

Service Investigation

Accident / Incident Report

P&WC 8114 (11-98)



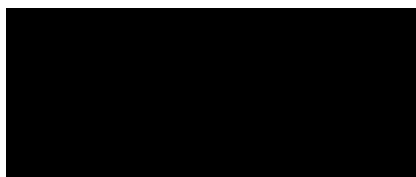
Pratt & Whitney Canada

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Report No.: 18-124

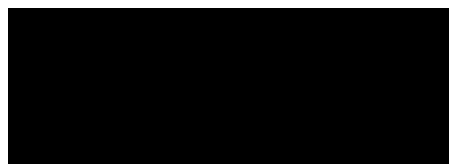
**AirSpray Airtankers
Air Tractor AT-802F, N397AS
Stevens County, Washington, USA
14 August 2018
PT6A-67F, RZ0138**

Written By:



Service Investigation Department

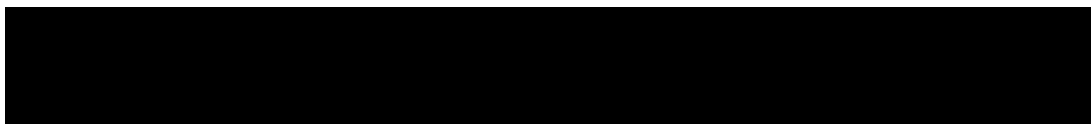
Approved By:



Manager, Service Investigation Department

Date of Issue: 20 November 2019

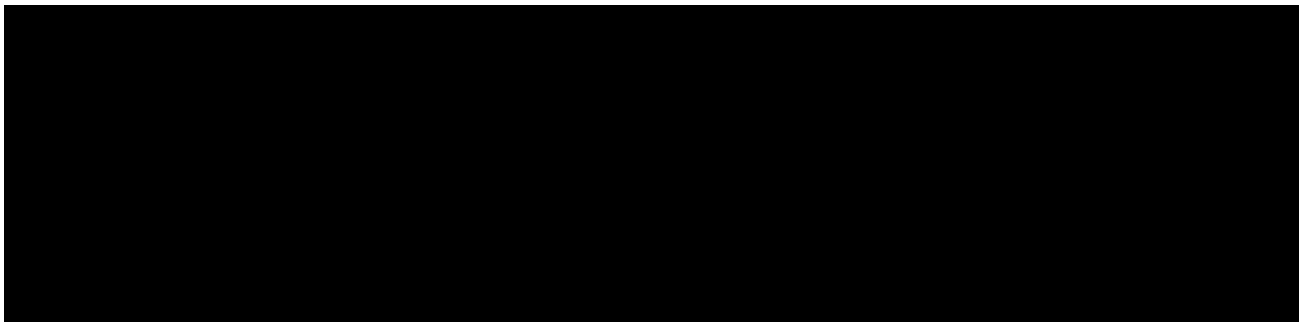
Distribution:



NTSB Identification: WPR18LA222

TSB Identification: A18F0191

P&WC Reference: File No. 18-124



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	P-ECCN or P-USML (Non US Origin)	9E991



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I ANALYSIS

1.0 ACCIDENT SYNOPSIS

- 1.1 On August 14, 2018, about 1500 Pacific daylight time, an Air Tractor AT802 airplane (Fire Boss), N397AS, was substantially damaged during a forced landing near Northport, Washington. The commercial pilot was seriously injured. Visual meteorological conditions prevailed for the local area flight that had originated from a water dip site near the area of an active fire.
- 1.2 The accident flight was a flight of 3, with the accident airplane in the number 2 position. The pilot reported that he heard a "thud" followed by a bang and the airframe began to shake. He jettisoned the water and turned away from the other two airplanes. The pilot initially was going to land on an old logging road; however, the landing area was lined with trees on both sides of the road. He opted instead to stall the airplane over the tree tops. After impact with the trees, the airplane came to rest upright at the base of the trees adjacent to the road.
- 1.3 The subject engine was then submitted to Pratt & Whitney Canada (P&WC) Service Investigation for detailed examination.

2.0 SUMMARY OF FINDINGS AND DISCUSSIONS

- 2.1 A foreign melted debris was found in the engine combustion chamber with the molten mass stuck to the combustors, turbine vane rings and turbine blades. The debris was identified as environmental particles with a low melting point. The source of the debris could not be identified.
- 2.2 One PT2 blade [REDACTED] exhibited evidence of fatigue. The fatigue was observed to have initiated from several regions of microshrinkage porosities. However, due to secondary impact damages sustained at the blade's leading edge, the exact origin area could not be established with certainty. The fact that no foreign melted debris was observed on the fracture surface is indicative of the PT2 blades having fractured after the foreign melted debris had accumulated on the blade airfoil. It is believed that all PT2 blades fractured by tensile overload due to the accumulation of the foreign melted debris. The foreign melted debris stuck on the airfoil increased the airfoil weight.
- 2.3 P&WC Quality Escape Management organisation was advised of the PT2 blade microshrinkage porosity findings.
- 2.4 Investigation of the accessories was comprised of inspection and testing of the fuel pump, fuel control unit (FCU), flow divider valve (FDV), fuel oil heat exchanger (FOHE), over-speed governor (OSG) and fuel nozzles. This also included disassembly and inspection of the compressor bleed valve (BOV) and propeller governor (CSU). There were no defects or damages evident that would have prevented normal operation prior to the event.



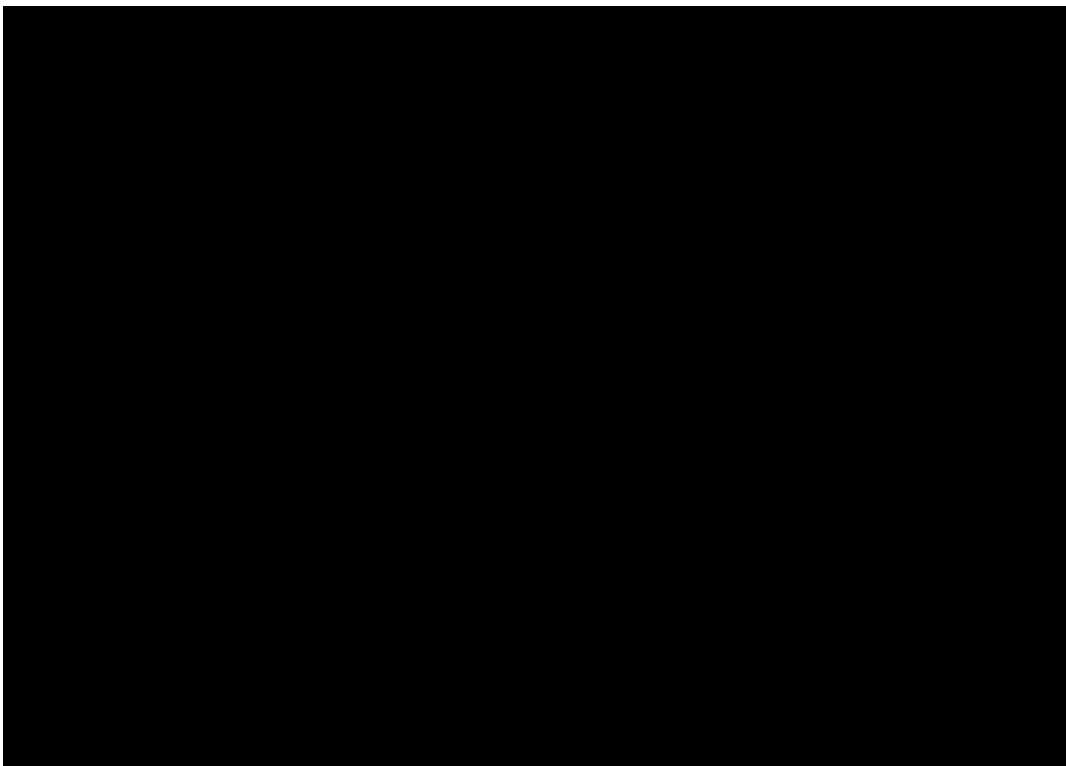
3.0 CONCLUSIONS

- 3.1 The engine power loss was due to the accumulation of the foreign melted environmental debris on the hot section components, which led to the PT1 and PT2 blades fracture by tensile overload.
- 3.2 All other observed damages were secondary to the PT distress except for the microshrinkage porosities found on the one PT2 blade.
- 3.3 The source of the contamination could not be determined.

II FACTUAL INFORMATION

1.0 INVESTIGATION PARTICIPANTS

The powerplant investigation was performed on 4 to 16 May 2019 at the P&WC St-Hubert facility. The following individuals participated in the investigation as representatives of their respective organisations:





2.0 ENGINE HISTORY

Engine Model: PT6A-67F, **Engine Serial No.:** RZ0138

Date of Manufacture: March 2014

Logbook Available: Yes ☒ No ☐

Time Since New (TSN): 559.0

Cycles Since New (CSN): 321

Time Since Overhaul (TSO): N/A

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 exhaust.

3.1 External Condition

The shipping box was in good condition. Removal of the shipping box, revealed the engine with parts of the airframe mount, some airframe accessories, wiring harnesses, and firewall still attached (Photo No. 1). The external surfaces of the engine, mainly in the fuel nozzles area, showed signs of post-impact fire (PIF). The compressor rotor and the power turbine (PT) / propeller shaft rotor were both seized. The PT blades were examined on the downstream side through the exhaust duct ports. The first stage PT (PT1) and second stage PT (PT2) blades were all fractured (Photo No. 2). The gas generator module and power section module data plates confirmed the engine serial No. RZ0138 (Photo No. 3).

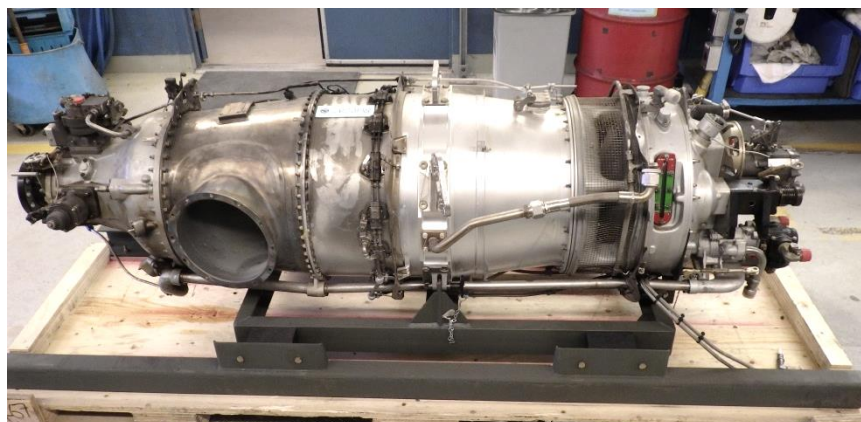


Photo No. 1

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Photo No. 2



Photo No. 3

3.1.1 External Cases

Reduction Gearbox (RGB): The lower portion of the reduction gearbox (RGB) was covered with a mixture of environmental debris and oil. The RGB was found cracked at the 6 O'clock position close to the propeller shaft flange (arrow, Photo No. 4).

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Photo No. 4

Exhaust Duct: The exhaust case upper external surfaces showed signs of PIF (Photo No. 5). The exhaust duct was cracked (arrow) from impact and showed dents from PT blades release (Photo No. 6).

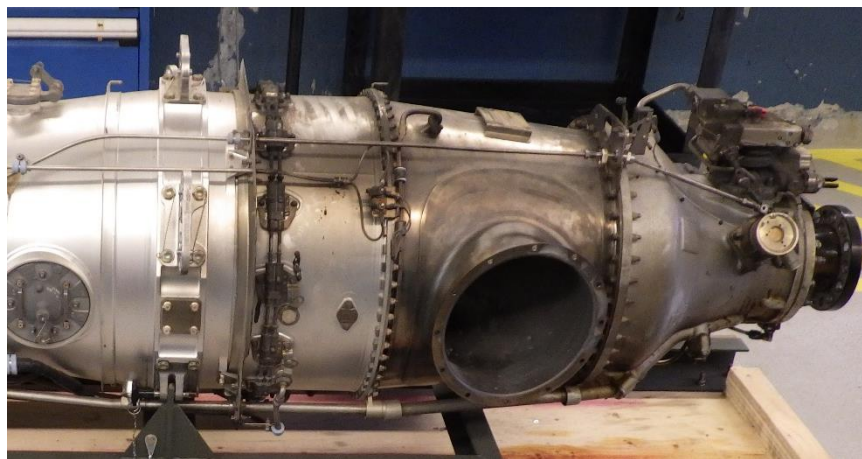


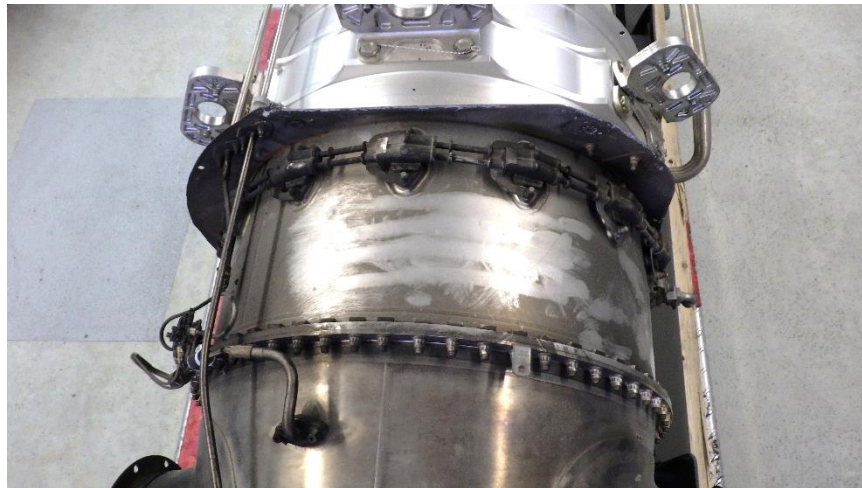
Photo No. 5



Photo No. 6



Gas Generator Case (GGC): The GGC upper external surfaces showed signs of PIF (Photo No. 7). The GGC was displayed impact damages. The fuel line and oil scavenge lines were mechanically deformed (circled, Photo No. 8). All fuel nozzle manifolds were still secured and tightened. Both igniter plugs were still secured and tightened.

**Photo No. 7****Photo No. 8**



Accessory Gearbox (AGB) and Inlet Case / Oil Tank: The inlet screen was not punctured, but was slightly soiled. A portion of the inlet screen and wash ring had been compressed inwards from impact (arrow, Photo No. 9). The internal gas path of the inlet case was covered by a light layer of dust.

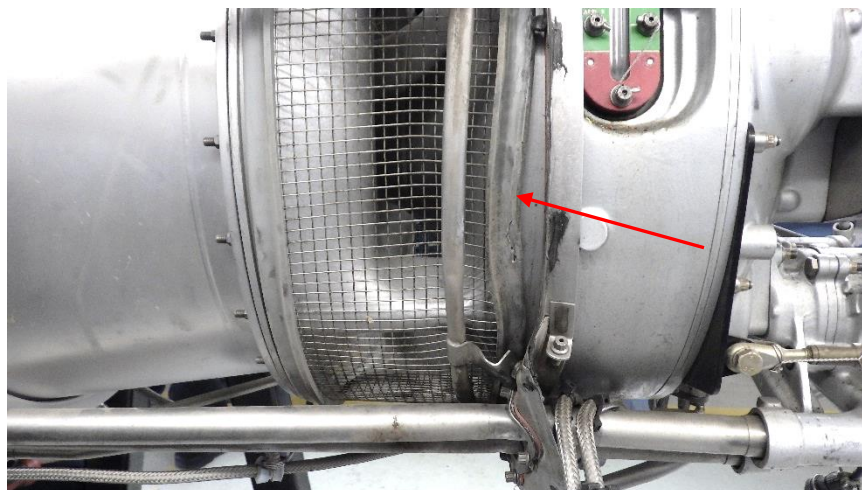


Photo No. 9

3.1.2 Power Control and Reversing Linkage

No damage was observed to the Power Control Linkage and it was continuous from the CAM box up to the Fuel Control Unit (FCU). The reversing cable was disconnected from the beta lever and propeller speed control lever (circled, Photo No. 10). The reversing cable was attached to the CAM box and secured. The reversing cable was found loose and not secured at the “A” flange (arrow, Photo No. 10).

