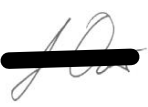




Report No.: 20-042

**FMR Aviation LLC
Piper PA-31T1, Aircraft Registration No. N926K
Billings, Montana
April 20, 2020
PT6A-11
Left Engine Serial No. 10234
Right Engine Serial No. 10239**

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I ANALYSIS

1.0 ACCIDENT SYNOPSIS

On April 20th 2020, a Piper PA-31T1, Aircraft Reg. No. N926K, impacted the terrain shortly after takeoff from the Billings Logan International Airport, in Billings, Montana. The pilot was fatally injured. The aircraft was destroyed by impact and a post impact fire.

2.0 SUMMARY OF FINDINGS AND DISCUSSION

The left hand engine propeller shaft exhibited a torsional fracture. The downstream side of the compressor turbine and the upstream side of the power turbine exhibited circumferential scoring from contact with the power turbine vane. The 1st stage compressor rotor blade tips exhibited rolled over material from contact with their shroud.

The downstream side of compressor turbine and the upstream side of the power turbine exhibited circumferential scoring from contact with the power turbine vane on the right hand engine. The 1st stage compressor rotor blade tips exhibited rolled over material from contact with their shroud.

The static impact marks on both engines that were evident on the downstream side of the power vane are overlaying the circumferential rub marks on the outer rim from contact with their respective power turbines. This suggests that the power sections stopped rotating during the impact sequence.

3.0 CONCLUSION

The compressor rotor blade tip rubs, rotational scoring on the compressor and power turbines of both engines are consistent with the engines producing symmetrical power at the time of the impact.

The engines did not display any pre-impact anomalies or distress that would have precluded normal engine operation prior to impact.

II FACTUAL INFORMATION

1.0 INVESTIGATION PARTICIPANTS

The powerplant investigation was performed on July 27th and 28th 2020 at Pratt & Whitney Canada's Service Investigation Facilities in Bridgeport WV. The following individuals participated in the investigation as representatives of their respective organizations.

Jerry Morgan	Federal Aviation Administration (FAA) Aviation Safety Inspector
Karel Currey	Pratt & Whitney Canada (P&WC) Investigator
Jeff Davis	P&WC Investigator

2.0 LEFT HAND (LH) ENGINE HISTORY

Engine Model: PT6A-11, **Serial No.:** 10234

Manufacture Date: March 1980

The engine logbook information was obtained from Piper's photos.

Time Since New (TSN): 4696.8 per the engine logbook/Hobbs meter reading dated 11-25-19

Cycles Since New (CSN): Unknown

Time Since Overhaul (TSO): No recorded overhaul was shown in the engine logbook photos

3.0 LEFT HAND (LH) 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

An overview of the accident site shows that left hand engine was orientated approximately 90 degrees opposite the directional orientation of the aircraft, suggesting it was most likely impact separated (Ref. Photo No. 1, red oval). The right hand engine was orientated in the same direction as the aircraft (Ref. Photo No. 1, blue oval). The left hand engine was situated in an upright orientation (Ref. Photo No. 2). The engine and propeller were received in a sealed shipping container (Ref. Photo No. 3). The exterior of the engine exhibited impact damage and thermal damage from the post impact fire (Ref. Photo No. 4). The propeller shaft was impact fractured, separating the propeller from the engine. All three propeller blades were bent and the exterior of the propeller did not exhibit any thermal damage (Ref. Photo No. 5). The bottom portion of the front reduction gearbox housing was partially consumed by the post impact fire. The accessory gearbox housings and portions of the inlet case were consumed by the post impact fire. The heater, fuel control housing and portions of the fuel pump were consumed by the post impact fire. The fire had separated the engine data plate from the inlet case. The data plate showed the engine was a PT6A-11 and the serial number was PC-E 10234 (Ref. Photo No. 6).



Photo No. 1, courtesy of the FAA



Photo No. 2, courtesy of the FAA



Photo No. 3



Photo No. 4



Photo No. 5



Photo No. 6

3.1.1 External Cases

Reduction Gearbox (RGB): The propeller shaft was impact fractured and the gearbox mounted accessories were thermally damaged from exposure to the post impact fire (Ref. Photo No. 7). The bottom section of the gearbox was burned exposing several of the internal components (Ref. Photo No. 8).

Exhaust Duct: The duct was partially coated in soot, was impact compressed, and it exhibited a crack at the 12 o'clock position along a creased region (Ref. Photos No. 9, red arrow & 10).

Gas Generator Case: The case was coated in soot and it exhibited a bent region adjacent to the right hand engine mount (Ref. Photos No. 11 & 12).

Accessory Gearbox (AGB) and Inlet Case: The gearbox housings were consumed by the fire, exposing the internal spur gears and pump gears (Ref. Photo No. 13). Portions of the inlet case were consumed by the fire and the inlet struts were all fractured or consumed by the fire.



Photo No. 7



Photo No. 8



Photo No. 9



Photo No. 10



Photo No. 11

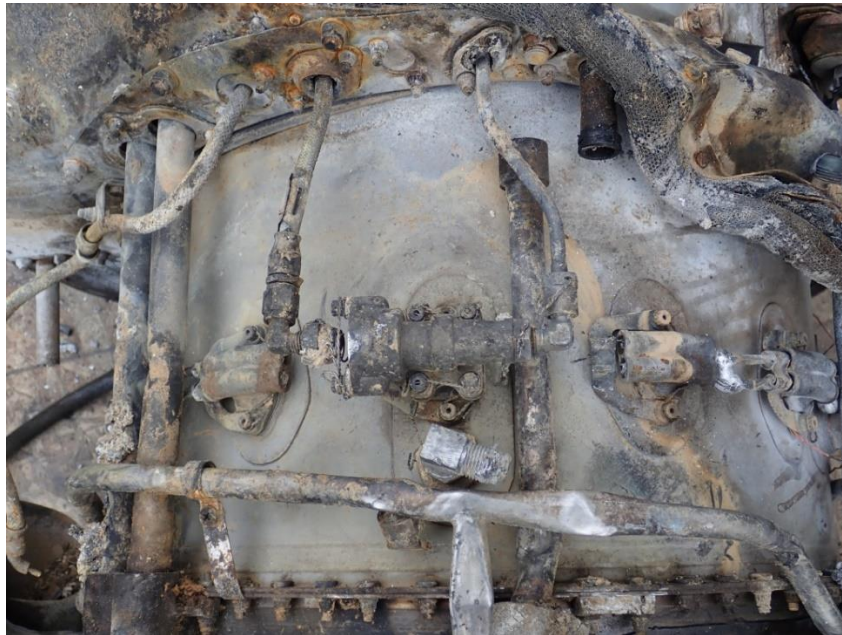


Photo No. 12



Photo No. 13

- 3.1.2 **Power Control Linkage and Reversing Linkage:** The reversing lever guide pin was bent (Ref. Photo No. 14, red arrow). The end airframe cable was attached to the propeller speed control lever (Ref. Photo No. 14, blue arrow). The low pitch stop adjuster was thermally damaged partially separating the front push-pull swivel joint casing from the low pitch adjusting stop reversing mechanism (Ref. Photo No. 15, red arrow). The wire rope was in place and the remaining linkage was in place and secure. The CAM box was discoloured from corrosion due to heat exposure (Ref. Photo No. 16, red arrow). The airframe power control cable was attached to the CAM lever (Ref. Photo No. 16, blue arrow). The connecting rod between the CAM and the fuel control arm was in place (Ref. Photo No. 17). A comparison between Photo No. 14 that was taken during the engine examination to Photo No. 18 that was taken at the accident site, show the propeller speed control had moved during the engine recovery and/or handling for shipment. A comparison between Photo No. 16 that was taken during the engine examination to Photo No. 19 that was taken at the accident site, show the CAM box components are in slightly different positions.



