

FACTUAL NOTES, ENGINE TEARDOWN INVESTIGATION IN SUPPORT OF ACCIDENT INVESTIGATION OF PIPER PA-31T CHEYENNE II, N779MF, PERFORMED FOR THE NATIONAL TRANSPORTATION SAFETY BOARD.

P&WC Ref. File No: 16-188

1. INVESTIGATION PARTICIPANTS

The powerplant investigation was performed on May 16th to 19th, 2017 at Pratt & Whitney Canada Corp., St Hubert, Qc. The following individuals participated in the investigation as representatives of their respective organisations:

Zoë Keliher	National Transportation Safety Board
Noreen Price	National Transportation Safety Board
George Tanos	Air Medical Resource Group
John Burrue	Air Medical Resource Group
David Barnard	Pratt & Whitney Canada Corp.
Marc Gratton	Pratt & Whitney Canada Corp.

2. LEFT HAND ENGINE HISTORY

PT6A-28 S/N 52075

Hours Since New: 6690.1

Cycles Since New: 6831

Hours Since Overhaul: 3117.2

Cycles Since Overhaul: 3917

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	P-ECCN or P-USML (Non US Origin)	EAR99

The above information is as of Nov. 4th, 2016. The fuel pump drive pad garlok seal had been replaced by a new part on October 15th, 2016, The fuel control unit was replaced by an overhauled unit on the same date.

3. **LEFT HAND 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 engine showed extensive fire damage. The propeller was still installed on the propeller shaft and showed 2 of the blades still attached to the hub. The 3rd blade was not included in the shipment. The 2 blades showed evidence of melting approximately 12” from the hub.

3.1.1 **External Cases**

Reduction Gearbox: The front housing was covered with fire residues and molten material but appeared physically intact. The protective paint showed blistering.

Exhaust Duct: Compressive damage was present resulting in displacement of the front section of the engine towards the 3 o’clock position. Both bolting flanges were deformed.

Gas Generator Case (GGC): Compressive deformation was present on all surfaces including the inner compressor housing. The housing was also deformed around No. 2 bearing. The GGC had been painted in a blue colour. The paint showed blistering and discoloration. Many areas were bare where paint had melted off as a result of exposure to post crash fire. Various locations showed surface corrosion.

Accessory Gearbox (AGB): The AGB housing was partially consumed by fire. The damage covered the portion between the 6 and 12 o’clock position.

Inlet Case: A large portion of the case was consumed by fire between the 8 & 10 o’clock. The inlet struts were fractured resulting in the complete AGB to be separated from the remainder of the engine.

3.1.2 **Power Control and Reversing Linkage**

The linkage was bent but still capable of free movement. The Fuel Control Unit (FCU) rod was still connected and the fuel lever was sitting against the max fuel flow stop of the FCU.

3.1.3 Pneumatic Lines

Compressor Discharge Air (P3): The fitting at the air inlet side of the P3 filter housing was found lockwired but finger tight (contact surfaces intact). The outlet side was tight. The fittings at the firewall were tight and secure. The fitting at the P3/Py adapter had separated from the adapter but the “B” nut was tight. The Px orifice was clear of debris.

Power Turbine Control (Py): Was found tight at the propeller governor; tight at the firewall; finger tight at the FCU where the elbow was separated from the air adapter (contact surfaces however were in good condition).

Fuel lines: All lines were separated from the fuel heater. The line to the pump inlet was finger tight at the fuel pump end. There was however no evidence of pre-impact leaks. The line from the FCU outlet to start flow control inlet was loose at the start flow control but still lockwired. The seating faces were intact. The other fitting from the same line was tight.

3.1.4 Chip Detectors and Filters

Reduction Gearbox Chip Detector: Not available for review.

Oil Filter: Charred. No evidence of metallic particles was found.

Fuel Filter: Charred. The paper portion of the filter was partially consumed by exposure to post crash fire.

P3 Air Filter: The housing was partially consumed by fire. The filter was exposed and charred.

3.2 Disassembly Observations

Both rotors were not capable of rotation.

3.2.1 Compressor Section

All components of the compressor were covered by fire residues.

Compressor 1st, 2nd, and 3rd Stage Discs and Blades: All blades were in place. The shaft portion of the 1st stage disk was fractured at the webs. Corrosion as well as blue paint drips were visible on the upstream face of the disk. The 2nd stage blades and disk were intact. The trailing edge of the 3rd stage blades were bent from contact with the 3rd stage stator.