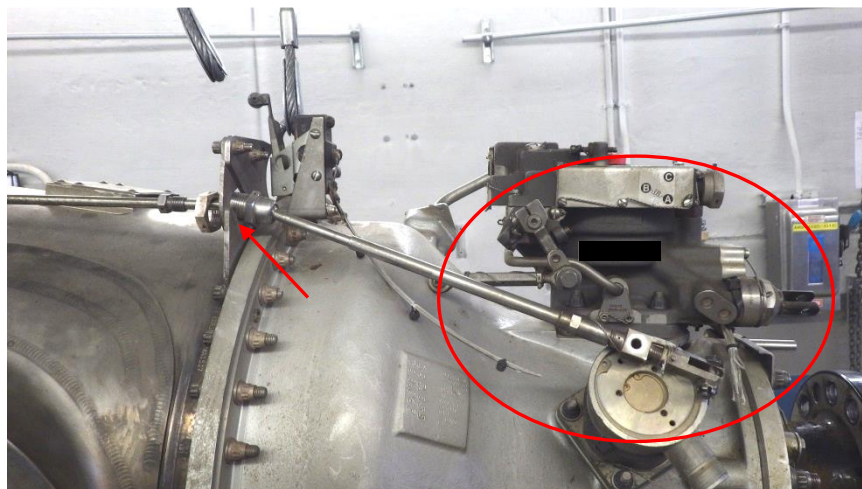


Photo No. 10



3.1.3 Pneumatic Lines

Compressor Discharge Air (P3): The P3 pneumatic line was continuous from the GGC to the FCU. All the “B” nuts were secured with lockwire and found tight. Leak check was performed on P3 line and no leak was found. The P3 air filter was dry and free of contaminants.

Power Turbine Control (Py): The Py pneumatic line was not received. Based on cleanliness of the FCU and propeller governor (CSU) fittings threads (arrows, Photo No. 11 and Photo No. 12), the Py line was likely removed post-accident during engine removal.

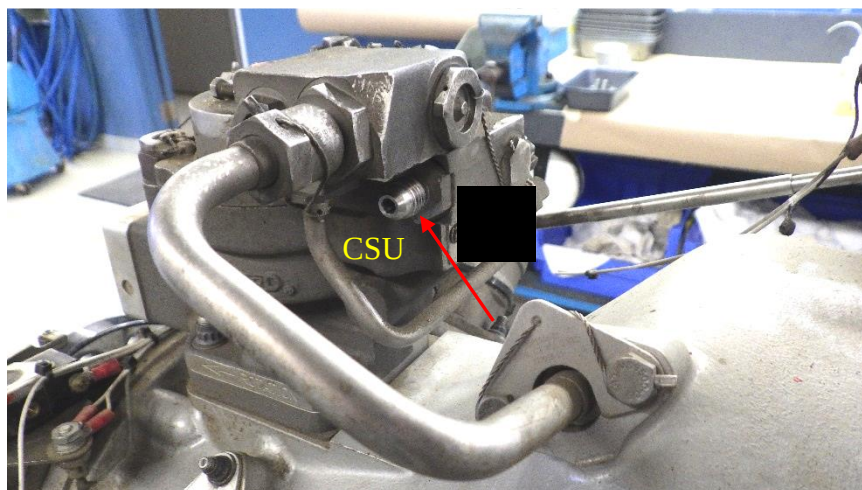


Photo No. 11

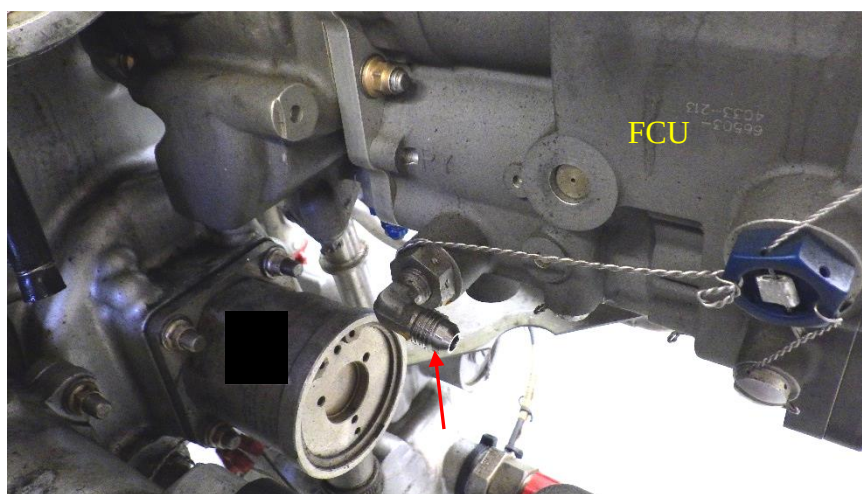


Photo No. 12



3.1.4 Chip Detector(s) and Filters

Chip Detector(s): The RGB and AGB magnetic chip detector (MCD) showed only some “Fuzz” (Photo No. 13).

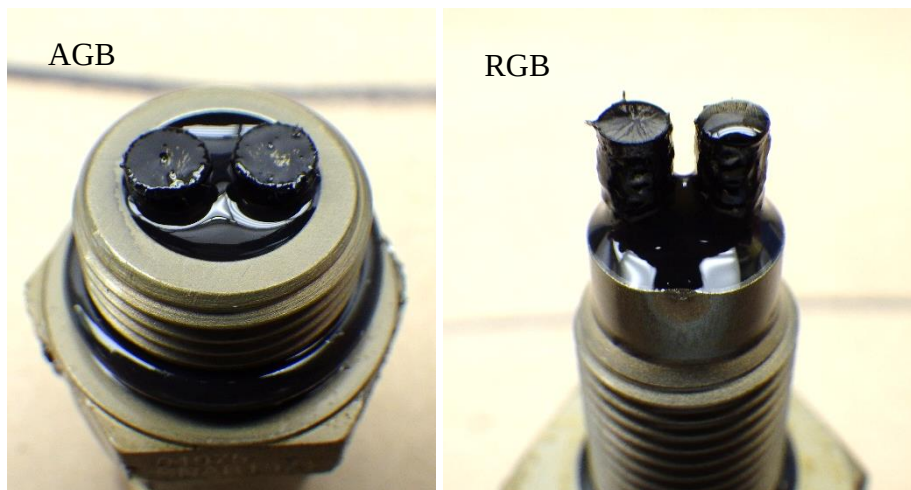


Photo No. 13

Oil Filter: The oil filter was dirty (Photo No. 14). The oil filter housing showed some metallic particles (circled, Photo No. 15). The oil filter was submitted to the P&WC Chemical Laboratory for further analysis (see section 5.0).



Photo No. 14



Photo No. 15

Oil Samples: The AGB and oil tank oil samples were clean and free of contaminants. The RGB oil sample displayed a darker discoloration, but was free of contaminants.

Fuel Filter: The fuel pump outlet filter and inlet screen were not removed. The fuel filters were inspected as part of the accessories investigation (see section 6.0).



3.2 Disassembly Observations

3.2.1 Compressor Turbine (CT) Section

The engine was split at “C” flange to access the hot section components. The compressor turbine (CT) blades were all fractured near the tip (Photo No. 16). All CT blades were coated with foreign melted debris, dark grey in appearance (Photo No. 17). The CT disk downstream side exhibited heat discoloration and severe circumferential rubbing (Photo No. 17). The CT shroud segments presented rub, material transfer and fused debris accumulation (Photo No. 18). The CT vane ring showed normal operational wear, but displayed foreign melted debris build-up (Photo No. 19). The CT blades were sent to the P&WC Materials Laboratory for further analysis (see section 4.0). Sample of the foreign melted debris was collected from the CT vane ring and was submitted to the P&WC Chemical Laboratory for further analysis (see section 5.0).

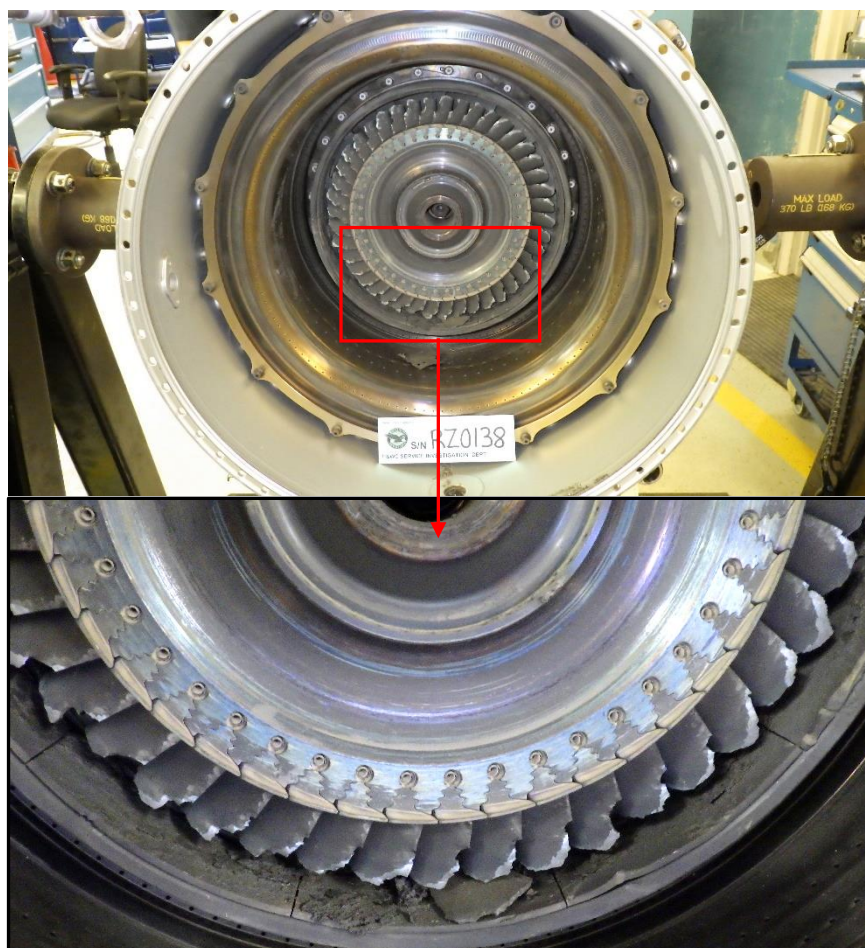


Photo No. 16

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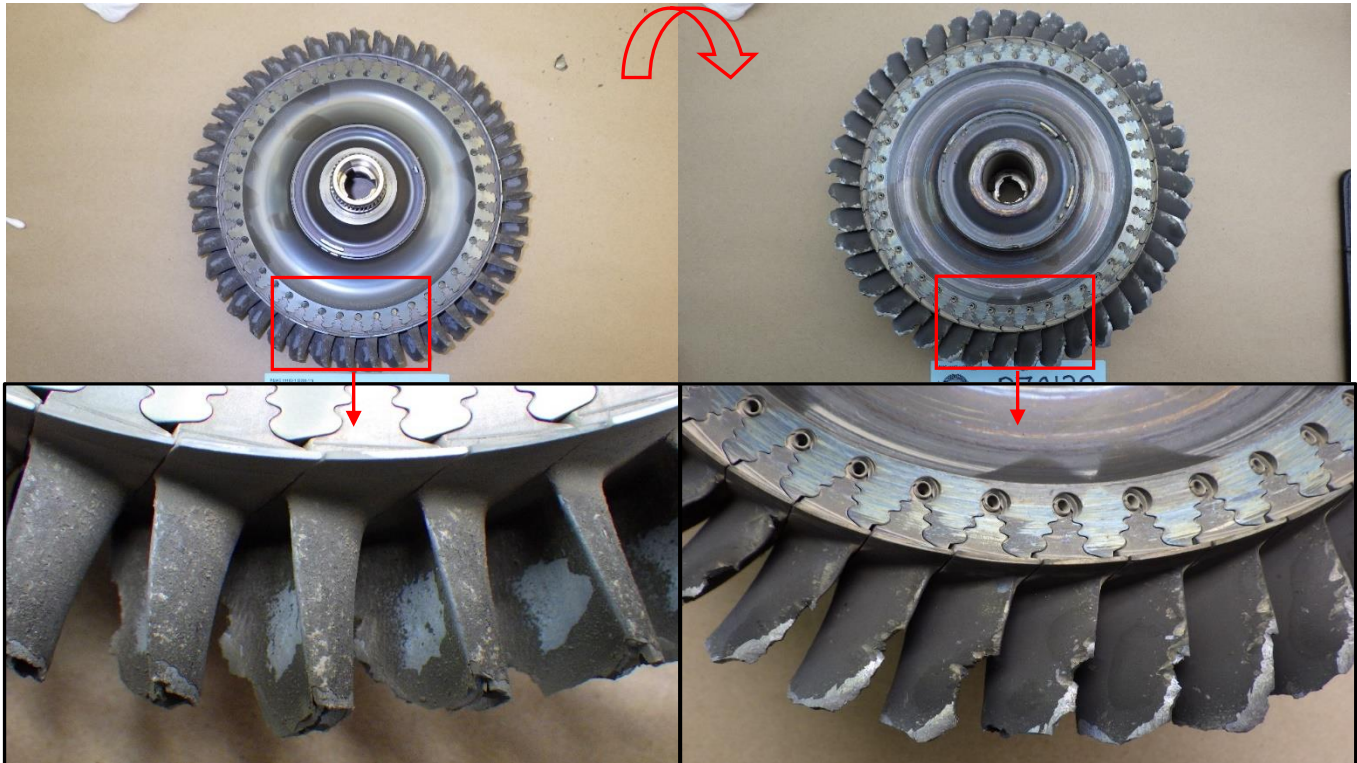


Photo No. 17



Photo No. 18

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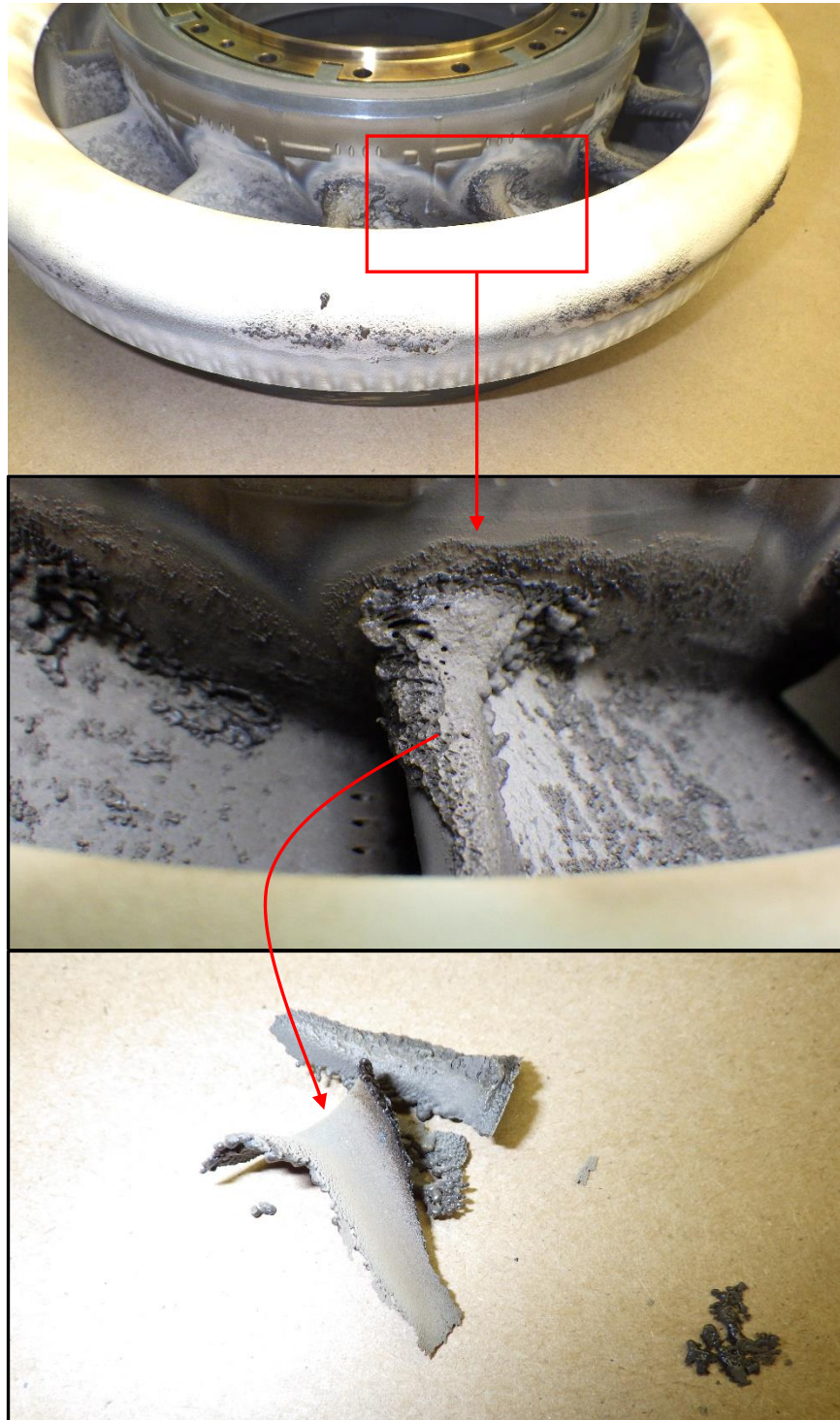


Photo No. 19



3.2.2 Combustion Section

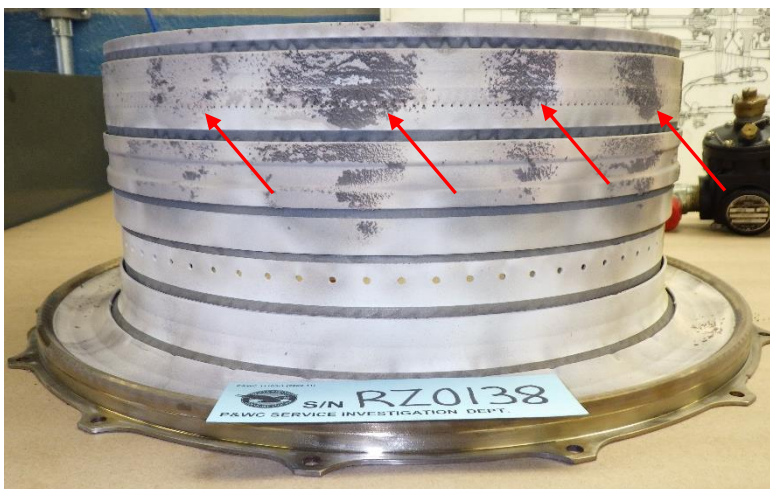
The combustion chamber displayed a significant accumulation of dislodged foreign melted debris, dark grey and tan in appearance (Photo No. 20 to Photo No. 22). The combustion chamber inner and outer liners did not show evidence of overtemperature exposure. The small exit duct showed normal operational wear, but also displayed foreign melted debris build-up. Samples of the foreign melted debris was collected from the combustion liners and were submitted to the P&WC Chemical Laboratory for further analysis (see section 5.0).