Photo No. 14

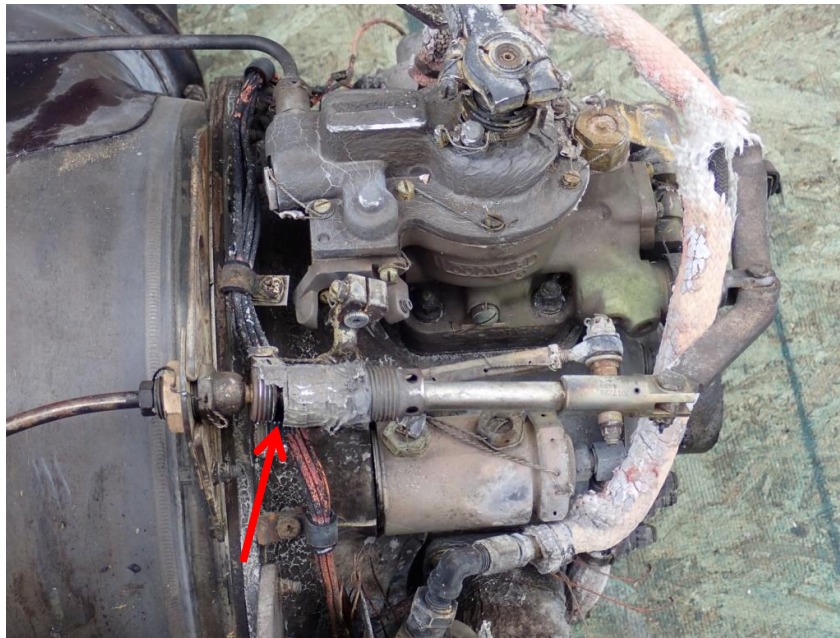


Photo No. 15

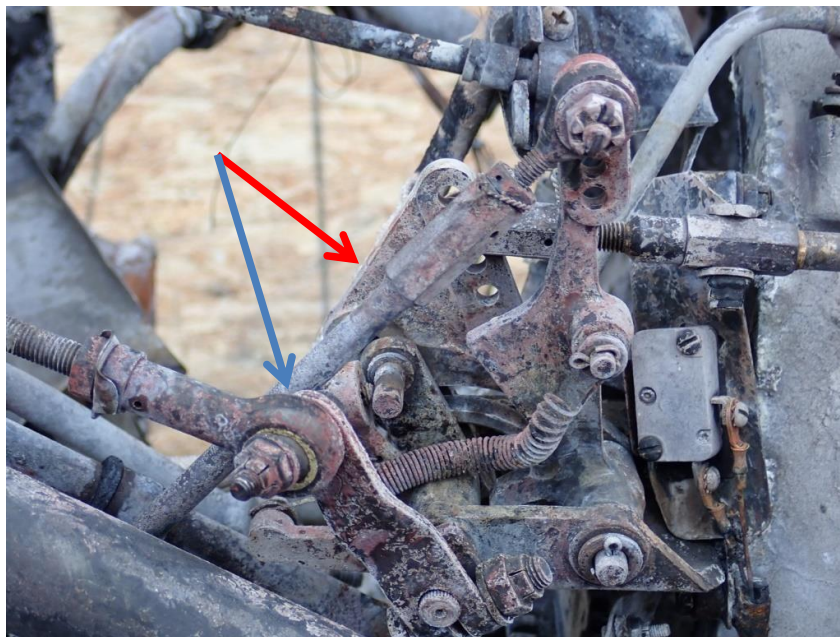


Photo No. 16



Photo No. 17



Photo No. 18, courtesy of Piper



Photo No. 19, courtesy of Piper

3.1.3 Pneumatic Lines

Compressor Discharge Air (P3): The exterior coating was burned off of the insulated section. The line was in place from the fuel control fitting to the gas generator case port (Ref. Photos No. 20 & 21, red arrows).

Power Turbine Control (Py): The exterior coating was burned off of the insulated section. The line was in place from the fuel control fitting to the propeller governor fitting (Ref. Photo No. 22 & 23, red arrows). The connections at the propeller governor and the center fire seal were tight/torqued.

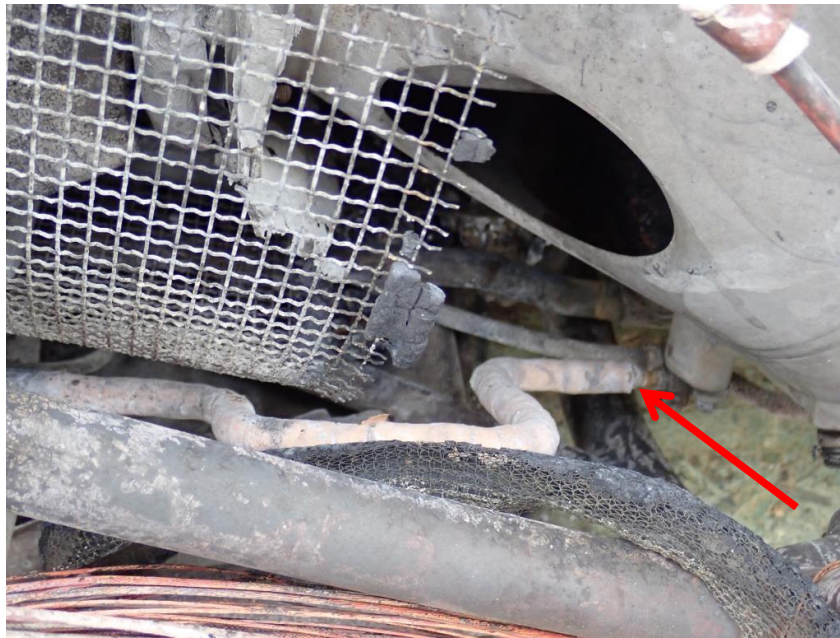


Photo No. 20



Photo No. 21



Photo No. 22

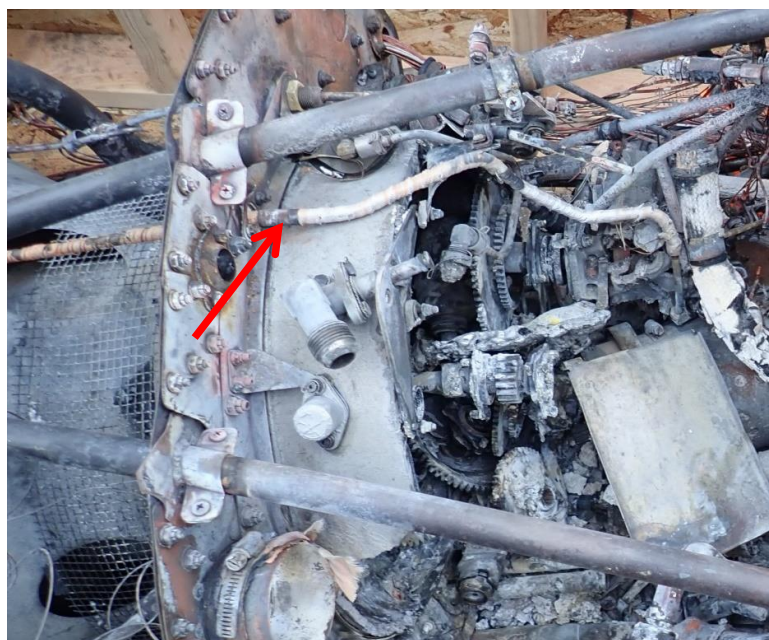


Photo No. 23

3.1.4 Chip Detector and Filters

Chip Detector: The detector was missing. The detector boss is located in the region of the reduction gearbox that was consumed by the fire.

Oil Filter: The filter exhibited thermal damage and was not removed from the filter housing for the purpose of this investigation (Ref. Photos No. 24 & 25).

Fuel Filter: The filter exhibited thermal damage from the post impact fire (Ref. Photo No. 26).



Photo No. 24



Photo No. 25



Photo No. 26

- 3.2 **Disassembly Observations:** Although the No. 1 bearing was not supported due to the fractured and burned inlet case struts, the compressor was capable of limited rotation by utilizing mechanical tooling on the compressor turbine retention bolt.

The power section was capable of limited manual rotation utilizing mechanical tooling on the power turbine retention bolt.

3.2.1 **Compressor Turbine (CT) Section**

Compressor Turbine: The downstream side of the compressor turbine disc and blades exhibited circumferential scoring from contact with the power turbine vane (Ref. Photo No. 27 & 28). The hub adjacent to the retention bolt bore was rubbed from contact with the lip of the inner baffle (Ref. Photo No. 29). The upstream side of the turbine did not exhibit any visible damage (Ref. Photo No. 30). The blade tips exhibited some polished regions from contact with their respective shroud (Ref. Photo No. 31).

Compressor Turbine Vane: The vane was not removed for the purpose of this investigation. The visible section of the vane did not exhibit any visible damage (Ref. Photo No. 32).

Compressor Turbine Shroud: The shroud exhibited some rubbing as viewed through the soot buildup coating the surface (Ref. Photo No. 33).



Photo No. 27, view of the downstream side



Photo No. 28, view of the downstream side



Photo No. 29, view of the downstream side



Photo No. 30, view of the upstream side



Photo No. 31



Photo No. 32, view of the downstream side

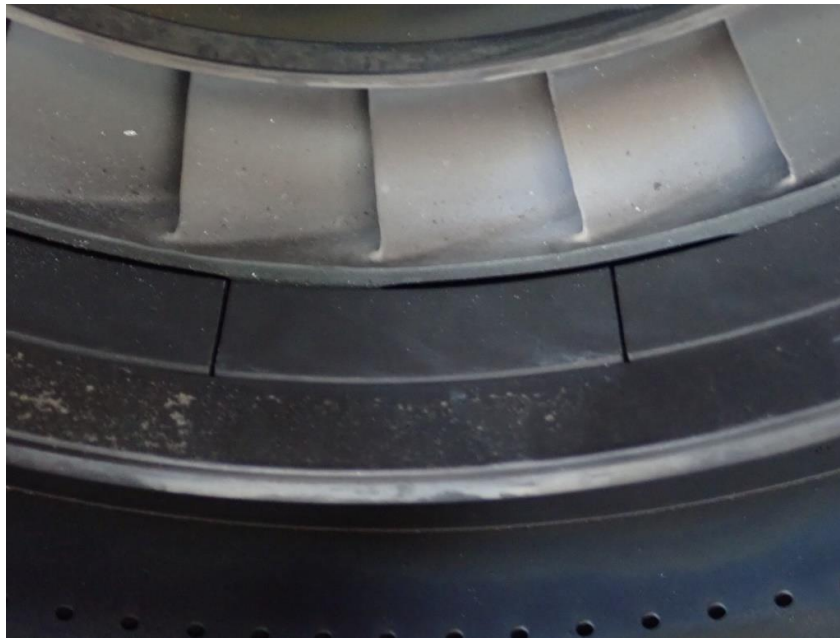


Photo No. 33

3.2.2 Combustion Section

Combustion Chamber Liner: The liner was not removed for the purpose of this investigation. The visible section of the liner exhibited operational staining (Ref. Photo No. 34). The large exit and small exit ducts were not accessed for the purpose of this investigation.



Photo No. 34

3.2.3 Power Turbine (PT) Section

Inter Turbine Temperature Probes, Busbar, and Harness: The probes, busbar, and harness were in place and no visible damage was evident (Ref. Photo No. 35).

Power Turbine Vane and Baffle: The upstream side of the vane inner rim and baffle exhibited circumferential scoring from contact with the compressor turbine (Ref. Photos No. 36 & 37). The inner baffle on the upstream side exhibited circumferential scoring from contact with the compressor turbine disk (Ref. Photo No. 38). The downstream side of the baffle exhibited light circumferential rubbing from contact with the power turbine (Ref. Photo No. 39 & 40, red arrow). The baffle also exhibited static imprints of the power turbine blade platforms (Ref. Photo No. 41, blue arrow). The 10 to 2 o'clock region of the outer rim exhibited rubbing from contact with the blade tips (Ref. Photo No. 42, blue arrow). The outer rim also exhibited static imprint marks from contact with the power turbine blade tips (Ref. Photo No. 42, yellow arrow). The downstream side of the inner baffle exhibited circumferential scoring on the majority of the diameter and the lip was bent outwards at the 6 o'clock position (Ref. Photo No. 43).