Compressor 1st, 2nd, and 3rd Stage Stators and Shrouds: All shrouds showed contact rubbing. The stators exhibited vane tip rubbing. The 3rd stage stator exhibited many bent vanes from contact with the adjacent spacer.

Compressor 1st, 2nd, and 3rd Stage Spacers: Rubbing damage consistent with the vane tip damage was noted.

Centrifugal Impeller: The leading edges of the blades appeared intact; it not removed.

Centrifugal Impeller Shroud: Not accessed.

Front Stub Shaft: Not accessed.

No. 1 Bearing and Airseals: The flex cage was intact. The bearing was not accessed.

No. 2 Bearing and Airseals: Not accessed.

3.2.2 Combustion Section

Combustion Chamber Liner: Deformed by impact but otherwise intact with no evidence of burning. Blue paint drips were visible on the outer portion of the liner between the 5 and 6 o'clock position; some of those drips were found on the liner itself and on the fuel nozzles sheath rings. The inner portion of the liner exhibited an accumulation of blue pigments between the 5 & 6 o'clock position as well as paint accumulation between the small exit duct seal rings.

Large Exit Duct: Deformed by impact but otherwise intact. It had to be physically bent to allow for removal from the GGC.

Small Exit Duct: Intact.

3.2.3 Turbine Section

Compressor Turbine Guide Vane Ring: Blue paint deposits were present on the downstream side of the airfoils. All vanes were present with no evidence of burning. The trailing edge of 2 of the vanes were deformed and the outer shroud was cracked at the 1 o'clock position. The inner shroud showed rubbing damage on the trailing edge side.

Compressor Turbine Shroud: Light rubbing damage was found on most of the circumference. The rubbing covered the downstream portion of the shrouds.

Compressor Turbine: All blades were in place. Some blue paint deposits could be seen on the convex side of the blade airfoils. The downstream side of the disk showed circular rubbing on its complete face. The balancing rim was fractured and was found sitting against the PT stator. The blade tips showed rubbing on the downstream half of the tips. The upstream side of the blade platforms exhibited rubbing from contact with the inner shroud of the CT vane ring.

ITT Probes, Busbar, and Harness: Intact.

Power Turbine Housing: Intact.

Power Turbine (PT) Guide Vane Ring and Interstage Baffle: All vanes were in place. Some vanes showed impact damage and/or bending adjacent to the inner shroud on the downstream side. The inner shroud, downstream side was partially fractured and displayed impact imprints of the PT blades. The edge of the outer shroud exhibited discontinuous scores corresponding to each of the PT blades tips. The baffle was deformed and separated from the vane. On the downstream side, it exhibited static imprints of the PT blade fixings. The upstream side of the baffle showed circular scoring from contact with the CT disk. The centre portion of the baffle was fractured subsequent to the rubbing.

Power Turbine Shroud: Light rubbing noted but otherwise intact.

Power Turbine: All blades had been pushed out of their fixings from contact with the PT vane at impact. 23 blades out of 42 were available for review. 13 of these blades showed bending of their airfoil at approximately mid span with associated cracks. Two blades were actually fractured. There was no evidence of significant rubbing of the blade tips. The upstream side of the disk showed no significant circular rubbing other than a partially fractured centre hub.

Power Turbine Shaft and Shaft Housing: The housing was deformed by impact. There was no evidence of metallic debris originating from the No. 3 & 4 bearings.

3.2.4 Reduction Gearbox

The internal components of the RGB were covered with black coloured oil.

Rear Housing: Intact.

1st Stage Sun gear: The gear had moved out of axial position due to the compressive damage on the exhaust case. It appeared intact.

1st Stage Planet Gear Carrier: Intact.

1st Stage Planet Gears: Intact.

1st Stage Ring Gear: Intact.

Torque Meter: Not accessed

2nd Stage Sun Gear and Flex Coupling: The gear portion was intact. Some scoring was noted on the internal diameter of the inner coupling from contact with the propeller oil sleeve.

2nd Stage Planet Gear Carrier: Intact.

2nd Stage Planet Gears: Intact.

2nd Stage Ring Gear: Intact.

No. 5 & 6 Bearings: Not accessed.