Photo No. 20



Photo No. 21

**Photo No. 22**

3.2.3 Power Turbine (PT) Section

The PT section components were coated with foreign melted debris, dark grey in appearance (inset, Photo No. 24). All Inter Turbine Temperature (ITT) probes had fractured (Photo No. 23). The PT vane ring was fractured and some fragments were not retrieved (Photo No. 25). The interstage baffle was severely deformed, battered and showed severe circumferential rubbing marks due to contact with the CT disk assembly on the upstream side and the PT1 disk assembly on the downstream side (Photo No. 24 and Photo No. 26). The PT shroud was deformed and fractured (red arrow, Photo No. 27). The PT1 and PT2 blades were all fractured. All PT1 blades were pushed backward and were fractured at about the same airfoil heights, close to the base (yellow arrow, Photo No. 27). The PT interstage vane ring was fractured and displayed foreign melted debris build-up (Photo No. 28). Some PT2 blades were pushed backward and were fractured at various airfoil heights (Photo No. 29). The PT2 disk downstream and upstream sides showed circumferential rubbing. The No. 3 roller bearing showed normal operational wear. The PT1 and PT2 blades were sent to the P&WC Materials Laboratory for further analysis (see section 4.0). Sample of the foreign melted debris was collected from PT1 vane ring and was submitted to the P&WC Chemical Laboratory for further analysis (see section 5.0).

**Photo No. 23**

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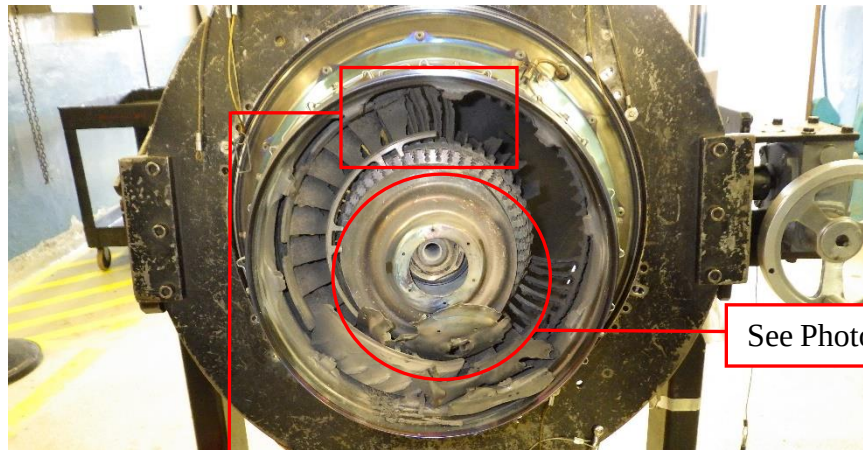


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See Photo No. 26



Photo No. 24



Photo No. 25

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Photo No. 26

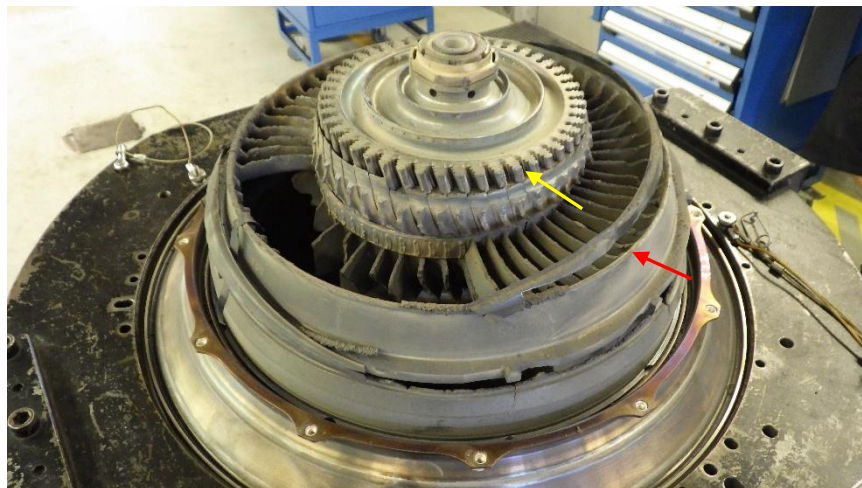


Photo No. 27

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Photo No. 28



Photo No. 29



3.2.4 Compressor Section

Some compressor 1st, 2nd, 3rd, 4th stages airfoils presented evidence of pre-impact foreign object damage (FOD) and displayed light erosion (Photo No. 30). The 1st, 2nd, 3rd, 4th stages stators showed environmental dust (light brown / tan) accumulation on the outer diameter (OD) (P2.5 area) (Photo No. 31). The 1st stage inner bore showed a significant amount of dust accumulation (inset, Photo No. 32). The centrifugal impeller presented evidence of pre-impact foreign object damage (FOD) and displayed light erosion (Photo No. 33). The back face of the impeller showed environmental dust (light brown / tan) accumulation (Photo No. 34). The No. 1 ball bearing and No. 2 roller bearing also showed normal operational wear. Samples of the dust collected in the cold section was submitted to the P&WC Chemical Laboratory for further analysis (see section 5.0).



Photo No. 30



Photo No. 31

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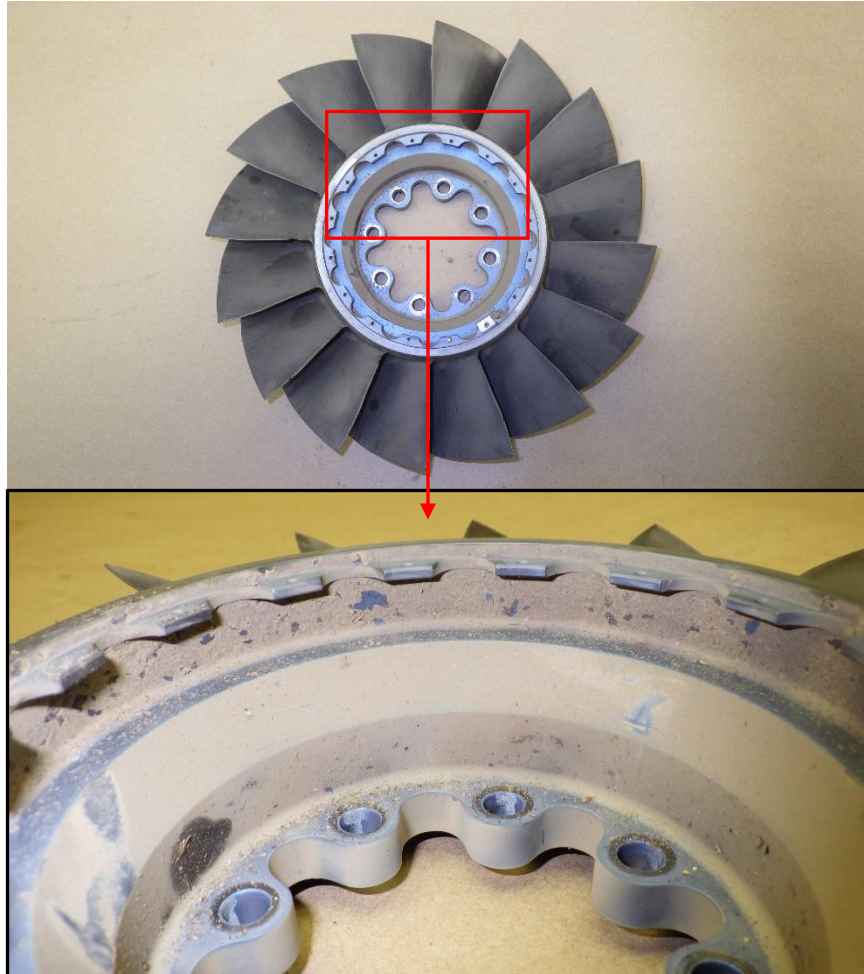


Photo No. 32

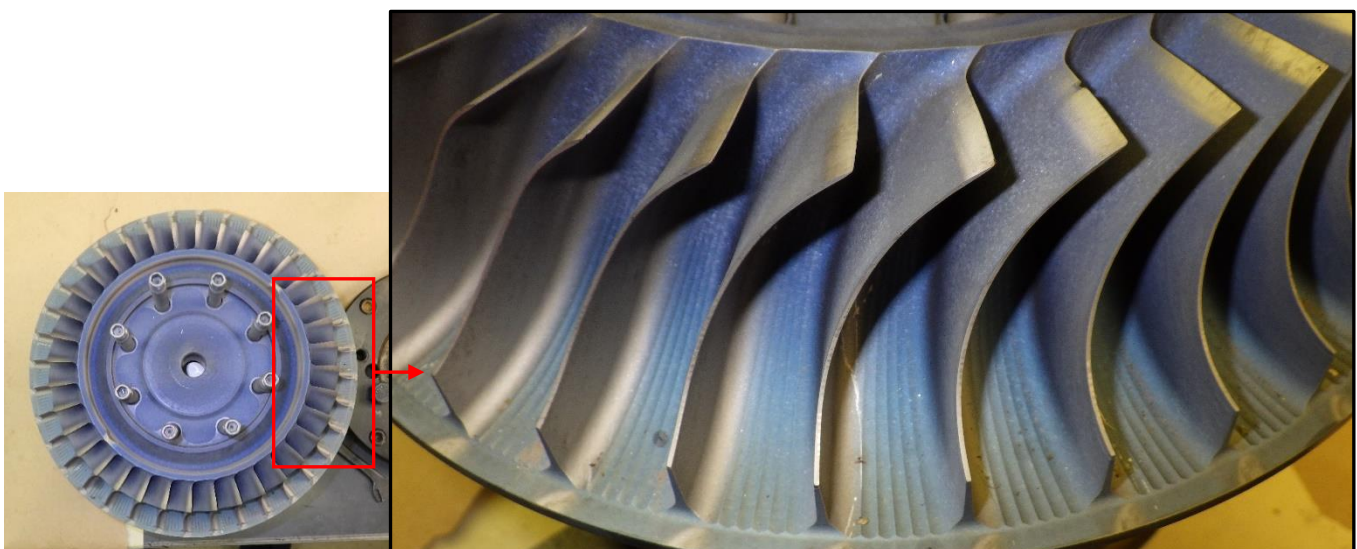


Photo No. 33

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Photo No. 34

3.2.5 Reduction Gearbox (RGB)

The RGB gears showed normal operational wear (Photo No. 35). The No. 4 roller bearing showed normal operational wear. The No. 4 bearing oil nozzle was intact. Nos. 5, 6 and 7 Bearings were not assessed.

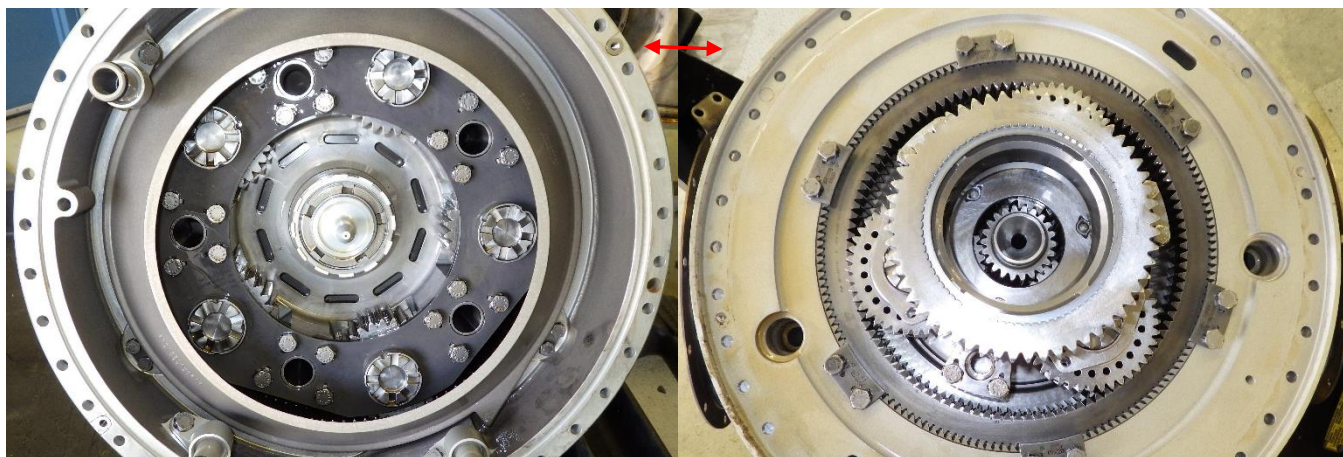


Photo No. 35

3.2.6 Accessory Gearbox (AGB)

The AGB gears showed normal operational wear.



4.0 MATERIALS INVESTIGATION

- 4.1 Examination of the CT blades showed that they exhibited overload fractures, likely corresponding to secondary damage (Photo No. 36 to Photo No. 38).

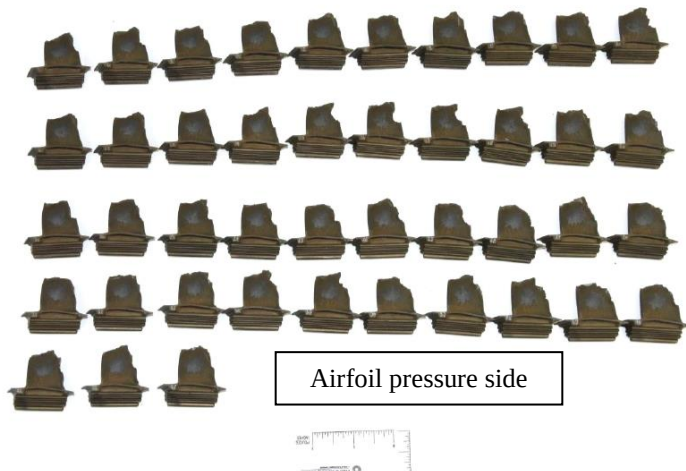


Photo No. 36

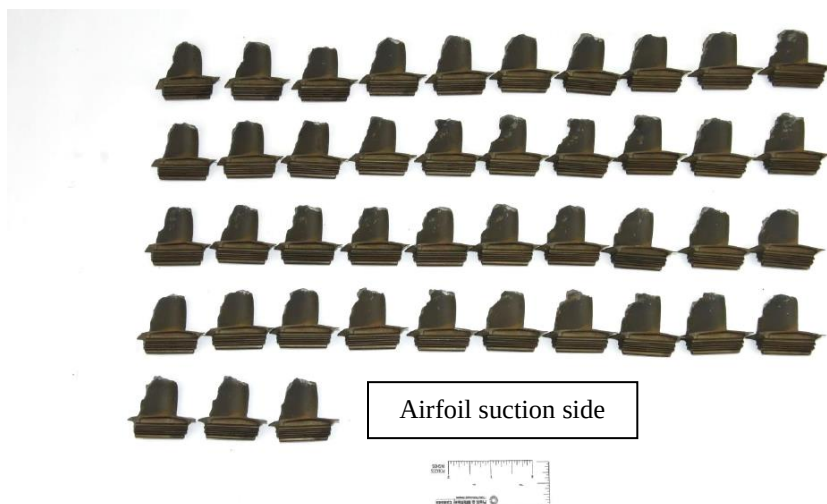


Photo No. 37

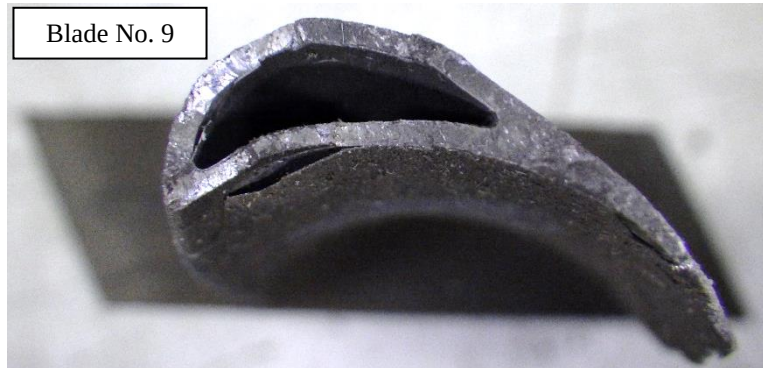
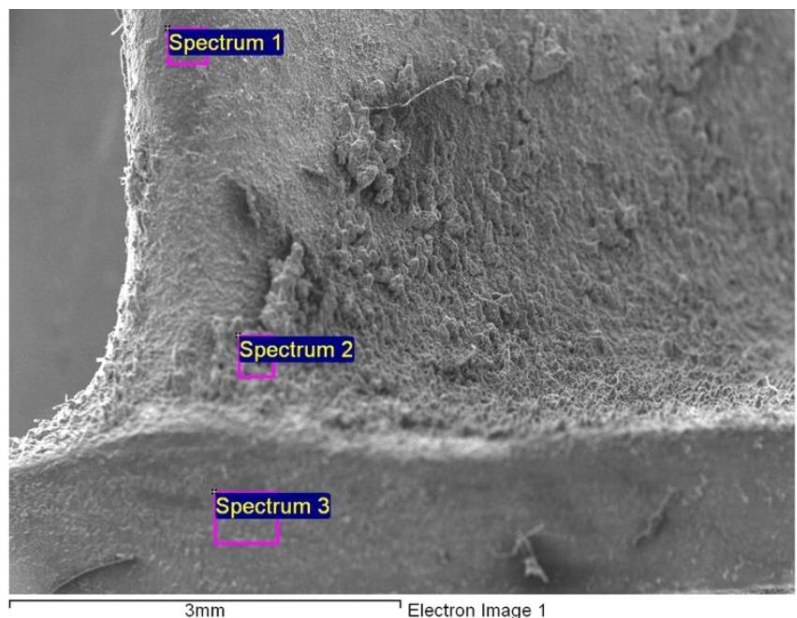


Photo No. 38

4.1.1 Energy Dispersive X-ray Spectroscopy (EDS) spot analyses of CT blade No. 11 leading edge area, semi-quantitative and standardless method, was used to determine the nature of the foreign melted debris build-up. The analyses showed aluminium and silicon rich mixed with a few other elements (Photo No. 39).