Power Turbine: The majority of the turbine blades exhibited some discolouration and some soot/debris buildup adhered to their surfaces (Ref. Photo No. 44 & 46). The exhaust duct was distorted resulting in a region where the turbine blades were positioned aft of their respective shroud (Ref. Photo No. 45). The upstream side of several of the blade platforms exhibited circumferential rubs from rotational contact with the power turbine vane baffle (Ref. Photos No. 46 & 47, red arrows). The disc hub adjacent to the retention bolt bore exhibited circumferential rubbing from contact with the lip of the inner baffle (Ref. Photo No. 48). The downstream side of the turbine was unremarkable except for discoloration (Ref. Photo No. 49). The blade tips exhibited rubs from contact with their respective shroud and the leading edge tips from contact with the power turbine vane (Ref. Photo No. 50).

Power Turbine Shroud: The shroud exhibited rubs on the knife edges with the more pronounced rubbing from 6 to 10 o'clock (Ref. Photos No. 51 & 52).

Power Turbine Shaft and Housing: The shaft and shaft housing were not accessed for the purpose of this investigation. The No. 3 bearing rotor air seal exhibited rubbing from contact with the No. 3 bearing stator air seal (Ref. Photo No. 53).

No. 3 & 4 Bearings: The bearings were not accessed for the purpose of this investigation.



Photo No. 35



Photo No. 36, view of the upstream side



Photo No. 37, view of the upstream side



Photo No. 38, view of the upstream side



Photo No. 39, view of the downstream side



Photo No. 40, view of the downstream side



Photo No. 41, view of the downstream side



Photo No. 42, view of the downstream side

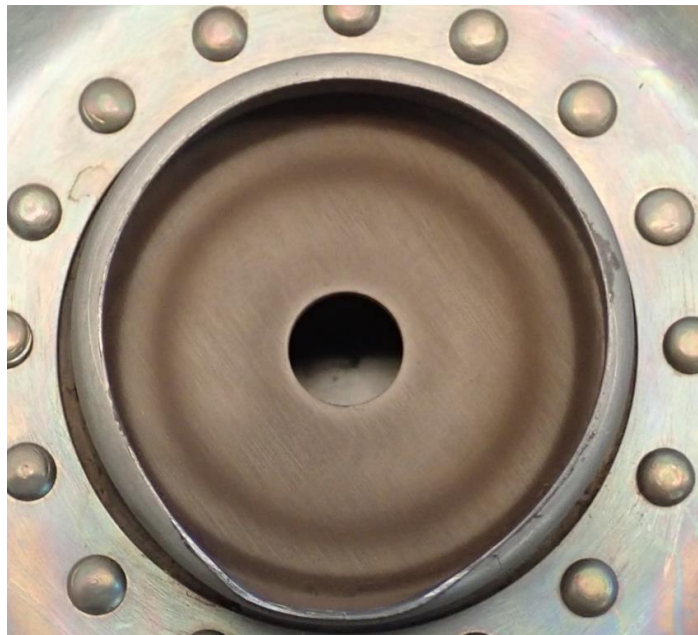


Photo No. 43, view of the downstream side



Photo No. 44, view of the upstream side



Photo No. 45

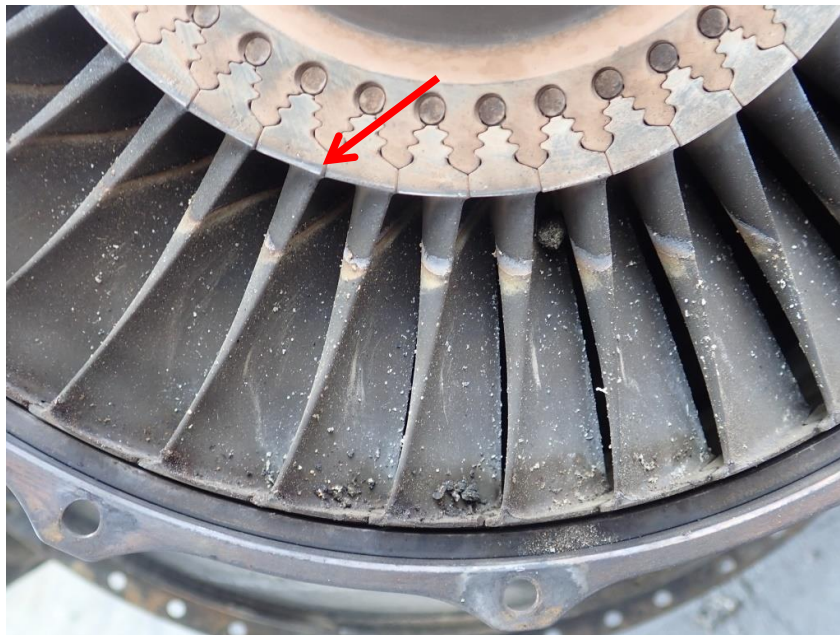


Photo No. 46, view of the upstream side

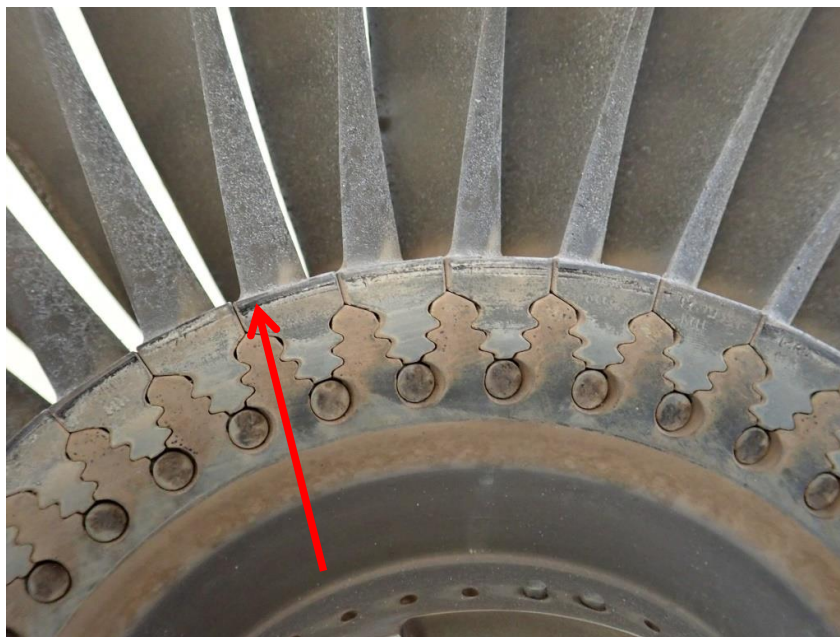


Photo No. 47, view of the upstream side



Photo No. 48, view of the upstream side



Photo No. 49, view of the downstream side



Photo No. 50



Photo No. 51



Photo No. 52

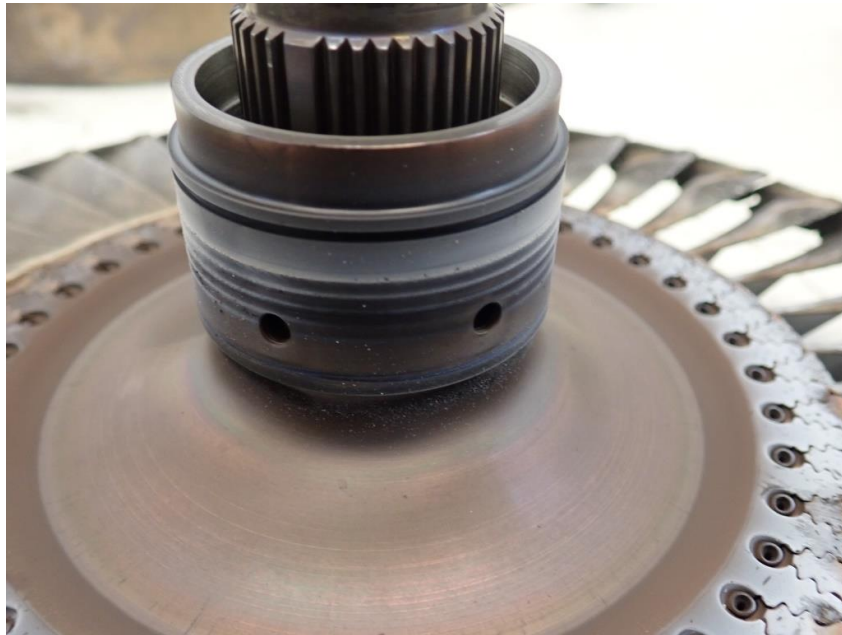


Photo No. 53

3.2.4 Compressor Section

The compressor was not removed from the gas generator case or disassembled for the purpose of this investigation (Ref. Photo No. 54). The 1st stage rotor blades were discoloured and the blade tips exhibited rolled over material from contact with their respective shroud (Ref. Photos No. 55 & 56, blue arrow). The rubbing is indicative of rotation at impact. The 1st stage stator was discoloured but appeared intact (Ref. Photos No. 56, red arrow). The remaining compressor components and the No. 2 bearing were not accessed.

The No. 1 bearing was dry but rotated freely (Ref. Photo No. 57). The bearing was not removed for the purpose of this investigation.



Photo No. 54



Photo No. 55



Photo No. 56



Photo No. 57

3.2.5 Reduction Gearbox (RGB)

Several of the gear train components were visible through the hole burned through the bottom of the front gearbox housing including two of the bevel gears, propeller shaft sleeve, No. 5 bearing, and the portions of the 2nd stage carrier (Ref. Photo No. 58). The visible internal components were discoloured from heat exposure but were in place. The propeller shaft fracture surfaces exhibited features consistent with torsional overload (Ref. Photos No. 59 & 60). The gearbox was not disassembled for the purpose of this investigation.