Propeller Shaft: The shaft was intact. The propeller shaft oil sleeve showed circular scoring damage from contact with the 2nd stage coupling.

Forward Housing: Covered by fire residues. The thread insert for the chip detector was partially pulled out.

3.2.5 Accessory Gearbox

All components were covered with fire residues and burnt housing debris. There was no evidence of pre-impact distress on the gears and bearings available for review.

3.3 Controls and Accessories Evaluation

3.3.1 Ignition System

Exciter Box: Not available for review.

Ignition Leads: Severed at the igniter box.

Ignition Plugs: Intact. One of the plugs showed a blue paint drip covering one of the spark holes.

3.3.2 Fuel System

Fuel Heater: All fittings were fractured off the unit and the heat exchanger housing was punctured.

Fuel Pump: The pump was separated from the AGB as a result of the fracture of its mounting flange. It showed exposure to post crash fire.

Fuel Control Unit: Damaged by impact and post-crash fire.

Fuel Nozzles: The nozzle transfer tubes were melted due to the post-crash fire. The nozzle tips were corroded but appeared to be free of carbon. Blue paint drips were visible on the nozzle sheaths and on the nozzle stems inside the sheaths. The drips were more predominant on the nozzles that were sitting at the top half (as the engine came to rest at the crash site) (mainly nozzles 2 to 8).

3.3.3 Air System:

Compressor Bleed Valve: Partially melted by fire.

3.3.4 Oil System:

Propeller Governor (CSU): Covered in soot. The beta valve was not capable of movement but the unit appeared otherwise physically intact.

Overspeed Governor: The housing was fractured and the solenoid was missing.

4. RIGHT HAND ENGINE HISTORY

PT6A-28 S/N 52069

Hours Since New: 6614.3

Cycles Since New: 6831

Hours Since Overhaul: 3117.2

Cycles Since Overhaul: 3917

The above information is as of Nov. 4th, 2016

5. RIGHT HAND 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.

5.1 External Condition

The engine showed fire and impact damage on all surfaces. The engine arrived with the full QEC still in place. The QEC showed a flat portion resulting from impact at the 5 o'clock position.

5.1.1 External Cases

Reduction Gearbox: The housing was covered with fire residues but appeared structurally intact.

Exhaust Duct: Severe impact and compression damage present on all surfaces. The case was partially ripped open at its 5/6 o'clock position. Both bolting flanges were distorted. The deformation of the case resulted in the reduction gearbox being displaced towards the 11 o'clock position.

Gas Generator Case: Compressive impact damage found on all surfaces. Flattening by impact was present at the 5 o'clock position and some twisting deformation could also be observed between the fuel nozzles and "C" flange. The case had been painted blue and some of this paint was blistered and melted off the case surface due to post crash fire.

Accessory Gearbox: The external surfaces were damaged by post-crash fire. The housing was fractured around the 5 o'clock position exposing internal gears.

Inlet Case: All struts were fractured resulting in complete separation of the AGB from the remainder of the engine.

5.1.2 Power Control and Reversing Linkage

The linkage was bent but still connected to the FCU and was capable of partial movement.

5.1.3 Pneumatic Lines

Compressor Discharge Air (P3): Tight and secure at the FCU, firewall and P3 filter housing..

Power Turbine Control (Py): The fitting at the CSU was tight and secure. Tight and secure at the FCU.

Fuel lines: Fuel out from FCU was loose. The lines were tight at the fuel nozzles.

5.1.4 Chip Detectors and Filters

Reduction Gearbox Chip Detector: Oil sludge found on the prongs but no metallic debris noted.

Oil Filter: Not accessed.

Fuel Filter: Charred.

P3 Air Filter: The filter housing was partially consumed by fire. The filter was charred.

5.2 Disassembly Observations

Both rotors were incapable of rotation. Mechanical cutting of the GGC was required in order to remove the compressor assembly.

5.2.1 Compressor Section

Compressor 1st, 2nd, and 3rd Stage Discs and Blades: All blades were in place. Some leading edge impact damage and blade tip rubbing was found on the 1st stage blades. The 2nd stage blades showed bent airfoils due to contact with the 2nd stage vanes.

Compressor 1st, 2nd, and 3rd Stage Stators and Shrouds: All vanes were in place. All stages of stators displayed bent vanes and tip rubbing from contact with their adjacent spacer.