Processing option: All elements analysed (Normalised)

All results in weight%

Spectrum	O	Na	Mg	Al	Si	P	S	Cl	K	Ca	Ti	Cr	Mn	Fe	Ni	Zn	Total
Spectrum 1	42.76		1.29	34.59	5.47	4.16			0.20	3.97	0.42	0.38		2.06	3.28	1.42	100.00
Spectrum 2	40.40	1.41	1.17	11.58	21.36	1.37			1.77	2.15	4.82	0.85	0.97	10.97	1.19		100.00
Spectrum 3	43.69	1.71	0.80	13.53	20.03	2.75	0.09	0.20	1.53	1.39	2.68	0.89	0.40	6.61	3.47	0.23	100.00

Photo No. 39

4.2 PT1 blades as received are shown in Photo No. 40 and Photo No. 41. Examination of the PT1 blades showed that they exhibited overload fractures (Photo No. 42), likely corresponding to secondary damage.

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Airfoil pressure side



Photo No. 40



Airfoil suction side



Photo No. 41

Blade No. 28



Photo No. 42

- 4.3 Examination of the PT2 blades showed that the blades with the longer airfoil remnants exhibited overload fractures and impact damage consistent with secondary damage. All of the other blades with airfoil fractures slightly above their platform also exhibited overload fractures (Photo No. 45) and

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impact damage consistent with secondary damage, with the exception of blade No. 33 (circled, Photo No. 43 and Photo No. 44).

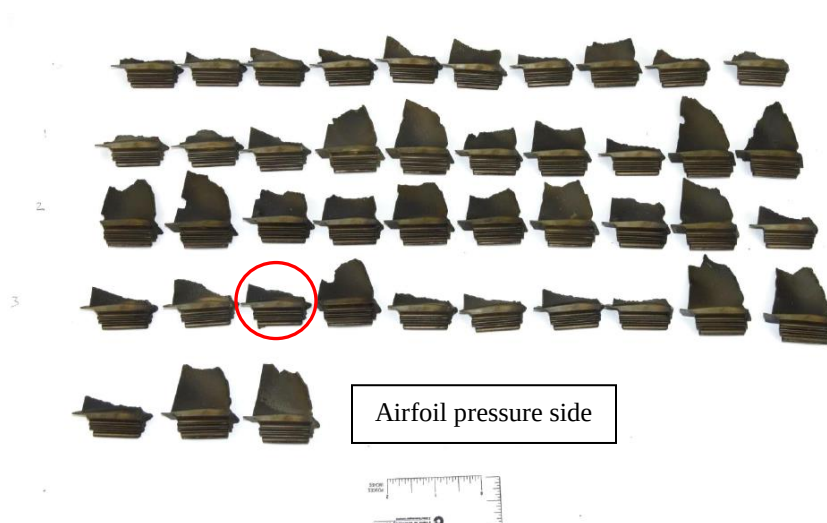


Photo No. 43

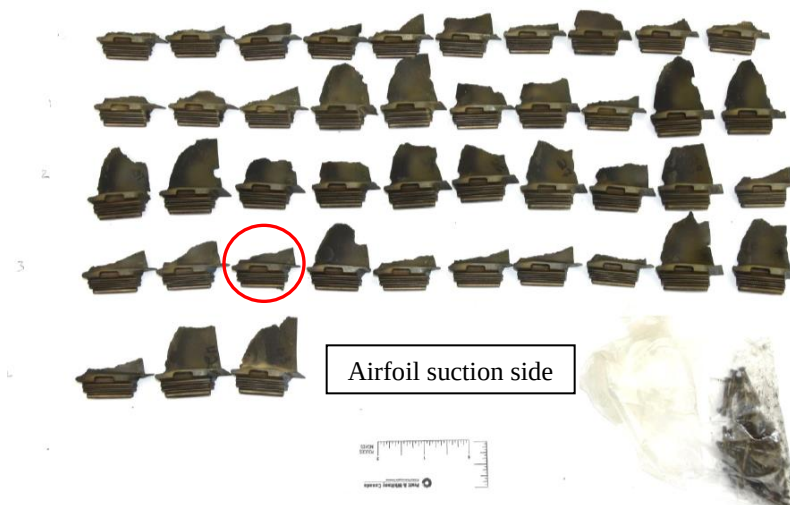


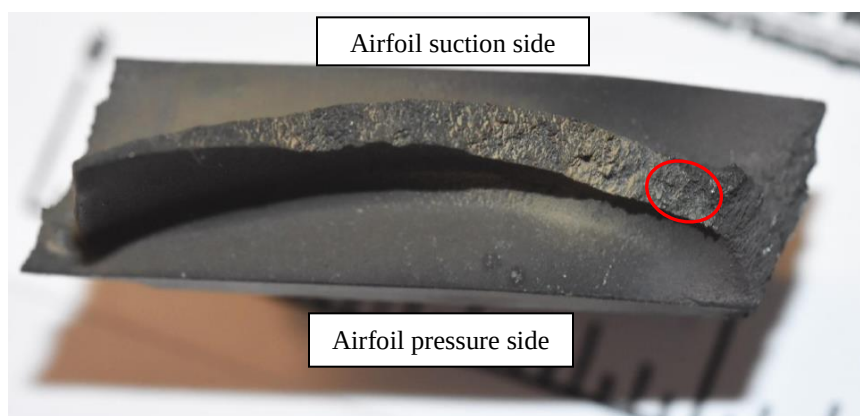
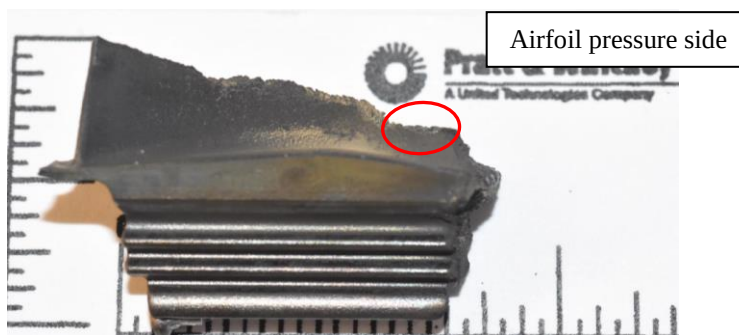
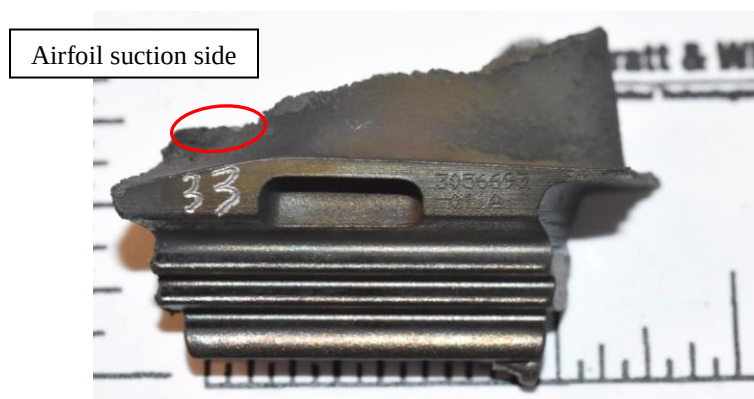
Photo No. 44



Photo No. 45



- 4.3.1 Examination of the blade No. 33 showed that the fracture surface immediately downstream from the leading edge secondary impact area exhibited evidence of fatigue (circled, Photo No. 46 to Photo No. 49). The PT2 blade No. 33 fracture portion immediately downstream from the leading edge secondary impact damage (delimited by the green dashed line, Photo No. 50) showed an area of the fracture with a granular aspect, of which several regions of fatigue initiated from microshrinkage porosities (Photo No. 51). This suggests that the microshrinkage likely acted as preferential initiation sites for the fatigue cracking. Due to the impact damage sustained by the blade leading edge, the exact origin area could not be established with certainty.

**Photo No. 46****Photo No. 47****Photo No. 48**

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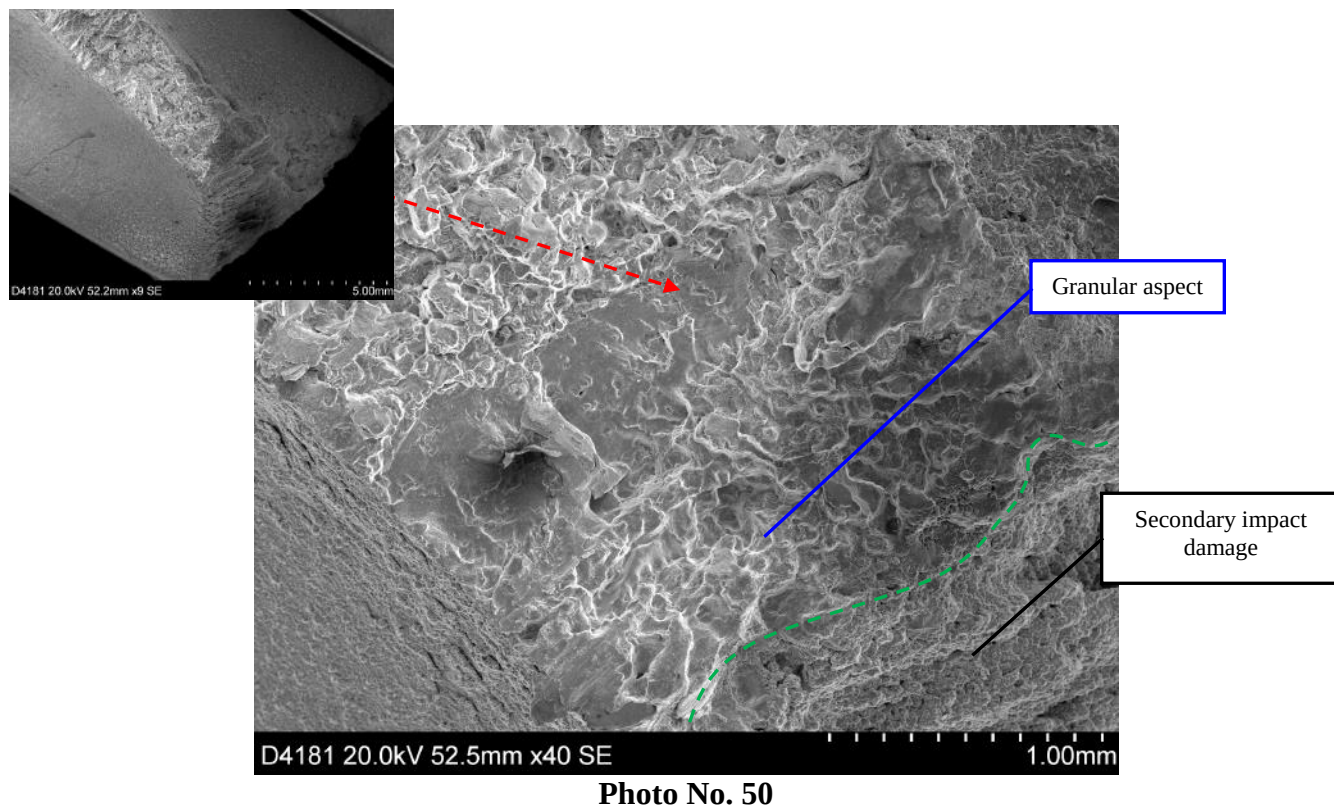
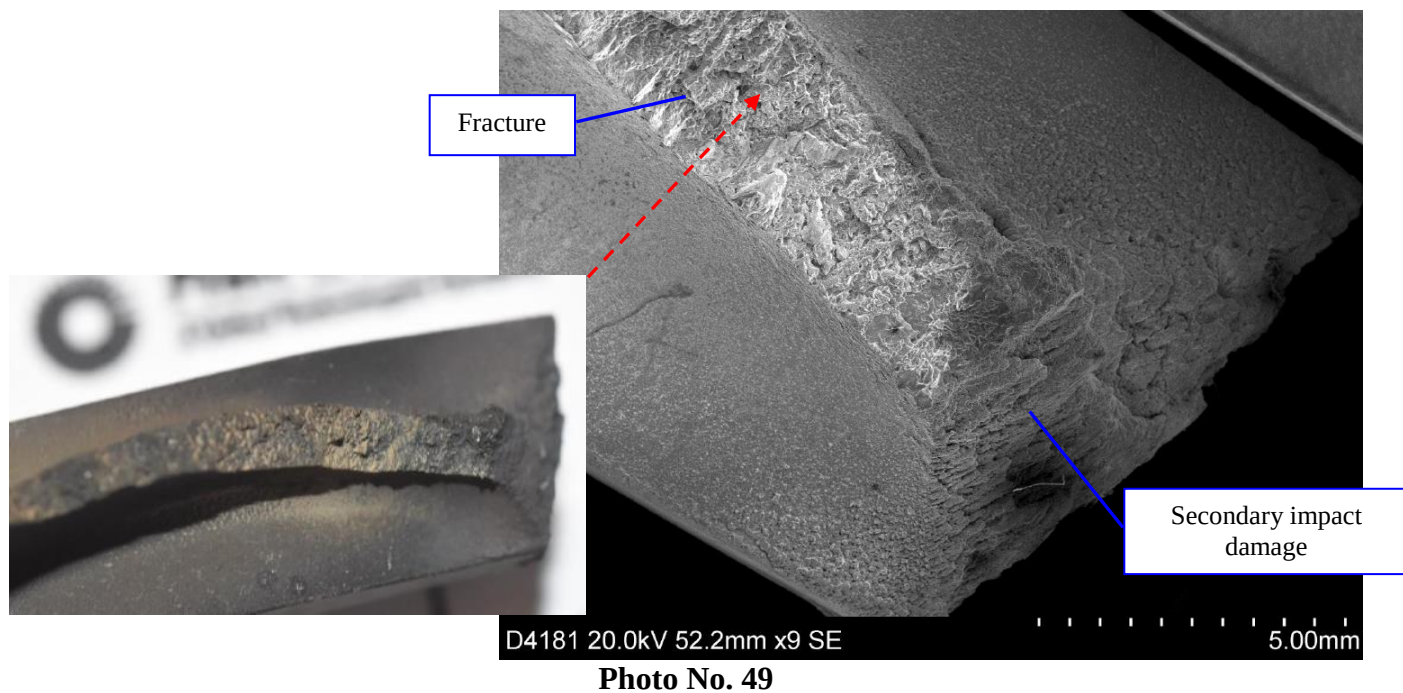
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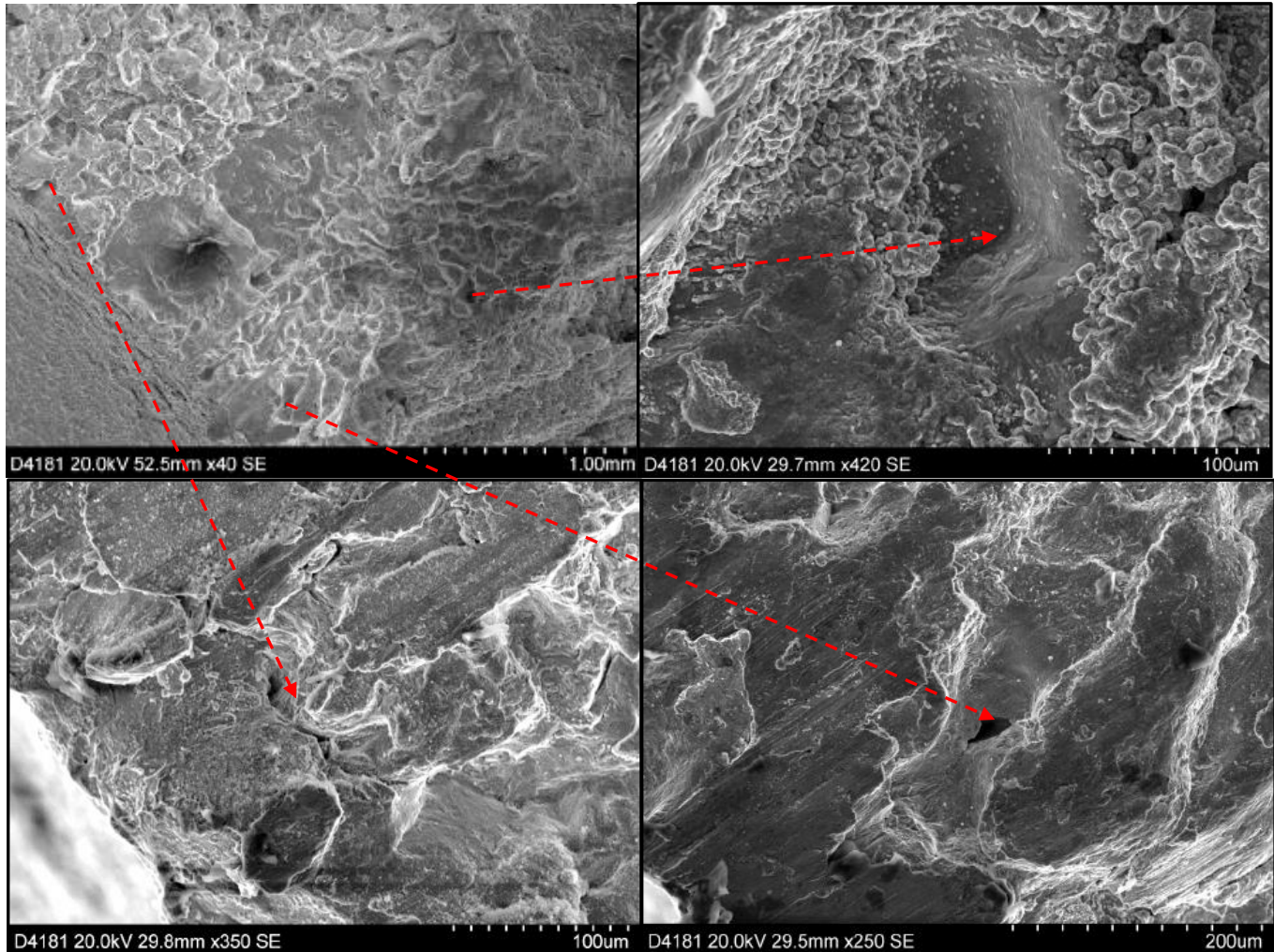