Photo No. 58



Photo No. 59



Photo No. 60

3.2.6 Accessory Gearbox (AGB)

The gearbox housings were consumed by the post impact fire, exposing the spur gears, bearings and the oil pump gears (Ref. Photos No. 61 & 62). The inlet case struts were either fractured or burned away (Ref. Photos No. 63). The lower section of the oil tank was consumed in the fire (Ref. Photo No. 64, red arrows).



Photo No. 61



Photo No. 62



Photo No. 63

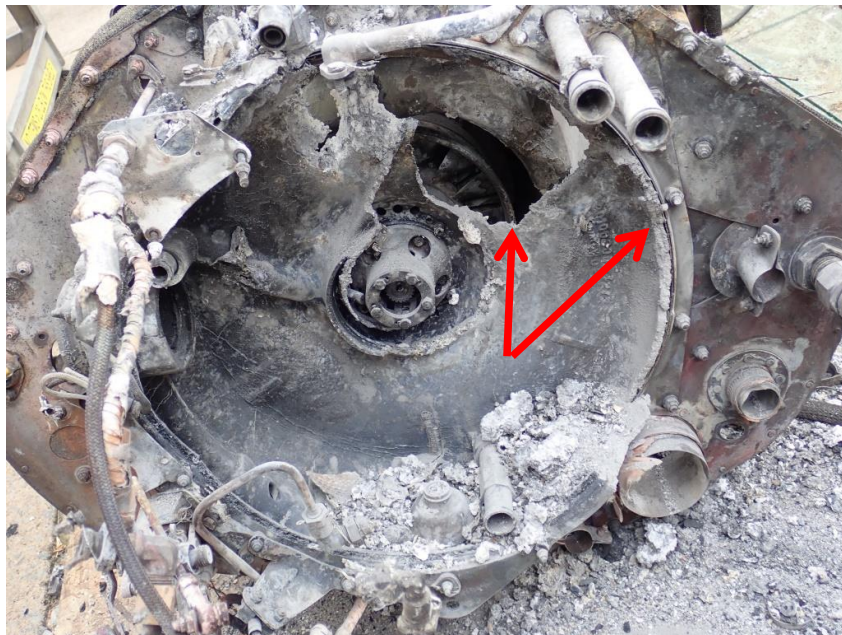


Photo No. 64

3.3 Controls and Accessories

3.3.1 Ignition System

Ignition Plugs: Both plugs were in place but were not removed for the purpose of this investigation (Ref. Photos No. 65 & 66, red arrows).

Ignition Leads: The left hand lead was fractured and both leads were thermally and impact damaged (Ref. Photo No. 65 & 66, blue arrows).

Ignition Exciter: The exciter was missing.

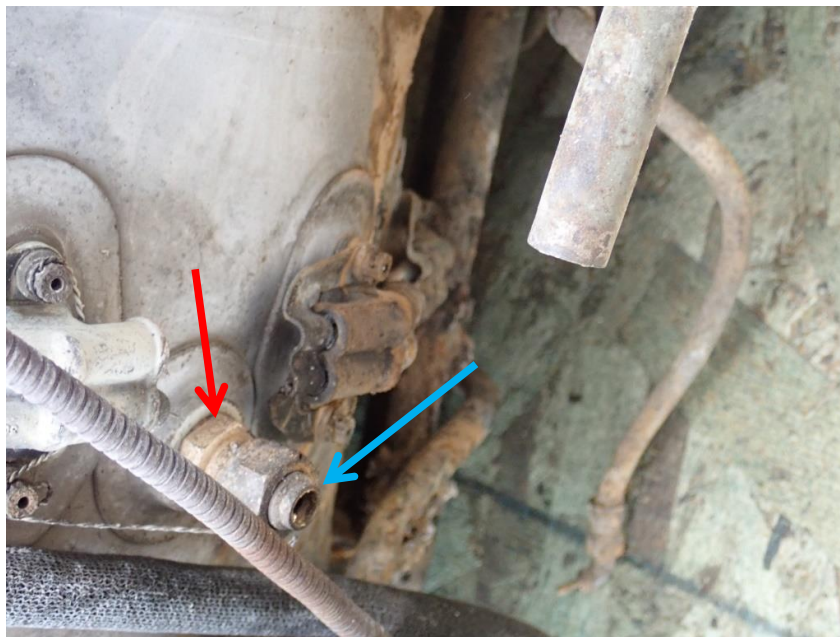


Photo No. 65



Photo No. 66

3.3.2 Fuel System

Fuel Oil Heat Exchanger (FOHE): The heater was consumed in the post impact fire.

Fuel Pump: The majority of the pump was consumed in the post impact fire (Ref. Photo No. 67).

Fuel Control Unit (FCU): The control unit housings were consumed in the post impact fire.

Flow Divider Valve (FDV): The valve was mounted to the inlet fuel nozzle but was thermally damaged (Ref. Photo No. 68).

Fuel Nozzles: All of the nozzles were attached to their respective mounting pads on the gas generator case (Ref. Photo No. 69). The exterior of the nozzles were thermally damaged and the fuel transfer tubes were thermally damaged or consumed by the post impact fire.



Photo No. 67

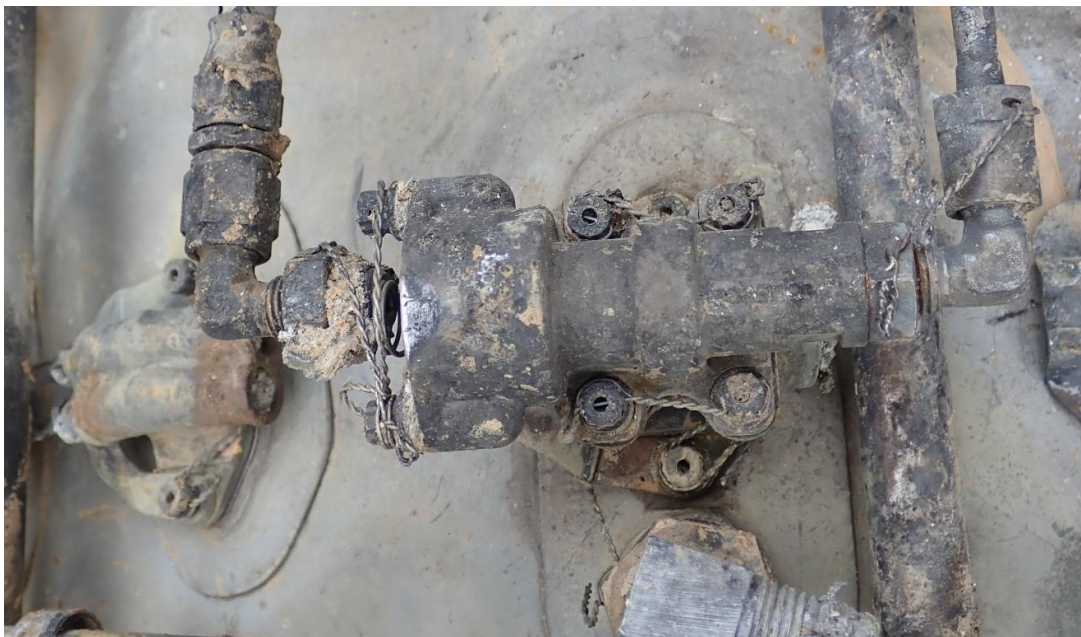


Photo No. 68



Photo No. 69

3.3.3 Air System

Compressor Bleed Valve (BOV): The majority of the valve was consumed in the post impact fire (Ref. Photo No. 70).



Photo No. 70

3.3.4 Oil System

Propeller Governor (CSU): The governor was mounted on its respective pad on the reduction gearbox and the housing was thermally damaged (Ref. Photo No. 71).

Overspeed Governor (OSG): The governor was mounted on its respective pad on the reduction gearbox and was thermally damaged (Ref. Photo No. 72).



Photo No. 71



Photo No. 72

4.0 RIGHT HAND (RH) ENGINE HISTORY

Engine Model: PT6A-11, **Serial No.:** 10239

Manufacture Date: April 1980

The engine logbook information was obtained from Piper's photos.

Time Since New (TSN): 4696.8 per the engine logbook/Hobbs meter reading dated 11-25-19

Cycles Since New (CSN): Unknown

Time Since Overhaul (TSO): No recorded overhaul was shown in the engine logbook photos

5.0 RIGHT HAND (RH) 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

An overview of the accident site shows that the right hand engine was orientated in the same direction as the aircraft (Ref. Photo No. 73, blue oval). The left hand engine was orientated approximately 90 degrees opposite the directional orientation of the aircraft, suggesting it was most likely impact separated (Ref. Photo No. 73, red oval). The right hand engine was positioned in an upright position but it was tilted toward the left hand side at the accident site (Ref. Photo No. 74). The engine and propeller were received in a sealed shipping container (Ref. Photo No. 75). The exterior of the engine exhibited thermal damage from the post impact fire (Ref. Photo No. 76). The propeller blades exhibited thermal and impact damage (Ref. Photo No. 77). The accessory gearbox housings and portions of the inlet case were consumed by the post impact fire. The heater, fuel control housing and portions of the fuel pump were consumed by the post impact fire. The engine data plate showed the engine was a PT6A-11 and the serial number was PC-E 10239 (Ref. Photo No. 78).



Photo No. 73, courtesy of the FAA



Photo No. 74, courtesy of the FAA



Photo No. 75



Photo No. 76



Photo No. 77



Photo No. 78

5.1.1 External Cases

Reduction Gearbox (RGB): The gearbox mounted accessories were thermally damaged from exposure to the post impact fire and melted airframe material was adhered to the housing (Ref. Photo No. 79). The bottom of the housing was discoloured (Photo No. 81, blue arrow).

Exhaust Duct: The duct was partially coated in soot and was impact compressed (Ref. Photo No. 80 & 81, red arrow).

Gas Generator Case (GGC): The external components and engine mounts were thermally damaged and the case exhibited a bent region adjacent to the right hand engine mount (Ref. Photos No. 82 & 83).

Accessory Gearbox (AGB) and Inlet Case: The gearbox housings were consumed by the fire, exposing the internal spur gears and scavenge pump gears (Ref. Photo No. 84). Portions of the inlet case were consumed by the fire and the inlet struts were all fractured or consumed by the fire.