Compressor 1st, 2nd, and 3rd Stage Spacers: Rubbing damage consistent with the vane tip damage was present.

Centrifugal Impeller: All blade tips were rubbed.

Centrifugal Impeller Shroud: The full circumference of the shroud exhibited rubbing from contact with the impeller blades tips

Front Stub Shaft: Intact.

No. 1 Bearing and Airseals: The bearing was covered with blackened oil however all components were intact. The airseal showed moderate rubbing.

No. 2 Bearing and Airseals: Intact.

5.2.2 Combustion Section

Combustion Chamber Liner: Impact deformation consistent with the GGC was noted. The visible portion of the liner showed no evidence of pre-impact damage. Some blue paint deposits were found on the inner portion at the 5 o'clock position.

Large Exit Duct: Not accessed.

Small Exit Duct: Not accessed.

5.2.3 Turbine Section

Compressor Turbine Guide Vane Ring: All vanes were present and were covered by blue paint on their downstream side. Four vanes exhibited deformation of their trailing edge. The downstream edge of the inner shroud showed scoring damage.

Compressor Turbine Shroud: Blade tip rubbing was noted on the full circumference.

Compressor Turbine: All blades were in place and partially covered with blue paint on their convex surfaces. The edge of the blade fixings on the upstream side exhibited scoring from contact with the CT vane ring. Blade tip rubbing observed on all blades. The downstream side of the disk and blades exhibited circular rubbing on all surfaces. The rubbing resulted in complete loss of the balancing ring and centre hub. All blades showed trailing edge contact rubbing and bending. Seven of the blades also showed consequential loss of material.

ITT Probes, Busbar, and Harness: Bent from impact but otherwise intact.

Power Turbine Housing: The housing and containment ring was deformed by impact. The containment ring required mechanical cutting to allow its removal

Power Turbine Guide Vane Ring and Interstage Baffle: the vane ring was distorted and the inner shroud was fractured and partially missing. A total of 9 vanes were fractured. The remaining vanes exhibited severe impact damage causing loss of material. The edge of the outer shroud on the downstream side displayed circular rubbing from contact with the PT blades. A portion of the outer shroud was also fractured by impact. The baffle was deformed, separated from the vane ring and exhibited circular rubbing on both sides. The centre portion of the baffle was ripped off as a result of contact rubbing.

Power Turbine Shroud: The shroud was deformed by impact. The full circumference exhibited rubbing and scoring damage from contact with the PT blades.

Power Turbine: A total of 25 blades had been pushed out of their fixings in a downstream direction. All blades were fractured and many fragments were recovered from inside the exhaust. The fragments which included a blade tip showed significant rubbing damage, partially obliterating the shrouded tip. The blades that remained on the disk exhibited rubbing on the upstream fixings and airfoil leading edge from contact with the PT vane ring. The disk upstream face displayed circular rubbing on the complete surface causing the loss of the balancing rim and centre hub. The blade fracture surfaces showed features characteristic of overload.

Power Turbine Shaft and Shaft Housing: The housing was bent from impact. It was not removed.

5.2.4 Reduction Gearbox

The reduction gearbox was not disassembled.

5.2.5 Accessory Gearbox

The AGB was not disassembled.

5.3 Controls and Accessories Evaluation

5.3.1 Ignition System

Exciter Box: The box was breached by post-crash fire and both lead connectors were fractured.

Ignition Leads: Severed by impact.

Ignition Plugs: Intact.

5.3.2 Fuel System

Fuel Heater: Its mounting flange was fractured.

Fuel Pump: The pump was fractured off the AGB

Fuel Control Unit: Damaged by impact.

Fuel Nozzles: The nozzle transfer tubes were melted due to the post-crash fire. Blue paint drips were visible on the nozzle sheaths and on the nozzle stems.

5.3.3 Air System:

Compressor Bleed Valve: Damaged by post-crash fire; the piston could not be moved.

5.3.4 Oil System:

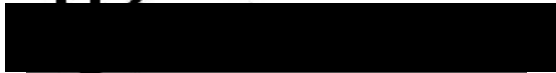
Propeller Governor: Covered by fire residues

Overspeed Governor: Covered by fire residues.

6. CLOSING:

These factual notes are based upon observations made on May 16th to 18th, 2017, and may be altered or corrected on the basis of further information.

PRATT & WHITNEY CANADA CORP.



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Service Investigation