Photo No. 51

4.3.2 In general, the fatigue crack progression was chord wise, from the impacted area on leading edge area towards the trailing edge (yellow arrow, Photo No. 52), evidenced by the presence of crack progression marks (some were depicted by blue arrows, Photo No. 52).

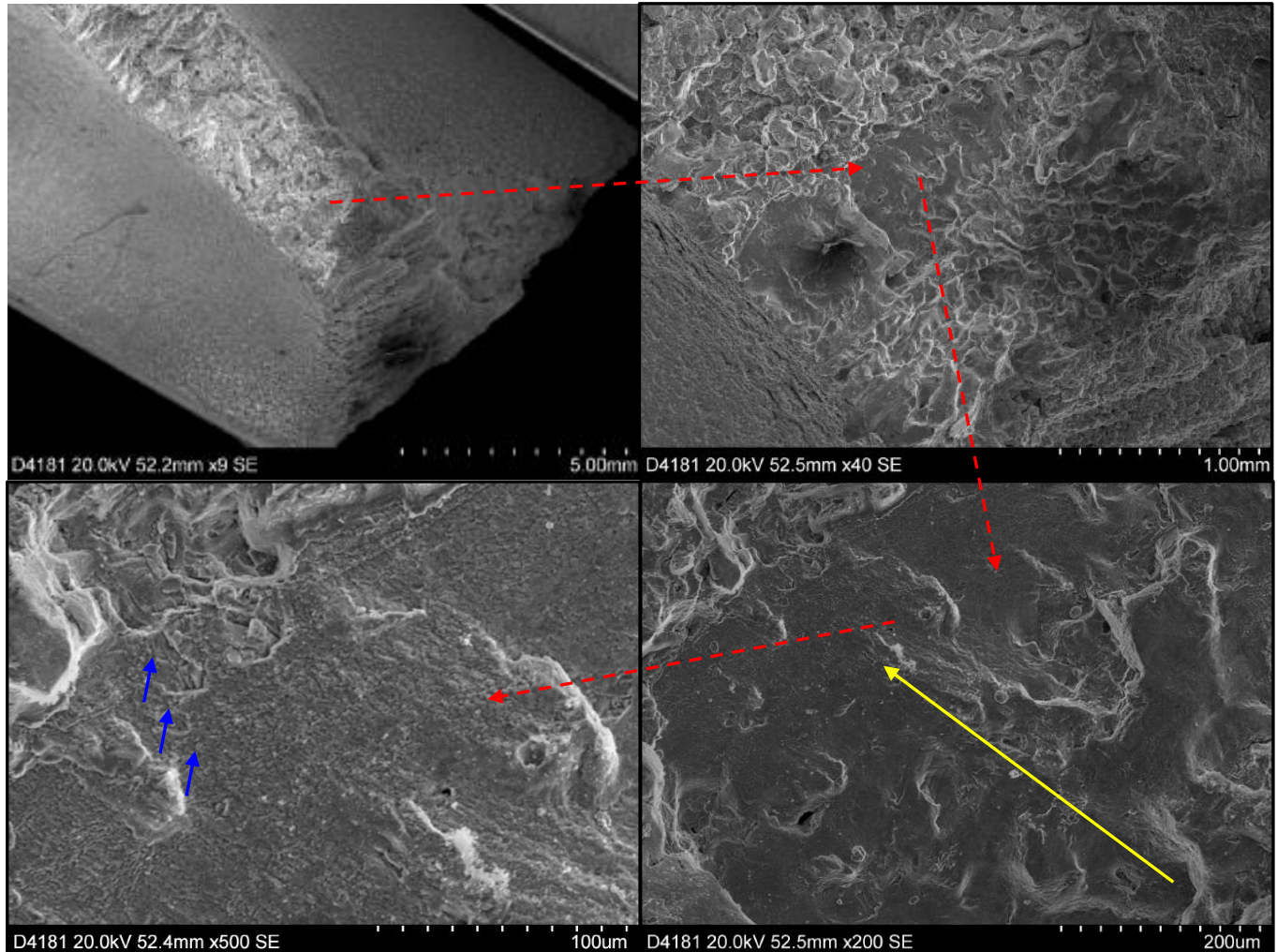


Photo No. 52

4.3.3 The remainder of the blade fracture exhibited evidence of ductile overload (circled, Photo No. 53).

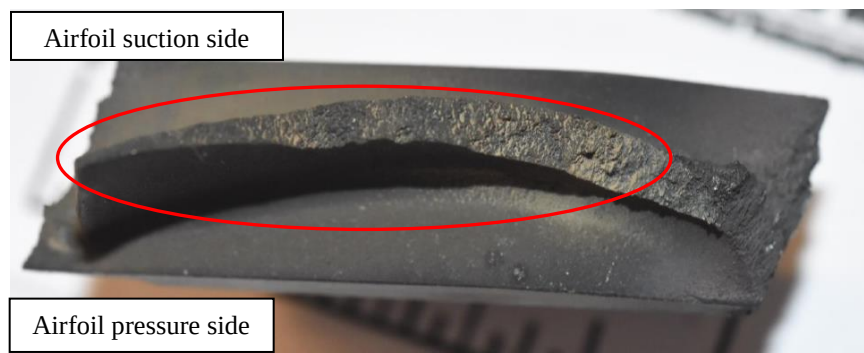


Photo No. 53



- 4.3.4 No metallurgical cross section was deemed necessary as the fatigue origin area could not be identified.
- 4.3.5 The secondary damage sustained by PT2 blade No. 33 platform prevented determining its S/N.
- 4.3.6 EDS spot analyses of PT2 blade No. 33 fracture surface slightly downstream from the leading edge impact area showed that the proportions of the elements detected, semi-quantitative and standardless method, were consistent with specifications (Photo No. 54). No evidence of foreign melted debris was found.

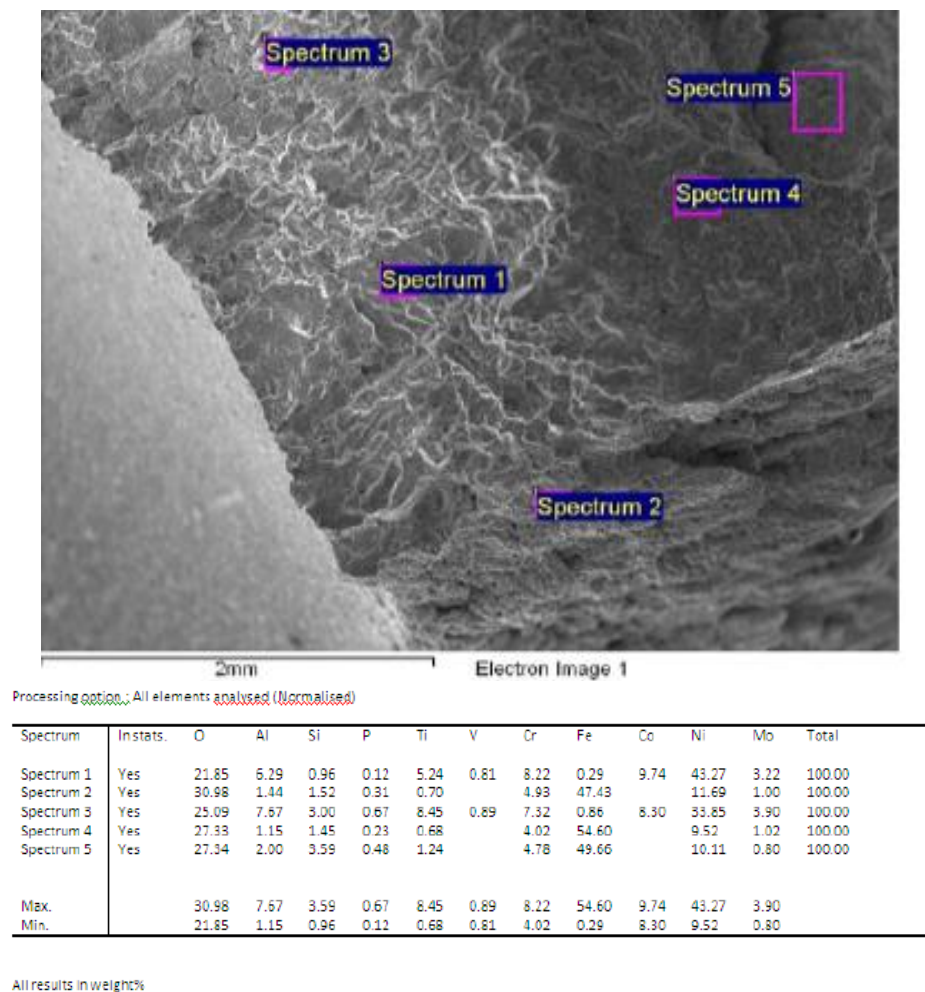


Photo No. 54

- 4.4 PT2 blades Nos. 32, 33 and 34 were submitted to the P&WC Chemical Laboratory for further analysis (see section 5.0).



5.0 CHEMICAL ANALYSIS

5.1

Some large particles from the oil filter were analysed by SEM-EDX. Results are shown in Table 1. The analysis revealed particles composition typical to the hardware which is indicative that severe rubbing occurred.

Sample ID	Summary of Analysis
Oil filter Sample No. 1 (Residue collected from the oil filter, Photo No. 55) (Patch with presence of large metallic particles, Photo No. 56)	The particles analysed by APA were mainly composed of : • Iron base alloy, some particles were similar to low alloy steel and similar to 300 series SST. The low alloy steel particles included particles similar to UNS G93106 (AMS6260, 6265, 6267) • An interaction between the low alloy steel UNS G93106 and the 300 series SST particles is observed. • Traces of Cadmium particles and presence of Cadmium contamination on some Iron base particles • Traces of Aluminum particles The large particles analysed by SEM-EDX were composed of Aluminum alloy.

Table 1



Photo No. 55

**Photo No. 56**

5.2 The debris from hot section (4 locations) were analysed by scanning electron microscopy (SEM-EDX).

5.2.1 The debris were similar to environmental debris (e.g. soil, sand). The shape of the debris could suggest that the debris have seen high temperature. Results are shown in Table 2.

Sample ID	Summary of Analysis
Debris from combustion chamber outer liner Sample No. 1 (Photo No. 57 and Photo No. 58)	The debris were mainly composed of Silicon with some Aluminum in presence of Oxygen. Traces of Sodium, Potassium, Calcium, Titanium and Iron were also detected.
Debris from combustion chamber inner liner Sample No. 2 (Photo No. 59)	Idem to sample No. 1
Debris from CT vane ring Sample No. 3 (Photo No. 60)	Idem to sample No. 1, but traces of Magnesium were also detected.
Debris from PT1 vane ring Sample No. 4 (Photo No. 61)	The debris were mainly composed of Silicon with some Aluminum in presence of Oxygen. Traces of Sodium, Potassium, Calcium, Titanium, Chromium, Iron, Cobalt and Nickel were also detected. In some areas the Nickel is higher, suggesting traces of Nickel alloy; however the alloy identification cannot be determined.

Table 2



Photo No. 57



Photo No. 58



Photo No. 59



Photo No. 60



Photo No. 61

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5.3 The debris from cold section (5 locations) were analysed by SEM-EDX.

5.3.1 The debris from samples were mainly composed of Silicon with some Aluminum in presence of Oxygen; these composition were similar to environmental residue (e.g. soil, sand). Results are shown in Table 3.

Sample ID	Summary of Analysis
Residue from 1 st stage compressor bore Sample No. 1 (Photo No. 62)	The debris were mainly composed of Silicon with some Aluminum in presence of Oxygen. Traces of Iron and Potassium were also detected.
Residue from P2.5 1 st stage stator external surface Sample No. 2 (Photo No. 63)	Similar to sample No. 1, but traces of Calcium and Titanium were also detected.
Residue from P3 GG case Sample No. 3 (Photo No. 64)	Similar to sample No. 1, but traces of Sodium and Calcium were also detected.
Residue from Diffuser Apex entries Sample No. 4 (Photo No. 55)	Similar to sample No. 1, but traces of Sodium, Calcium and Titanium were also detected
Residue from Impeller Sample No. 5 (Photo No. 56)	Similar to sample No. 1, but traces of Titanium were also detected.

Table 3**Photo No. 62**

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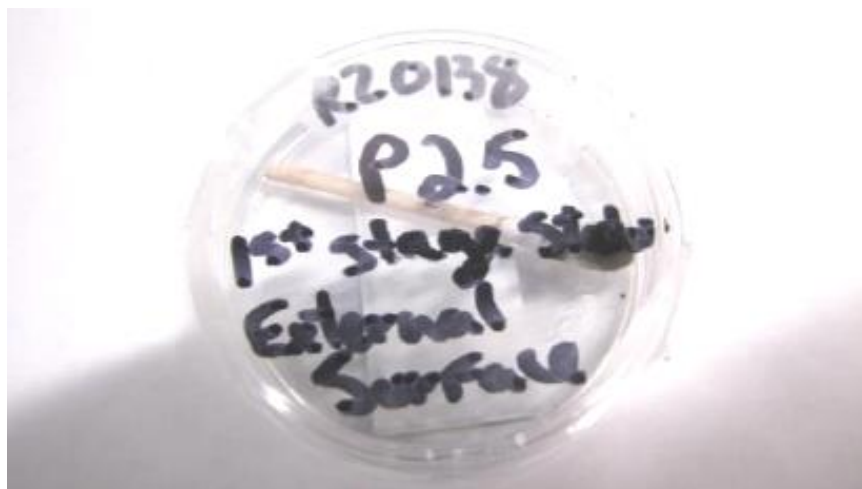


Photo No. 63



Photo No. 64



Photo No. 65

**Photo No. 66**

- 5.4 The three PT2 blades were analysed by SEM-EDX on their fracture surface and on their airfoil edge.
- 5.4.1 All three blades showed significant Silicon rich residue with presence of Aluminum. Also the three parts showed presence of Iron rich residue on their surface, but the high level of Oxygen found with the Iron could suggest Iron oxide. This may have been due to all PT2 blades rubbed against the PT housing and the No. 3 bearing Carbone seal which both are manufactured in steel. Results are shown in Table 4.