Photo No. 79



Photo No. 80

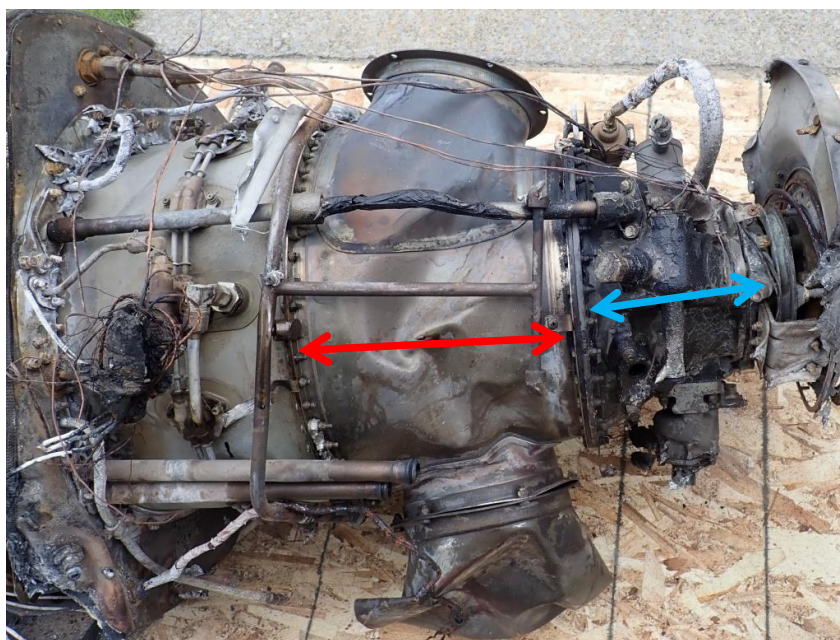


Photo No. 81



Photo No. 82



Photo No. 83



Photo No. 84

5.1.2 Power Control Linkage and Reversing Linkage

The end of the reversing lever was in position under the guide pin (Ref. Photo No. 85, red arrow). The end airframe cable was attached to the propeller speed control lever (Ref. Photo No. 86, blue arrow). The low pitch stop adjuster was consumed separating the front push-pull swivel joint casing from the low pitch adjusting stop reversing mechanism (Ref. Photo No. 86, red arrow). The wire rope was in place and the remaining linkage was in place and secure. The CAM box was discoloured from corrosion due to heat exposure (Ref. Photo No. 87, red arrow). The airframe power control cable was attached to the CAM lever (Ref. Photo No. 87, blue arrow). The connecting rod between the CAM and the fuel control arm was in place (Ref. Photo No. 88, red arrow). A comparison between Photo No. 86 that was taken during the engine examination to Photo No. 89 that was taken at the accident site show the propeller speed control appears to be in the same position. A comparison between Photo No. 87 that was taken during the engine examination to Photo No. 90 that was taken at the accident site, show the CAM box components appear to be in the same position.



Photo No. 85



Photo No. 86

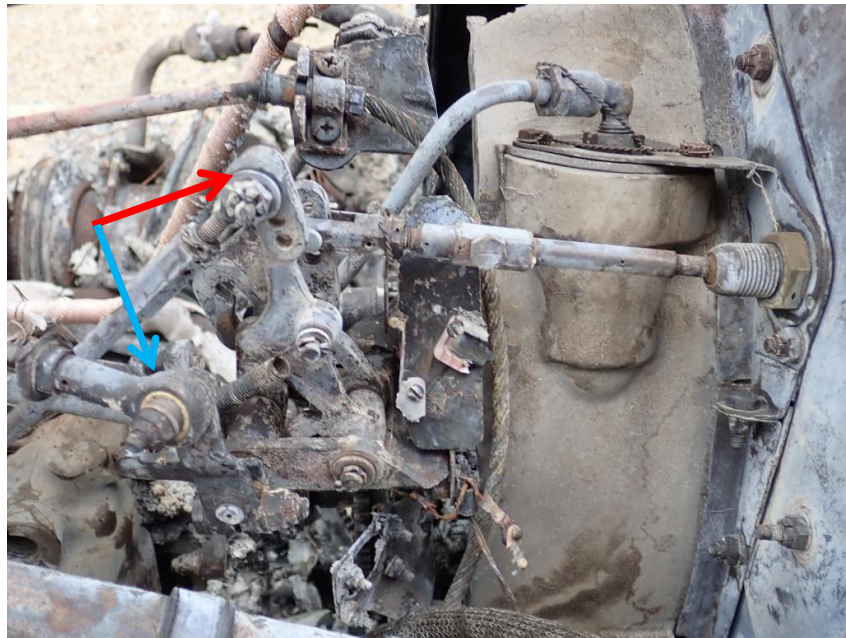


Photo No. 87

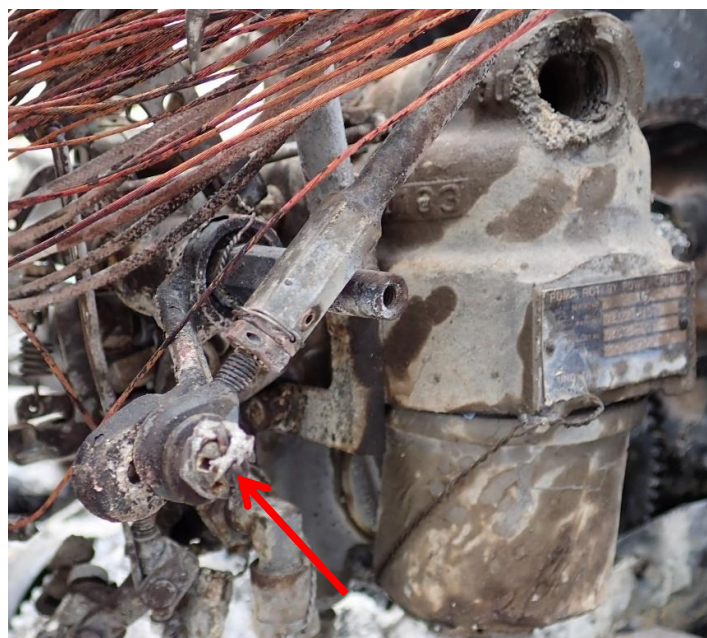


Photo 88



Photo No. 89, courtesy of Piper



Photo No. 90, courtesy of Piper

5.1.3 Pneumatic Lines

Compressor Discharge Air (P3): The exterior coating was burned off of the insulated section. The line was in place from the fuel control fitting to the gas generator case port (Ref. Photos No. 91 & 92, red arrows).

Power Turbine Control (Py): The exterior coating was burned off of the insulated section. The line was in place from the fuel control fitting to the propeller governor fitting (Ref. Photo No. 93 & 94, red arrows). The connections at the center fire seal were tight/torqued.



Photo No. 91



Photo No. 92

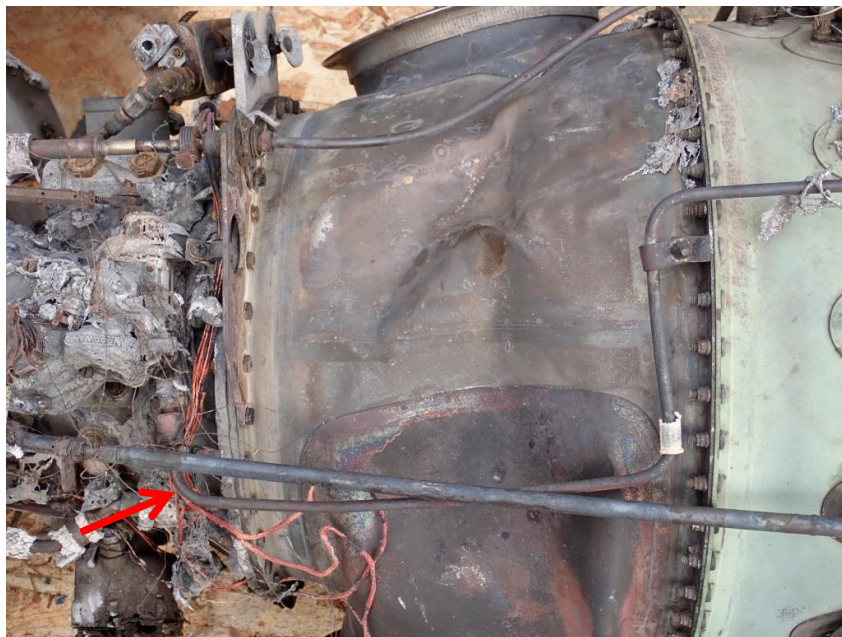


Photo No. 93

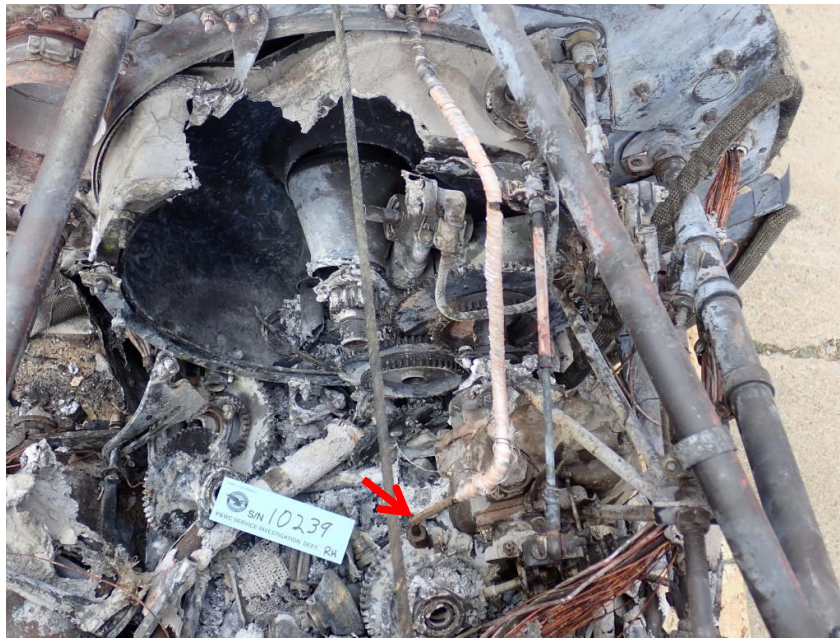


Photo No. 94

5.1.4 Chip Detector(s) and Filters

Chip Detector(s): The detector's magnetic poles were completely covered by the melted potting material (Ref. Photo No. 95).

