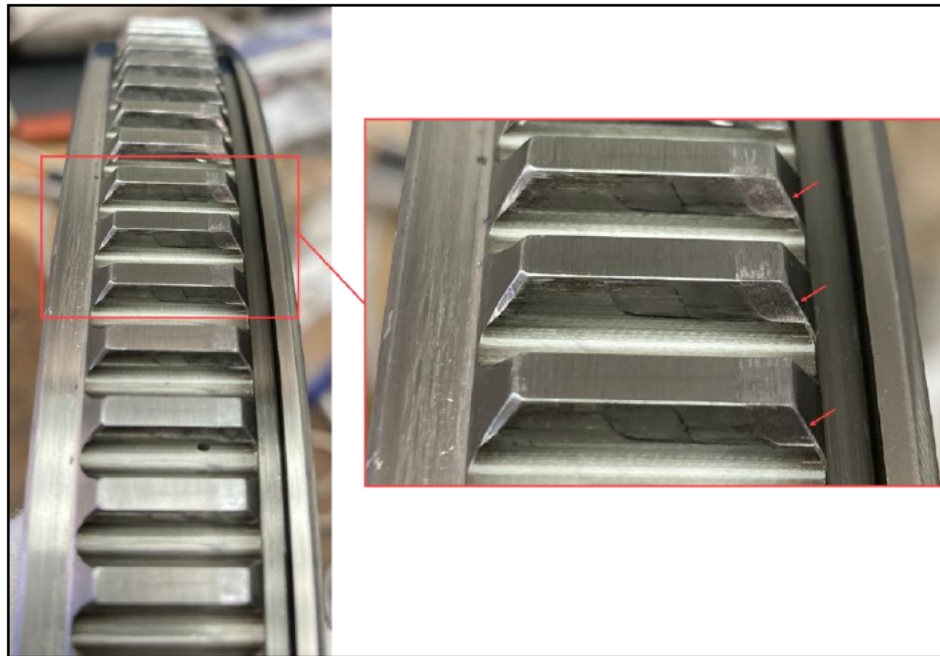


Photo No. 30, RGB 2nd Stage Ring Gear

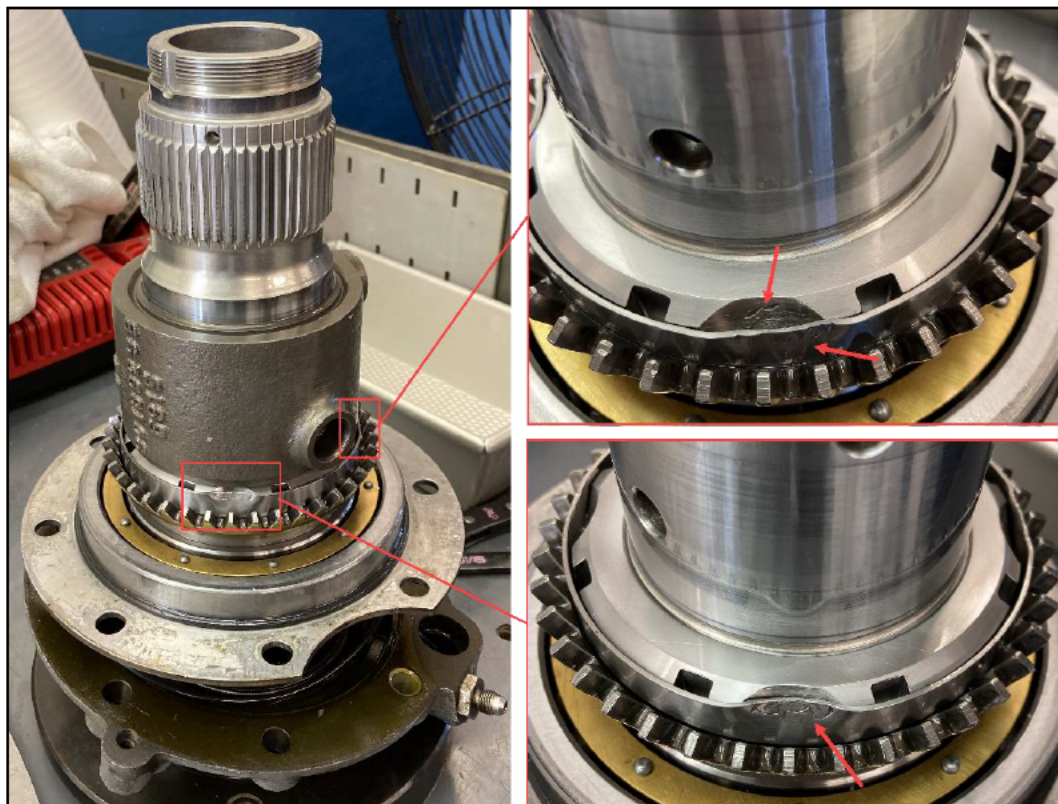


Photo No. 31, Propeller Shaft Assembly and Key Washer



GO BEYOND

Service Investigation

Accident / Incident Report

P&WC 8114 (2020-10)

Report No.: 23-125

Page: 26 of 26

3.2.6 Accessory Gearbox (AGB)

The AGB for the purpose of this parts review, was not examined.

3.3 Controls and Accessories

The fuel, air, oil, ignition, and propeller systems for the purpose of this parts review, were not examined.