Sample ID	Summary of Analysis
Blade No. 32 (Photo No. 67 to Photo No. 72)	Fracture area: Nickel base alloy similar to specifications. Some areas showed significant level of Silicon. On the airfoil edge and on the suction side: Presence of Silicon Close to the airfoil edge and mainly on the pressure side: Presence of high level of Iron with presence of Oxygen, Chromium and Nickel with traces of Silicon and Aluminum
Blade No. 33 (Photo No. 73 to Photo No. 78)	Fracture area: Nickel base alloy similar to specifications. Some areas with significant level of Silicon. On the airfoil edge and on the suction side: Presence of Silicon Close to the airfoil edge and mainly on the pressure side: Presence of high level of Iron with presence of Oxygen, Chromium and Nickel with traces of Silicon and Aluminum
Blade No. 34 Photo No. 79 to Photo No. 84)	Fracture area: Nickel base alloy similar to specifications. Some areas showed significant level of Silicon. At the shortest end of the fracture, high level of Iron was detected. On the airfoil edge and close to the leading edge on suction side: Presence of Silicon, sometime with Aluminum and/or Iron Close to the airfoil edge on pressure side and on both sides: Presence of high level of Iron with presence of Oxygen, Chromium and Nickel with traces of Silicon and Aluminum

Table 4



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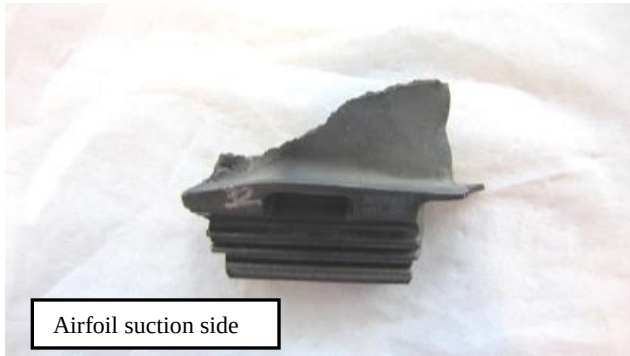


Photo No. 67



Photo No. 70

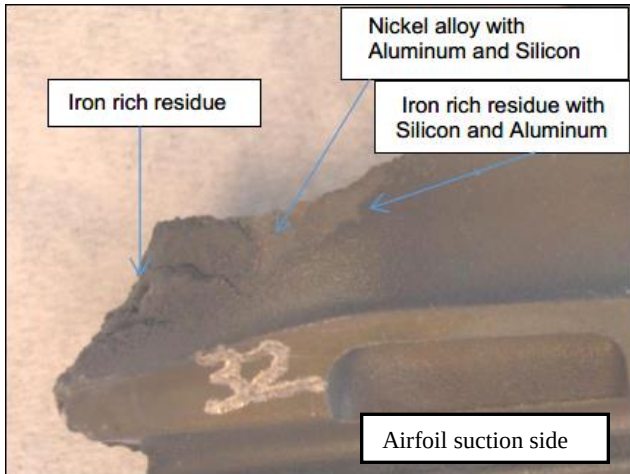


Photo No. 68

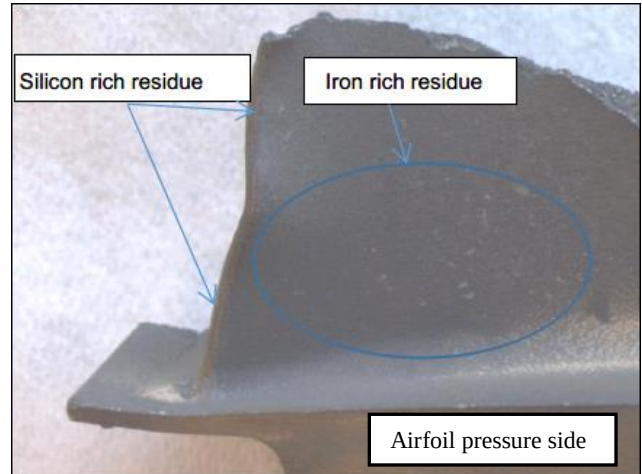


Photo No. 71

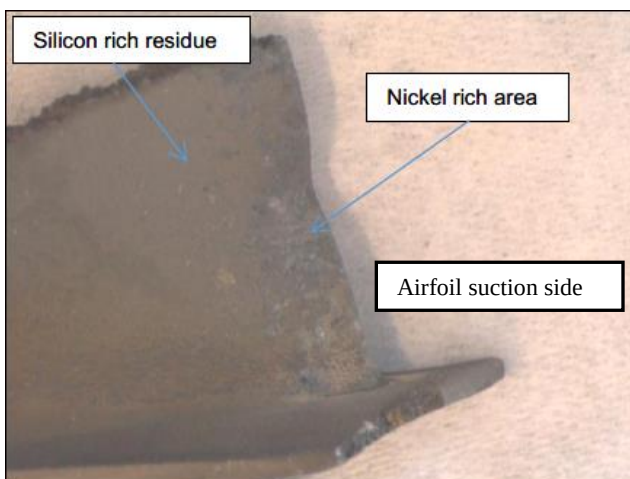


Photo No. 69

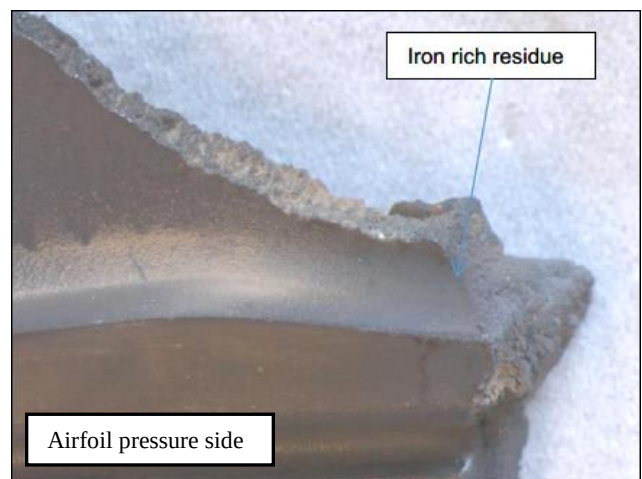


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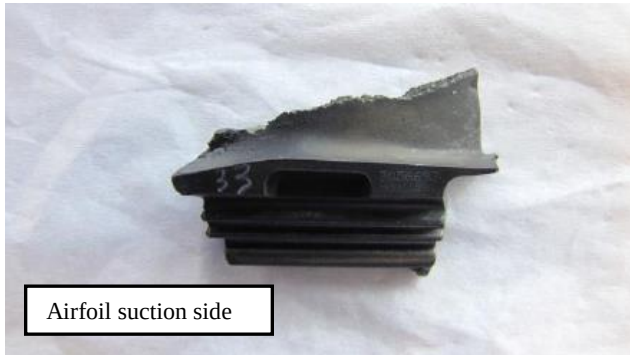


Photo No. 73

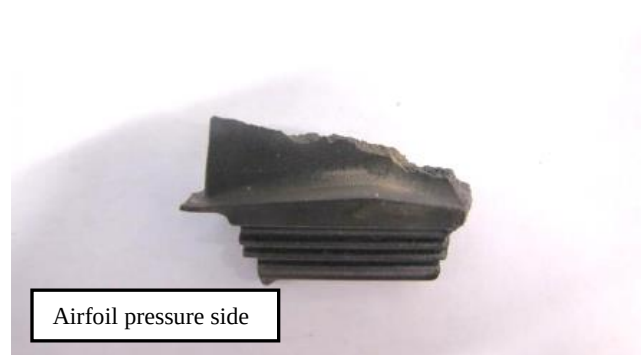


Photo No. 76



Photo No. 74

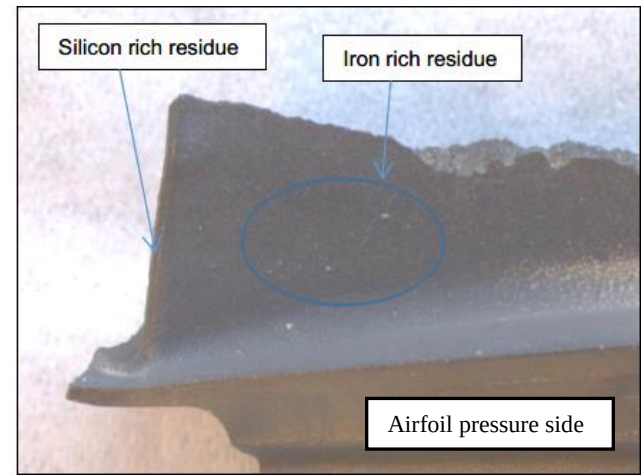


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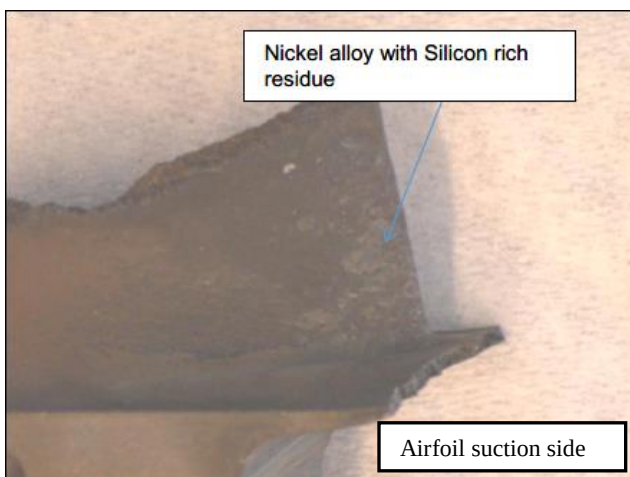


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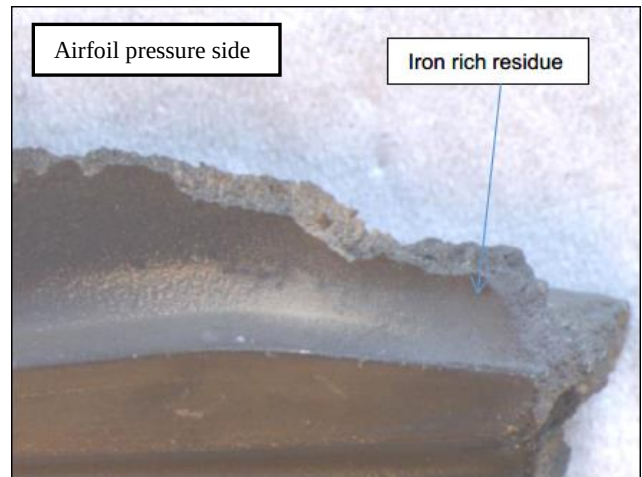


Photo No. 78



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Photo No. 79

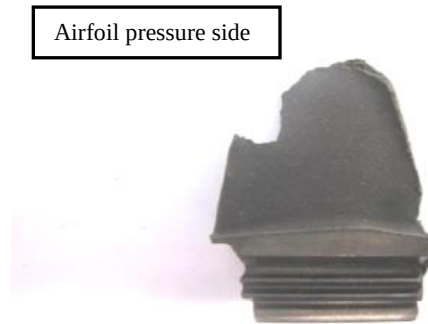


Photo No. 82



Photo No. 80

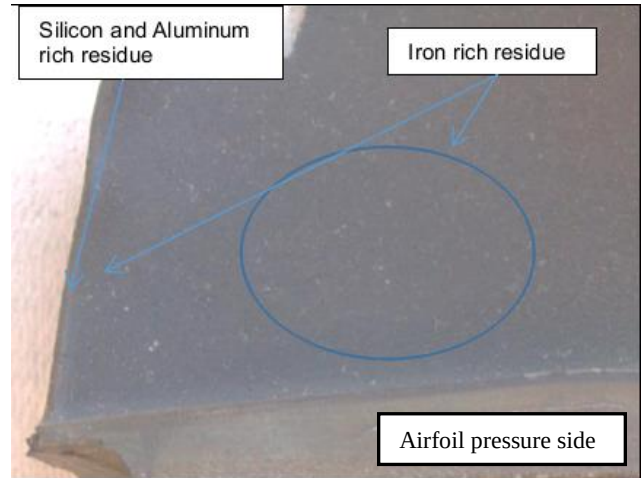


Photo No. 83

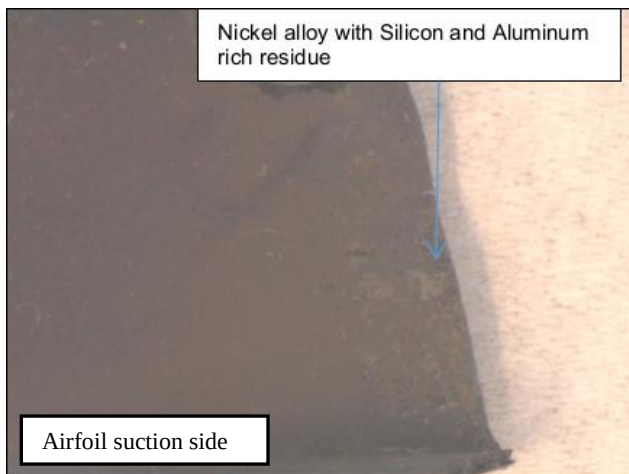


Photo No. 81

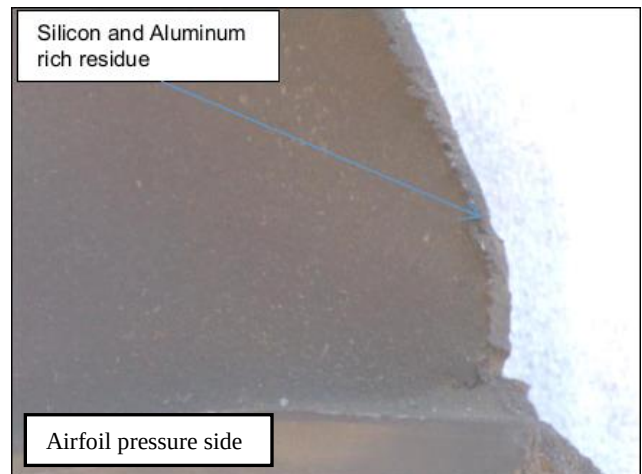


Photo No. 84



6.0 ACCESSORIES ANALYSIS

- 6.1 Investigation of the accessories comprised inspection and testing of the fuel pump, fuel control unit (FCU), flow divider valve (FDV), fuel oil heat exchanger (FOHE), over-speed governor (OSG) and fuel nozzles, and disassembly and inspection of the compressor bleed valve (BOV) and propeller governor (CSU). See Reference A for details.

7.0 REFERENCE LISTING

(A) P&WC Accessories Accident Report No. 19ECN00197.

Service Investigation

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REFERENCE “A”

ACCESSORIES ACCIDENT REPORT

Date issued: 2019-08-20

Customer: Air Spray Airtankers
Engine Model: PT6A-67F
Engine S/N: RZ0138

This report is to support the engine review regarding an accident that occurred on 14 August 2018.

1.0 Event:

The aircraft force-landed to logging road terrain during an aerial fire suppression flight in Stevens County north of Northport, Washington. The floatplane was substantially damaged and the sole pilot onboard was seriously injured.

2.0 Summary of findings:

Investigation of the accessories comprised inspection and testing of the fuel pump, fuel control unit (FCU), flow divider valve (FDV), fuel oil heat exchanger (FOHE), over-speed governor (OSG) and fuel nozzles, and disassembly and inspection of the compressor bleed valve (BOV) and propeller governor (CSU). Observations from testing of the fuel pump, FDV and FOHE were satisfactory. It was not possible to test the CSU due to impact damage. Observations recorded during investigation of the FCU, and OSG were indicative of impact and fire damage and typical field adjustment. The condition of the BOV components was unremarkable. Streaks and voids were observed during testing of two of the fuel nozzles and chemical analysis of residue collected from the fuel nozzles (before testing) identified minor organic and metallic traces.

Export Control Classification		
* Data is subject to the jurisdiction of the Export and Import Controls Bureau of the Department of Foreign Affairs and International Trade of Canada, Department of Commerce of the United States and/or Department of State of the United States ** Data is not subject to the jurisdiction of the Department of Commerce of the United States or Department of State of the United States but would become subject if exposed to any US involvement.	Jurisdiction	
	Canadian ECL(s)*	5400
	ECCN(s)*	9E991
	P-ECCN(s)**	9E991
	USML(ITAR)*	
	P-USML**	
Date: 8/23/2019		
Badge: E-28042		

ACCESSORIES ACCIDENT REPORT

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3.0 Conclusion:

There were no defects or damage evident that would have prevented normal operation prior to the event.