Oil Filter: Melted material from the packing and the filter were extruding between the filter housing and the filter element (Ref. Photos 96 & 97). The filter was not removed from the filter housing for the purpose of this investigation.

Fuel Filter: The filter housing was sectioned to view the filter. The filter was thermally damaged (Ref. Photo No. 98).



Photo No. 95



Photo No. 96



Photo No. 97



Photo No. 98

- 5.2 **Disassembly Observations:** Although the No. 1 bearing was not supported due to the fractured and burned inlet case struts, the compressor was capable of limited rotation by utilizing mechanical tooling on the compressor turbine retention bolt.

The power section was not capable of manual rotation.

5.2.1 Compressor Turbine (CT) Section

Compressor Turbine: The downstream side of the compressor turbine disc and blades exhibited circumferential scoring from contact with the power turbine vane (Ref. Photo No. 99 & 100). The hub adjacent to the retention bolt bore exhibited some localized score marks from contact with the lip of the inner baffle (Ref. Photo No. 101). The upstream side of the turbine did not exhibit any visible damage (Ref. Photo No. 102). The blade tips exhibited some polished regions from contact with their respective shroud (Ref. Photo No. 103).

Compressor Turbine Vane: The vane was not removed for the purpose of this investigation. The visible section of the vane did not exhibit any visible damage (Ref. Photo No. 104).

Compressor Turbine Shroud: The shroud exhibited some rubbing as viewed through the soot buildup coating the surface (Ref. Photo No. 105).



Photo No. 99, view of the downstream side



Photo No. 100, view of the downstream side

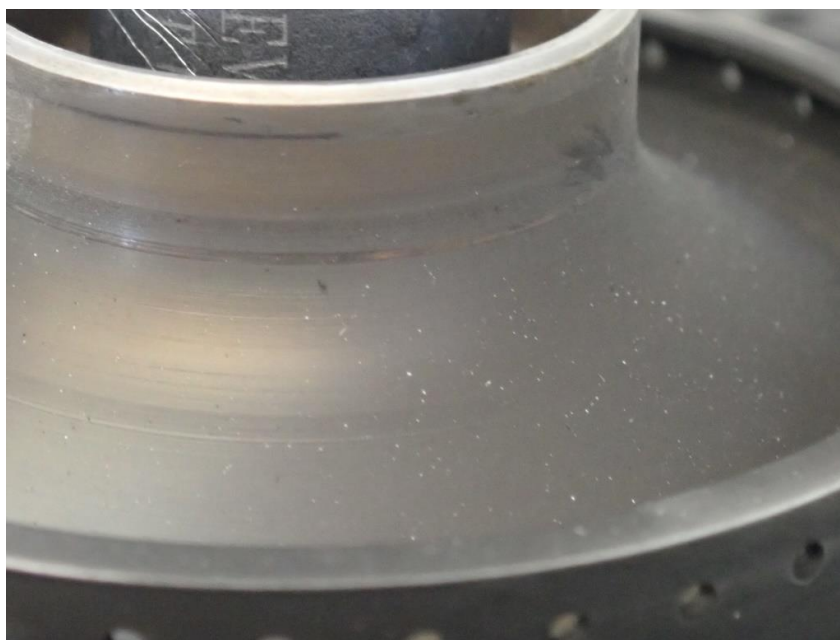


Photo No. 101, view of the downstream side



Photo No. 102, view of the upstream side



Photo No. 103



Photo No. 104, view of the downstream side



Photo No. 105

5.2.2 Combustion Section

The liner was not removed for the purpose of this investigation. The visible section of the liner exhibited staining, and was partially coated with oil residue, ingested debris and dirt (Ref. Photo No. 106). The large exit and small exit ducts were not accessed for the purpose of this investigation.



Photo No. 106

5.2.3 Power Turbine (PT) Section

Inter Turbine Temperature Probes, Busbar, and Harness: The probes, busbar, and harness were in place and no visible damage was evident (Ref. Photos No. 107 & 108).



Power Turbine Vane and Baffle: The upstream side of the vane inner rim and baffle exhibited circumferential scoring from contact with the compressor turbine (Ref. Photos No. 109, red arrows & 110). The inner baffle on the upstream side exhibited circumferential scoring from contact with the compressor turbine disk (Ref. Photo No. 111, red arrow). The downstream side of the baffle exhibited light circumferential rubbing from contact with the power turbine (Ref. Photo No. 112 & 113, red arrow). The baffle also exhibited static imprints of the power turbine blade platforms (Ref. Photo No. 113, blue arrow). The upper portion of the outer rim exhibited localized rubbing from contact with the blade tips (Ref. Photo No. 114, red arrow). The outer rim also exhibited static imprint marks from contact with the power turbine blade tips (Ref. Photo No. 114, blue arrow). The downstream side of the inner baffle exhibited circumferential scoring on the lip (Ref. Photo No. 115).

Power Turbine: The majority of the turbine blades exhibited some discolouration with soot/debris buildup adhered to their surfaces (Ref. Photo No. 116). The exhaust duct was distorted resulting in the turbine being loaded against the shroud at the 11 o'clock position (Ref. Photo No. 116). Photo No. 117 shows the gap between the blade tips and the shroud due to the exhaust duct distortion. The upstream side of several of the blade platforms exhibited circumferential rubs from rotational contact with the power turbine vane baffle (Ref. Photo No. 118, red arrows). The disc hub, adjacent to the retention bolt bore exhibited circumferential rubbing from contact with the lip of the inner baffle (Ref. Photo No. 119). The downstream side of the turbine was unremarkable except for discoloration (Ref. Photo No. 120). The blade tips exhibited rubs from contact with their respective shroud and the leading edge tips from contact with the power turbine vane (Ref. Photo No. 121).

Power Turbine Shroud: The shroud exhibited rubs on the knife edges with the more pronounced rubbing from 6 to 10 o'clock (Ref. Photos No. 122 & 123).

Power Turbine Shaft and Housing: The shaft and shaft housing were not accessed for the purpose of this investigation. The No. 3 bearing rotor air seal exhibited rubbing from contact with the No. 3 bearing stator air seal (Ref. Photo No. 124).

No. 3 & 4 Bearings: The bearings were not accessed for the purpose of this investigation.