4.0 Investigation:

Conducted at: Pratt & Whitney Canada

Initiated on: 14 May 2019

In attendance:

Name	Representing

List of Accessories:

Accessory	Times/cycles
Fuel pump	559.0 hours 321 cycles since new
Fuel control unit (FCU)	559.0 hours 321 cycles since new
Compressor bleed valve (BOV)	559.0 hours 321 cycles since new
Flow divider and dump valve (FDV)	559.0 hours 321 cycles since new
Fuel oil heat exchanger (FOHE)	559.0 hours 321 cycles since new
Propeller governor (CSU)	559.0 hours 321 cycles since new
Fuel nozzles	Unknown
Over-speed governor (OSG)	Unknown

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Accessory: Fuel pump

Note: This unit was on the engine at original engine delivery.

Investigation Results:

The fuel pump was removed from the engine attached to the fuel control unit. The exterior of the fuel pump was soiled. The driveshaft could not be turned by hand (this is normal for this pump configuration). Lockwire was present at all locations.

Prior to testing the fuel pump the outlet filter and inlet screen were removed for inspection and a small amount of fuel residue was collected. There was no significant debris in the outlet filter or inlet screen and no evidence of water or solid contamination in the fuel residue. A slave outlet filter was installed and the fuel pump was tested in accordance with [REDACTED]. The test was satisfactory.

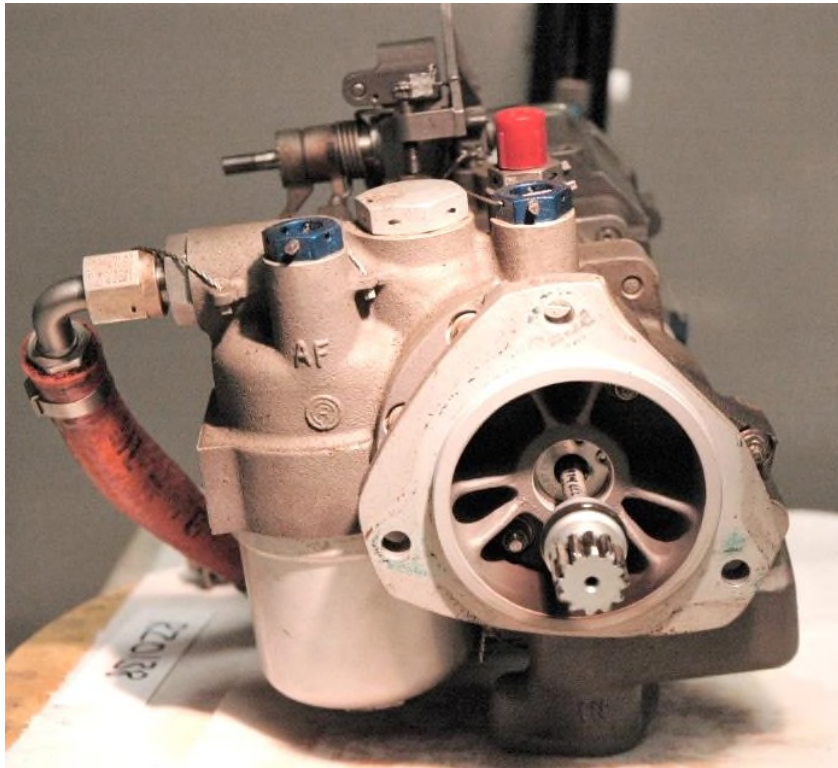


Figure 1
Fuel pump and fuel control unit as received

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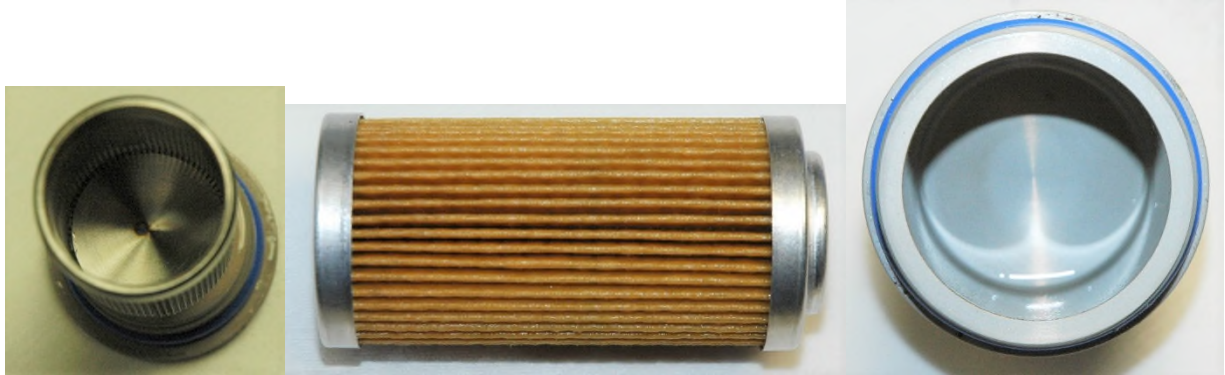


Figure 2

Fuel pump inlet screen (left), outlet filter (centre) and outlet filter bowl (right) before testing

Accessory: Fuel control unit (FCU)

Note: This unit was on the engine at original engine delivery.

Investigation Results:

The FCU was removed from the engine attached to the fuel pump. The exterior of the FCU was soiled. The condition lever, power lever and manual override lever moved freely over their full ranges. The condition lever was bent and the gap between the lever and the housing was greater than would normally be present (arrow, Figure 3). There was un-broken orange anti-tamper paint in the socket of the condition lever shut-down stop screw. There was unbroken orange anti-tamper paint in the socket of the base screws, and on the bellows locknut. Lockwire was present at all locations. The lockwire seals were marked [REDACTED].

Prior to testing the FCU the P3 inlet elbow, Py outlet elbow, fuel inlet elbow and fuel outlet elbow were removed for inspection. No contamination was present in the elbows. The tach-valve inlet screen was examined and confirmed to have no contamination present. The FCU was tested in accordance with [REDACTED]. The following observations were recorded:

[REDACTED] Lever torques: the torque required to rotate the power lever was 2in.lb above the maximum limit in a clockwise direction and 1in.lb over the maximum limit in a counter-clockwise direction. This may have been due to the impact.

[REDACTED] Condition lever and shut-down (low idle) test: the speed required to achieve the target fuel outlet flow was 263RPM above the maximum limit. With the speed set at the middle of the tolerance band the fuel outlet flow was 25pph above the target fuel flow.

[REDACTED] Condition lever and shut-down (high idle) test: the speed required to achieve the target fuel outlet flow was 202RPM above the maximum limit. With the speed set at the middle of the tolerance band the fuel outlet flow was 33pph above the target fuel flow.

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Power lever reserve (maximum reverse) test: the speed required to achieve the target fuel outlet flow was 580RPM above the maximum limit. With the speed set at the middle of the tolerance band the fuel outlet flow was 174pph above the target fuel flow.

Power lever reserve (maximum forward) test: the speed required to achieve the target fuel outlet flow was 130RPM above the maximum limit. With the speed set at the middle of the tolerance band the fuel outlet flow was 39pph above the target fuel flow.

These test results suggested that the FCU had been adjusted to govern slightly early.

Power lever reserve test (dead-band): The dead-band angle (the power lever position where the low idle stop screw lifts from its stop) was 3 degrees above the maximum limit.

Governor droop-schedule: The fuel outlet flow difference between the prior two test points was 121pph below the test point minimum limit.

Start and acceleration test: with the power lever at maximum and the condition lever at the fuel outlet flow was 5.6pph above the maximum limit.

In order to determine if the test observations were influenced by field adjustment the power lever low idle stop, maximum Ng stop, dead-band and the condition lever high idle were adjusted and the relevant test points were repeated. This restored the fuel outlet flows and speeds at . The condition lever gap was re-set. This corrected the torque at . There was no change at . The fuel outlet flow (start and acceleration test) with the power lever at maximum and the condition lever at the fuel outlet flow was 3pph above the maximum limit. The test observations were insignificant and would not impede the function of the FCU.

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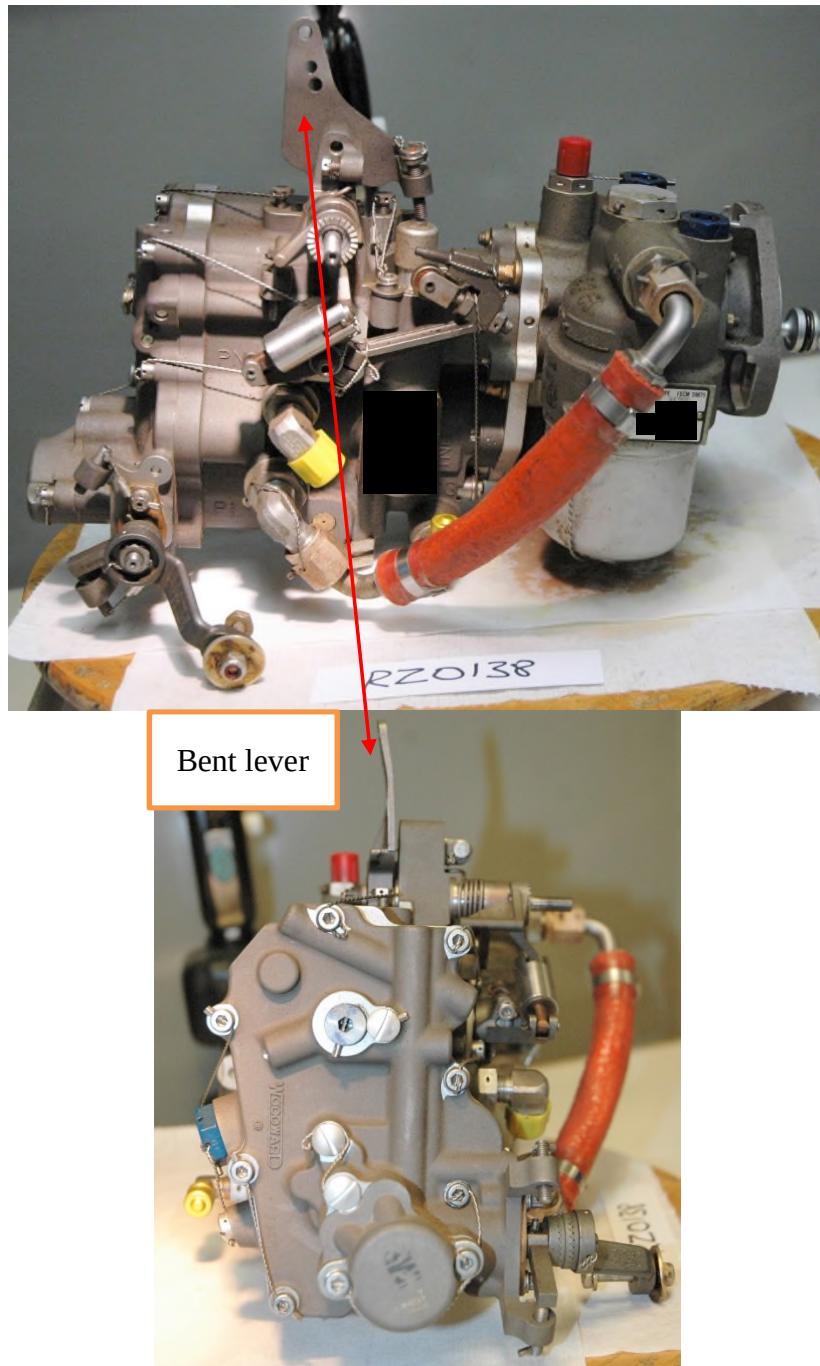


Figure 3
FCU and pump as received

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Accessory: Compressor bleed valve (BOV)

Note: This unit was on the engine at original engine delivery.

Investigation Results:

The exterior of the BOV was lightly soiled. The piston moved freely and there was a light ring of ash around the sides of the piston and slightly heavier ash deposits on the bottom of the piston. A packing was present on the seat at the guide-pin. Lockwire was present between the primary and secondary orifice plugs.

The BOV was disassembled to inspect the components. The sealing rings were present and intact. There was no significant wear or damage observed on the piston, housing, screws or seat. The gasket was present and intact between the cover and the main housing.

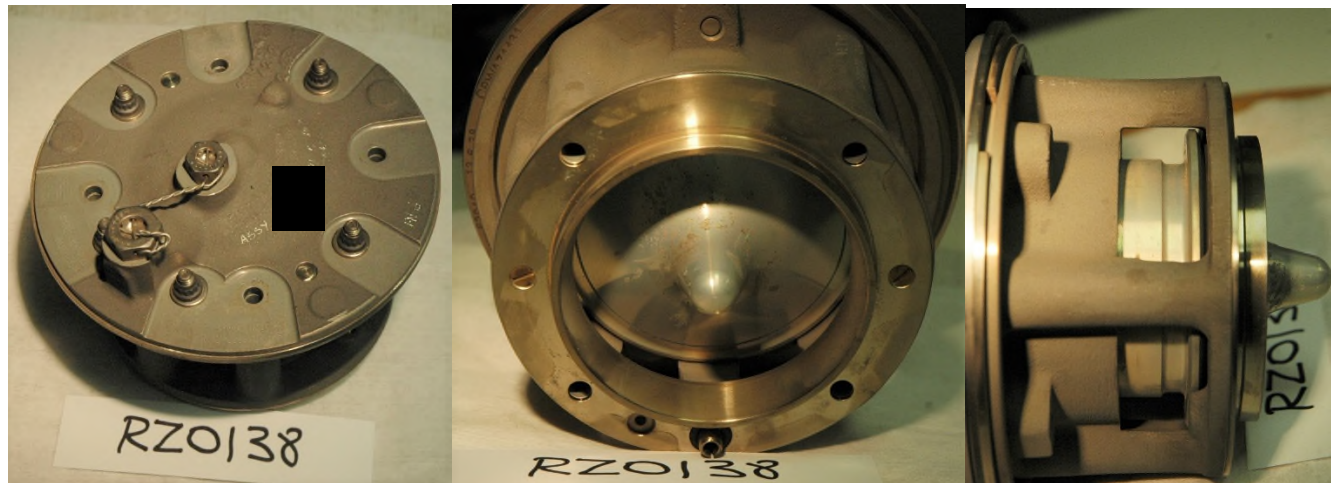


Figure 4
BOV as received

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Figure 5
BOV disassembled

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Accessory: Flow divider valve (FDV)

Note: This unit was on the engine at original engine delivery.

Investigation Results:

The FDV was removed from the engine attached to the No. 8 (inlet) fuel manifold adapter. The exterior of the FDV was generally clean and fuel wetting was observed. The coupling nipple at the dump port was loose and could be turned by hand (red arrow, Figure 6). Lockwire was present at the dump-port fitting screws and the inlet adapter screws. Following separation of the FDV from the inlet manifold adapter no significant scratches or leak-paths were observed on the sealing faces and the primary and secondary port passage packings were present and intact.

The FDV was tested in accordance with [REDACTED]. The test was satisfactory.

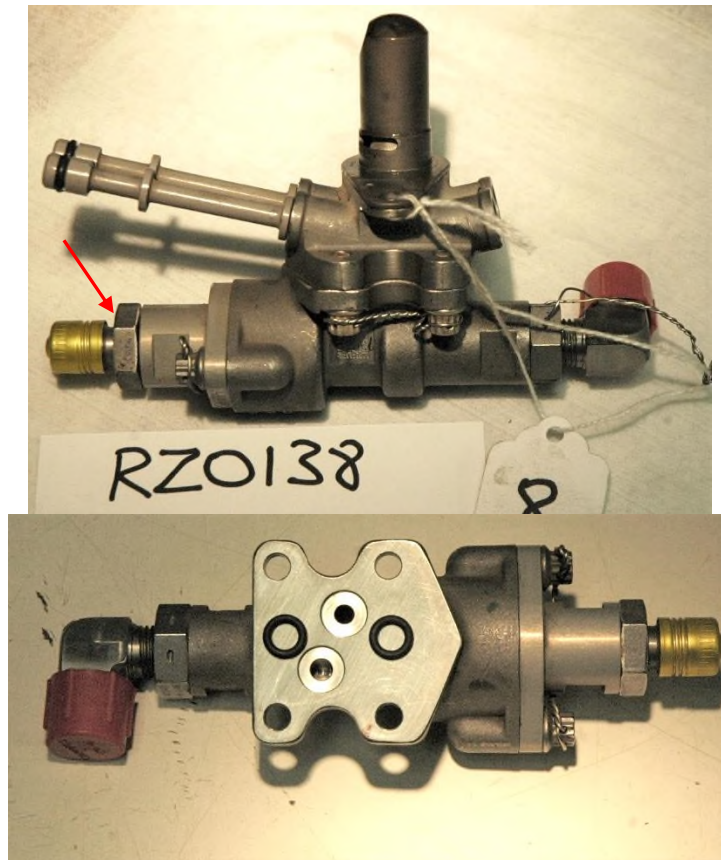


Figure 6
FDV and inlet fuel nozzle as received and before testing

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Date issued: 2019-08-20

Accessory: Fuel oil heat exchanger (FOHE)

Note: This unit was on the engine at original engine delivery.

Investigation Results:

The exterior of the FOHE was soiled. The identification label was present, intact and legible. There were two impact marks on the bottom of the tank (circled, Figure 7). Lockwire was present at the thermal element cap and the core flight-plug.

A low-pressure air supply was connected to the FOHE fuel inlet, the fuel outlet port was blanked and the unit was immersed in a water bath to check for bubbles that could indicate a breach between the oil and fuel cores. No bubbles were observed. The thermal element was removed from the unit and tested in accordance with [REDACTED]. The test was satisfactory.

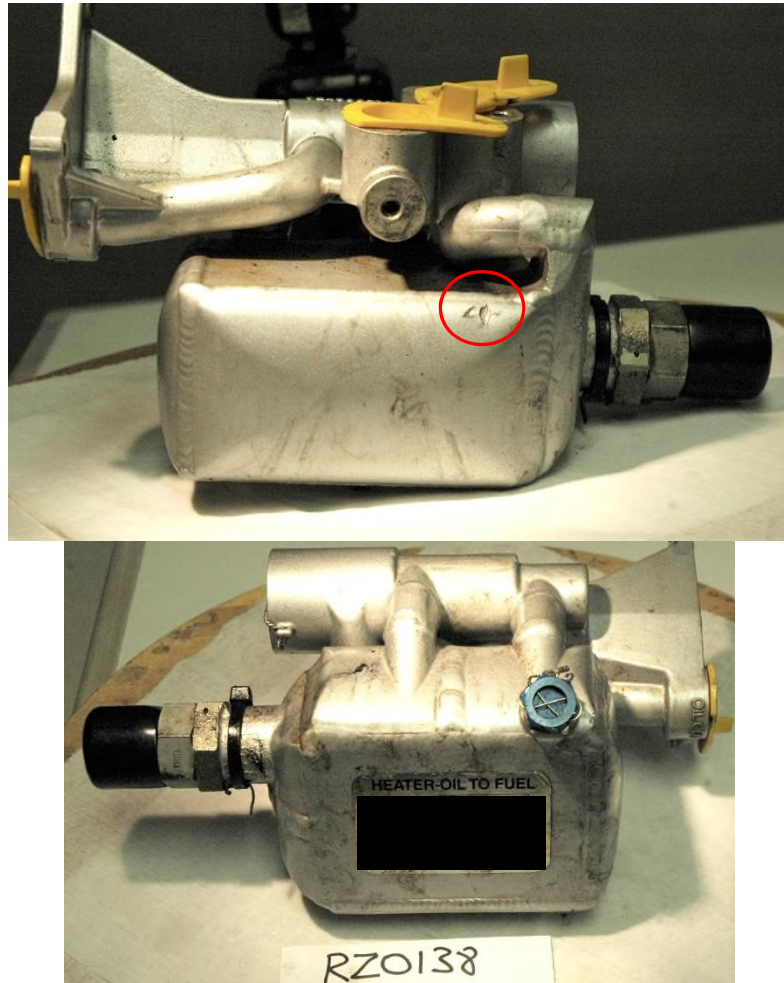


Figure 7
FOHE as received

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Date issued: 2019-08-20



Figure 8
FOHE thermal element

Accessory: Propeller governor (CSU)

Note: This unit was on the engine at original engine delivery.

Investigation Results:

The exterior of the CSU was soiled. The speed setting lever and top of the cover were missing and a red shipping-cap had been placed in the hole. The driveshaft turned freely. The reset arm moved freely and returned under the influence of its spring. The beta-valve clevis moved freely and returned under the influence of its spring. The feathering valve plunger moved freely and returned under the influence of its spring. There was an incomplete tie-wrap around the beta-valve housing. There was no debris observed in the gasket screen. There was unbroken red anti-tamper paint on the feathering stop screw and the reset-arm stop screw. There was an impact mark on the wiring pocket cover at the wiring schematic diagram (see figure 10). Lockwire was present at all locations. The lockwire seal was marked [REDACTED].

The inside of the ball-head cavity was clean and oil wetting was observed. There was no evidence of cavitation on the gears or in the pockets. The pilot valve slid freely in the gear-shaft. The packings were present on the beta-valve plunger and sleeve. The cover and bottom gaskets were present and intact. The reset rod was correctly engaged with the pilot-valve and slid freely in the bore of the housing. The packing was present and intact on the pressure relief valve housing.

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Figure 9
CSU as received



Figure 10
CSU impact marks

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Figure 11
CSU disassembled

Accessory: Fuel nozzles

Note: It was not possible to determine if this hardware was on the engine at original engine delivery.

Investigation Results:

The No. 8 (inlet) fuel nozzle was removed from the engine attached to the FDV. Powdered residue was present between the nozzle sheath and the adapter stem on the No. 2, 3, 4, 5, 6, 11, 12 nozzles. Soot accumulation was notable on the crowns of the No. 13 and 14 nozzle sheaths. Lock-washers were present at each nozzle tip.

The fuel nozzles were tested in accordance with [REDACTED]. The following observations were recorded:

Nozzle position	Observation
1	With the primary pressure [REDACTED] and the secondary pressure at [REDACTED] up to 30% streaks and voids were observed.
5	With the primary pressure at [REDACTED] up to 30% streaks and voids were observed.

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Chemical analysis of residue from the fuel nozzles identified the presence of mostly silicon (Si) and aluminum (Al) found in presence of oxygen (O) and carbon (C). Traces of potassium (K), calcium (Ca), titanium (Ti) and iron (Fe) were also observed.

The remainder were identified as:

- Several aluminum particles (size up to 240 x 160µm)
- Some particles rich in iron, aluminum, silicon and calcium (size up to 50 x 25µm)
- Some particles rich in nickel (size up to 60 x 60µm)
- Traces of particles rich in titanium
- Traces of particles similar to 400 SST
- Traces of particles similar to 300 SST

The presence of aliphatic hydrocarbons and a band around 1730 cm⁻¹ (possibly an ester group) were observed by Fourier-transform infrared spectroscopy (FTIR). The FTIR fingerprint was undefined.

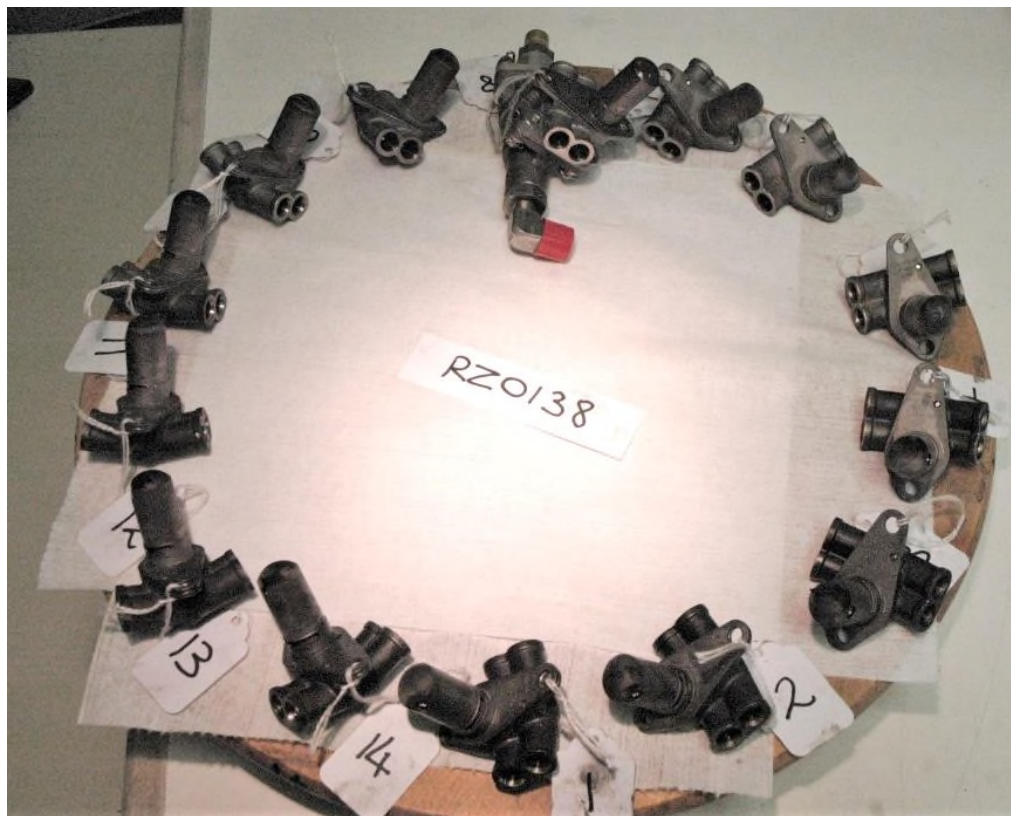


Figure 11
Fuel nozzles as received

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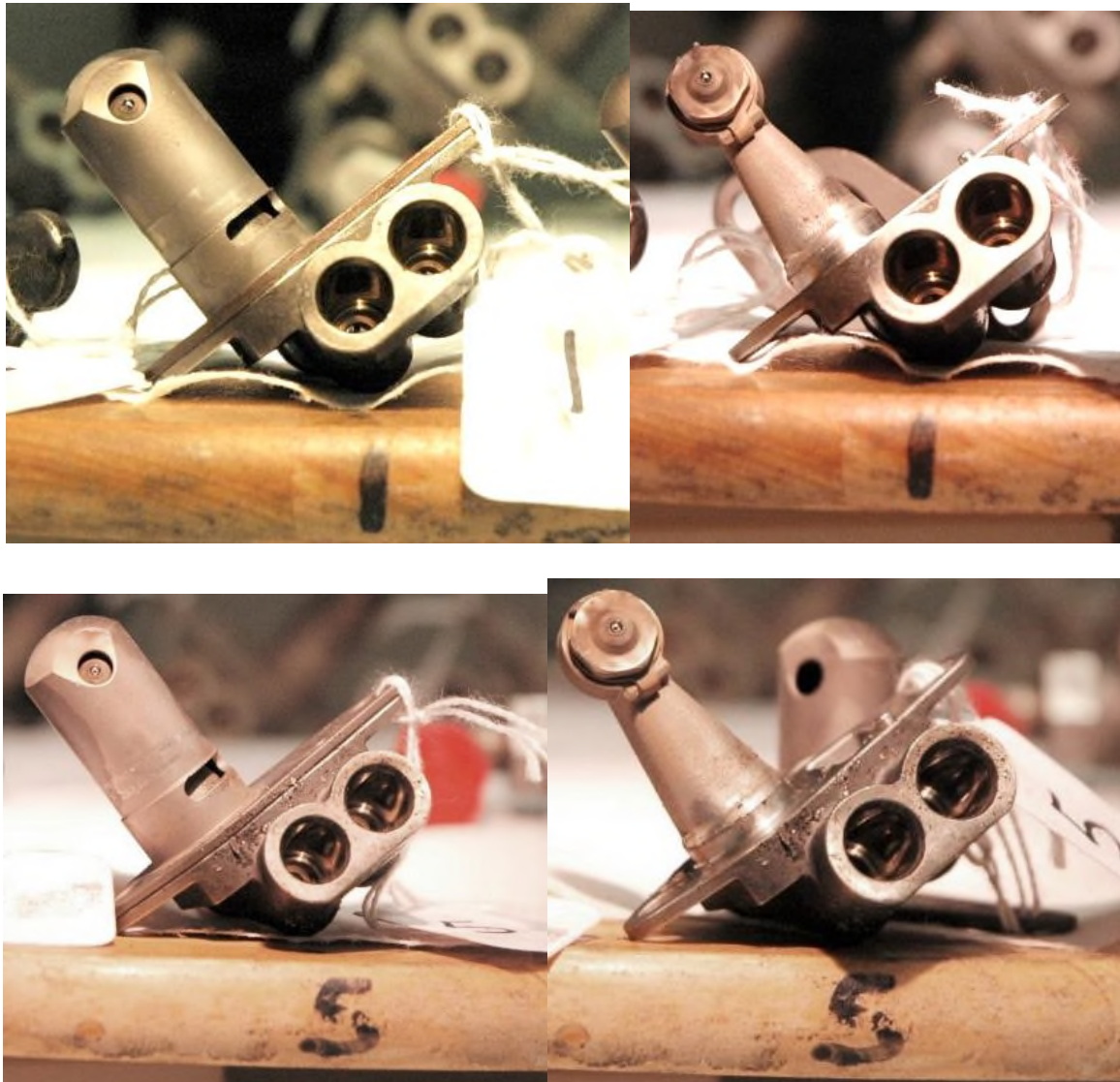


Figure 12
No. 1 (upper photos) and 5 (lower photos) fuel nozzles before testing

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Date issued: 2019-08-20

Accessory: Over-speed governor (OSG)

Note: This unit was not on the engine at original engine delivery.

Investigation Results:

The exterior of the OSG was lightly soiled. The driveshaft turned with slight resistance. There was unbroken orange anti-tamper paint on the pilot-valve stop screw. The inside of the solenoid electrical connector was lightly soiled and the pins were present and straight. Lockwire was present at all locations.

The OSG was tested in accordance with [REDACTED]. The following observations were recorded:

[REDACTED] Maximum speed: the speed required to achieve the target servo flow was 90RPM below the test point minimum limit.

This suggests that the OSG would react to a propeller over-speed approximately 2% earlier than the acceptance test limit.

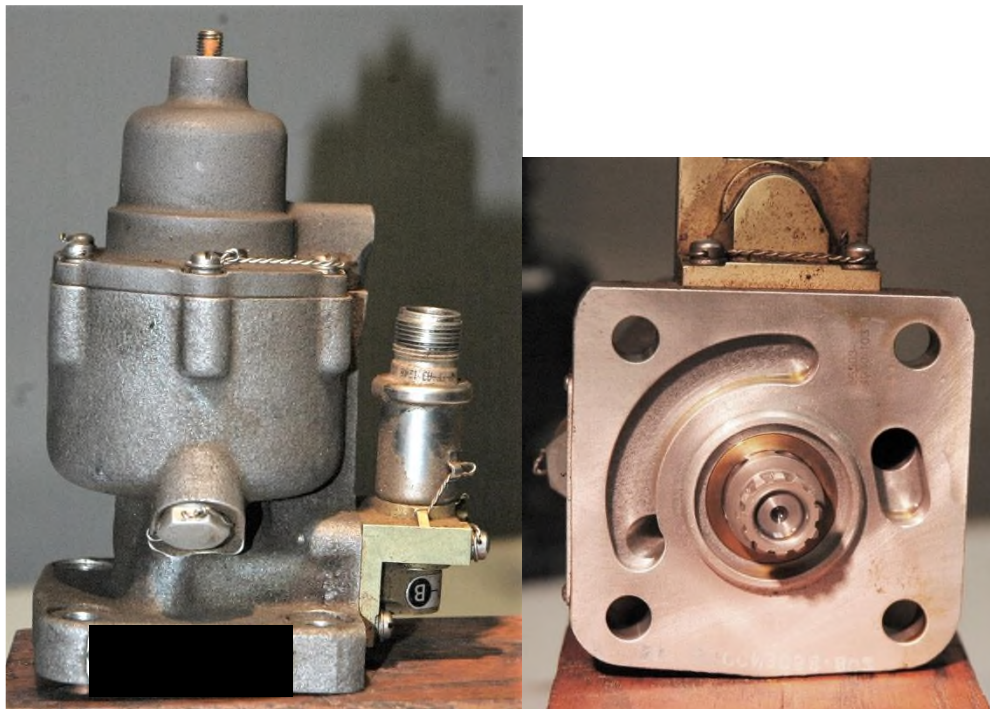


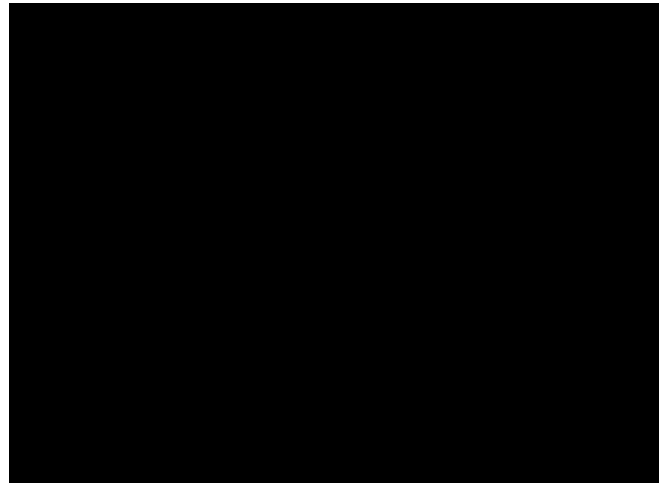
Figure 13
OSG as received

ACCESSORIES ACCIDENT REPORT

Date issued: 2019-08-20

5.0 Closing Statement

The data contained in this report, collected at the time of the review may be altered or corrected on the basis of further information.



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