Photo No. 107



Photo No. 108



Photo No. 109, view of the upstream side



Photo No. 110, view of the upstream side

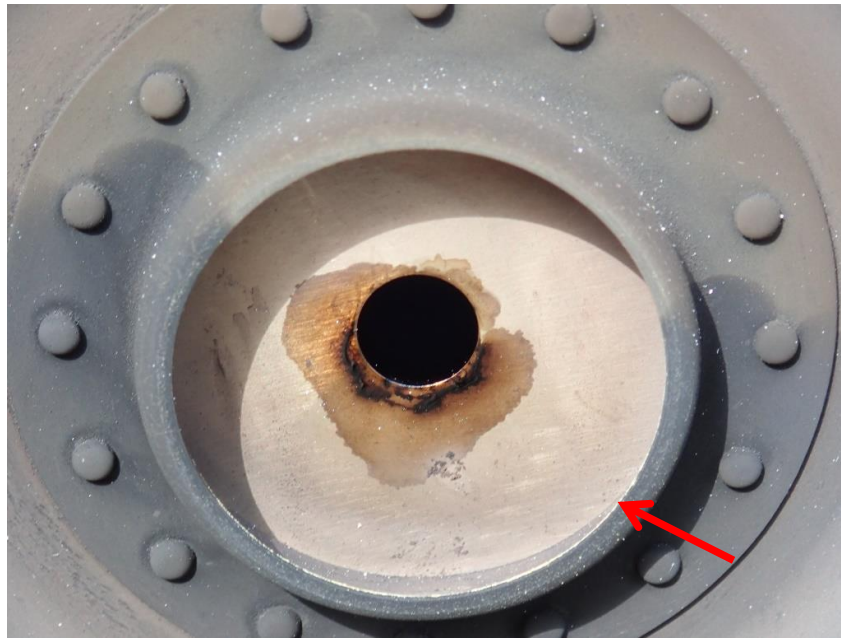


Photo No. 111, view of the upstream side



Photo No. 112, view of the downstream side

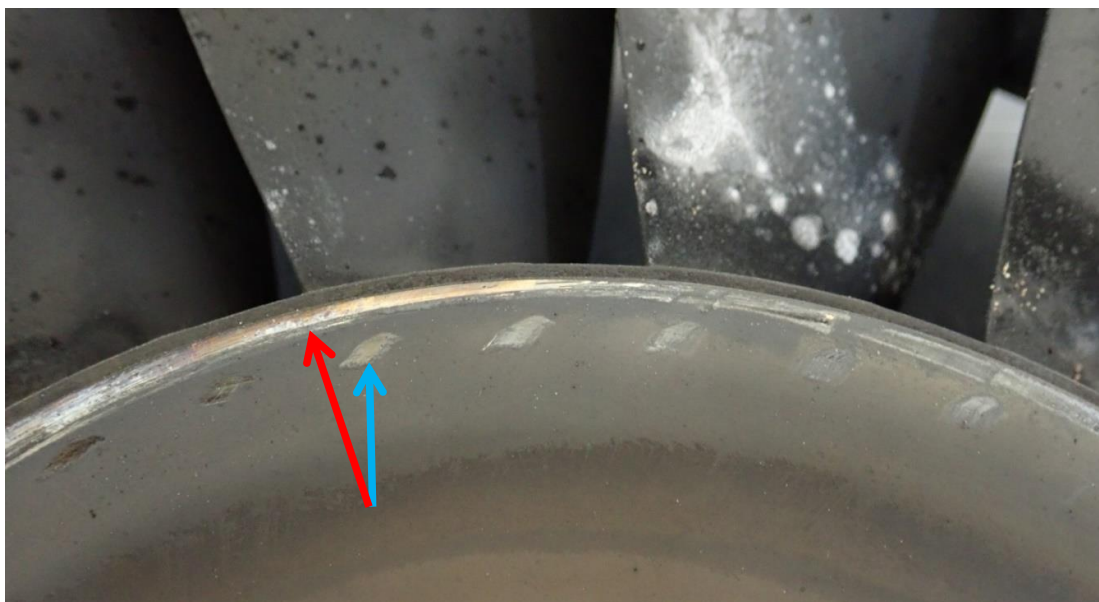


Photo No. 113, view of the downstream side

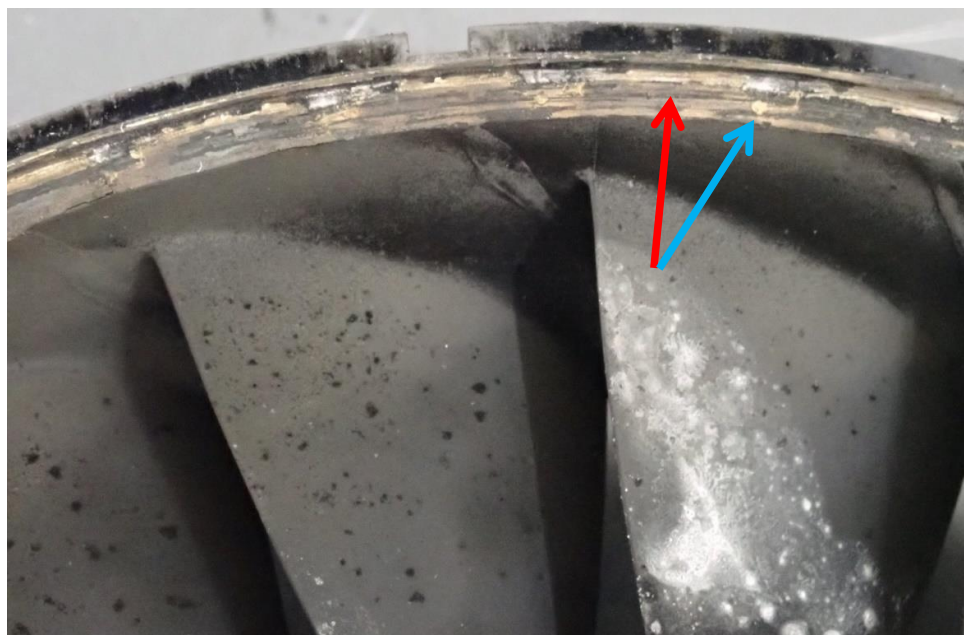


Photo No. 114, view of the downstream side



Photo No. 115, view of the downstream side



Photo No. 116, view of the upstream side



Photo No. 117, view of the upstream side

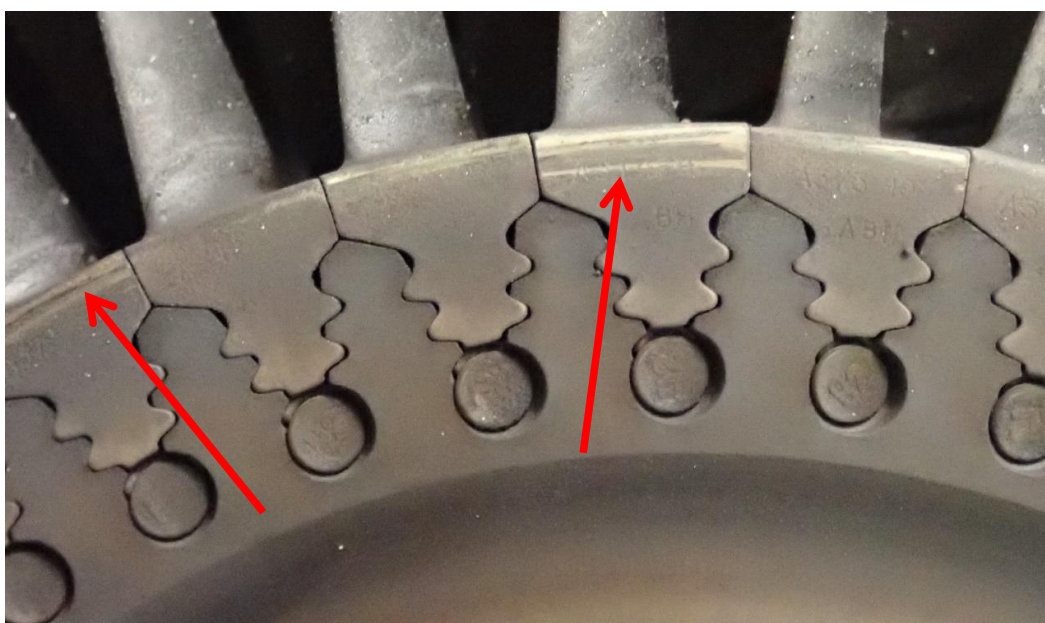


Photo No. 118, view of the upstream side



Photo No. 119, view of the upstream side



Photo No. 120, view of the downstream side



Photo No. 121



Photo No. 122



Photo No. 123



Photo No. 124

5.2.4 Compressor Section

The compressor was not removed from the gas generator case or disassembled for the purpose of this investigation (Ref Photo No. 125). The 1st stage rotor blades were discoloured and the blade tips exhibited rolled over material from contact with their respective shroud (Ref. Photo No. 126 blue arrow). The rubbing is indicative of rotation at impact. The 1st stage stator was discoloured but appeared intact (Ref. Photos No. 127, red arrow). The remaining compressor components and the No. 2 bearing were not accessed.

The No. 1 bearing was dry but rotated freely (Ref. Photo No. 128). The bearing was not removed for the purpose of this investigation.



Photo No. 125



Photo No. 126



Photo No. 127



Photo No. 128

5.2.5 Reduction Gearbox (RGB)

The exterior of the front gearbox housing was thermally distressed from exposure to the post impact fire (Ref. Photo No. 129). The gearbox was not disassembled for the purpose of this investigation.



Photo No. 129

5.2.6 Accessory Gearbox (AGB)

The gearbox housings were consumed by the post impact fire, exposing the spur gears, bearings and the scavenge oil pump gears (Ref. Photos No. 130 & 131). The inlet case struts were either fractured or burned away (Ref. Photos No. 132). The upper section and a portion of the lower wall of the oil tank were consumed in the fire (Ref. Photo No. 133, red arrows).



Photo No. 130



Photo No. 131

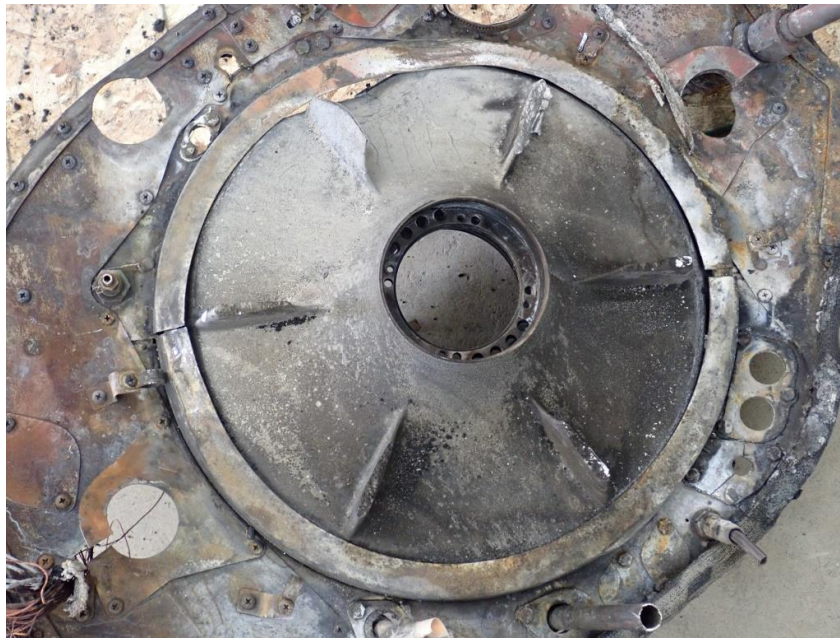


Photo No. 132

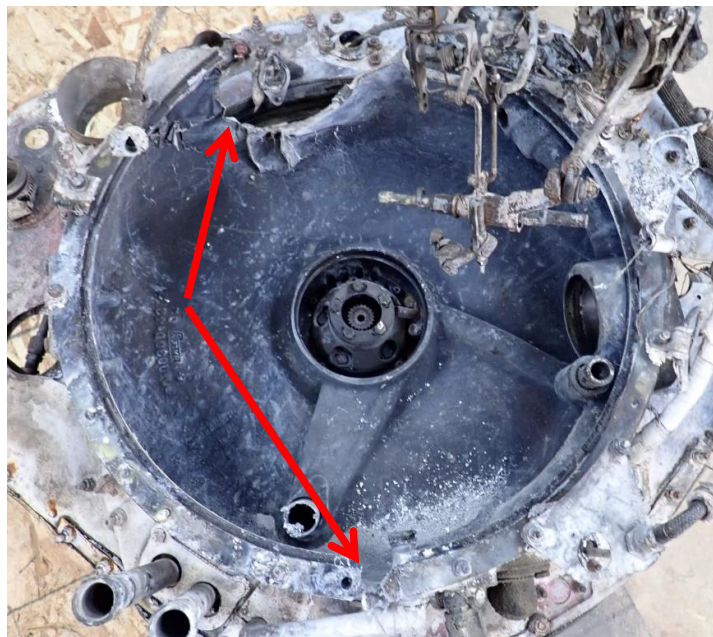


Photo No. 133

5.3 Controls and Accessories

5.3.1 Ignition System

Ignition Plugs: Both plugs were in place but were not removed for the purpose of this investigation (Ref. Photos No. 134 & 135, red arrows).

Ignition Leads: The left hand lead was fractured and both leads were thermally and impact damaged (Ref. Photo No. 134 & 135, blue arrows).

Ignition Exciter: The exciter was missing.



Photo No. 134

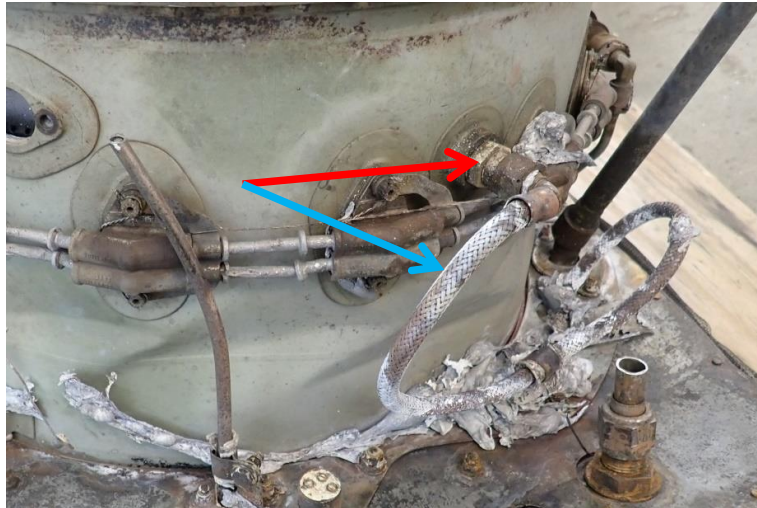


Photo No. 135

5.3.2 Fuel System

Fuel Oil Heat Exchanger (FOHE): The heater was consumed in the post impact fire.

Fuel Pump: The majority of the pump housings were thermally damaged in the post impact fire (Ref. Photo No. 136, red arrow).

Fuel Control Unit (FCU): Most of the control unit housings were consumed in the post impact fire. Portions of front housing and some of the internal components were attached to the fuel pump (Ref. Photo No. 137, red arrow).

Flow Divider Valve (FDV): The valve was mounted to the inlet fuel nozzle but was discoloured (Ref. Photo No. 138).

Fuel Nozzles: All of the nozzles were attached to their respective mounting pads on the gas generator case (Ref. Photo No. 139). The exterior of the nozzles were thermally damaged and the fuel transfer tubes were thermally damaged or consumed by the post impact fire.

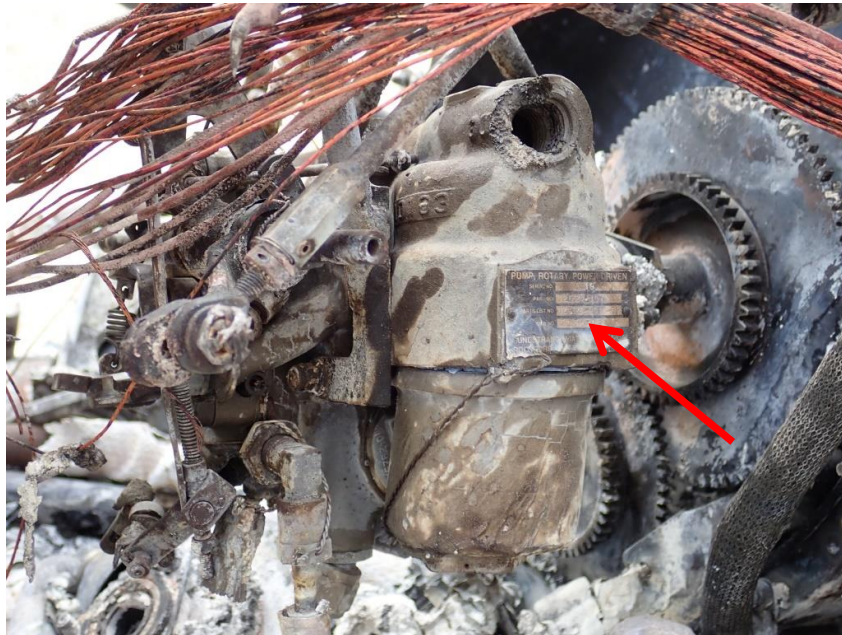


Photo No. 136

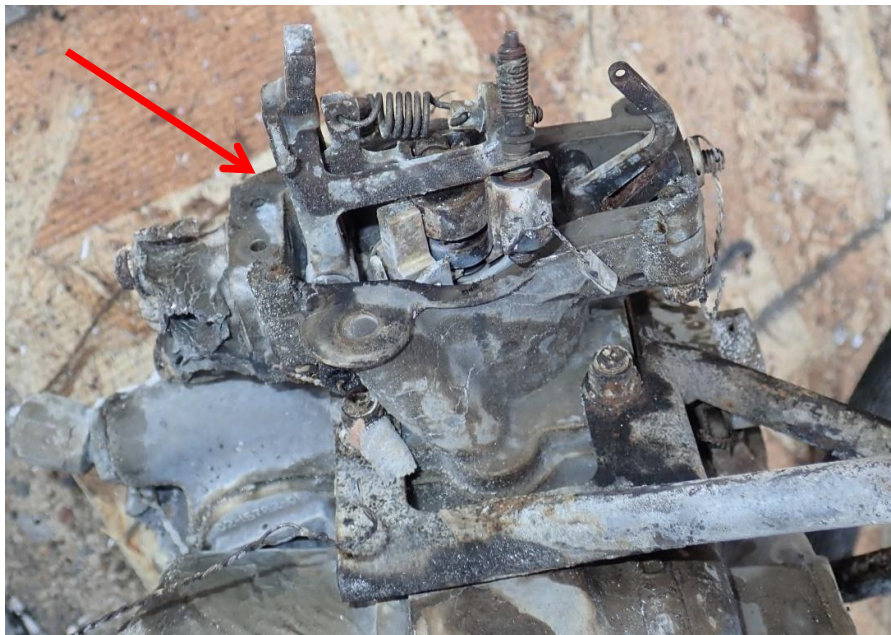


Photo No. 137

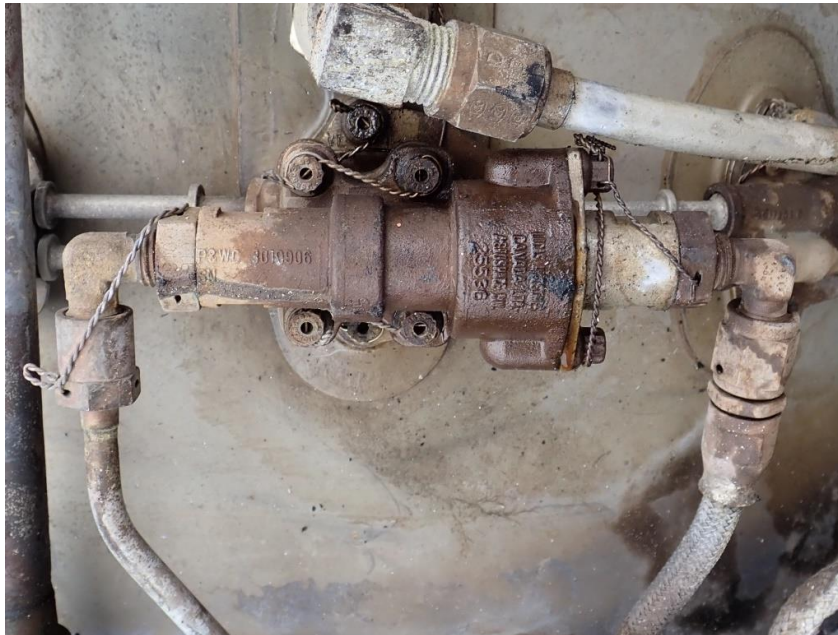


Photo No. 138

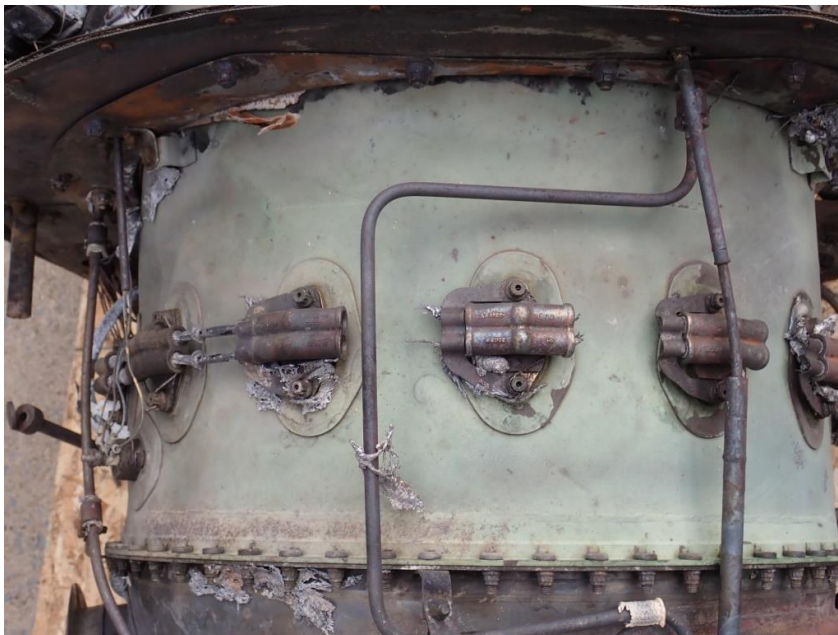


Photo No. 139

5.3.3 Air System

Compressor Bleed Valve (BOV): Portions of the valve housing was consumed in the post impact fire (Ref. Photo No. 140).



Photo No. 140

5.3.4 Oil System

Propeller Governor (CSU): The governor was mounted on its respective pad on the reduction gearbox and the housing was thermally damaged (Ref. Photo No. 141).

Overspeed Governor (OSG): The governor was mounted on its respective pad on the reduction gearbox and was thermally damaged (Ref. Photo No. 142).



Photo No. 141



Photo No. 142