NATIONAL TRANSPORTATION SAFETY BOARD
OFFICE OF AVIATION SAFETY
WASHINGTON, D.C. 20594

May 22, 2020

POWERPLANTS GROUP CHAIRMAN'S FACTUAL REPORT

NTSB ID: DCA2020MA059

A. ACCIDENT

Location:	Calabasas, California
Date:	January 26, 2020
Time:	0947 Pacific Standard Time (PST)
Aircraft:	Sikorsky S76B, N72EX, operated by Island Express Helicopters

B. POWERPLANTS GROUP

Chairman:	Carol Horgan National Transportation Safety Board Washington, DC
Technical Advisor to the Canadian Accredited Representative:	Jeff Davis Pratt and Whitney Canada Bridgeport, West Virginia

C. SUMMARY

On January 26, 2020, about 0945 PST, a Sikorsky S76B helicopter, N72EX, was destroyed when it was involved in an accident near Calabasas, California. The pilot and eight passengers were fatally injured. The helicopter was operated as a Title 14 Code of Federal Regulations Part 135 charter flight.

D. DETAILS OF THE INVESTIGATION

1.0 Engine information

The Sikorsky S76B helicopter is equipped with two Pratt & Whitney Canada PT6B-36A engines.

1.1 Engine description

The PT6B-36A is a free turbine turboshaft engine featuring a single-stage gas generator turbine driving a three-stage axial, one-stage centrifugal compressor; an annular reverse-flow combustor; and a single-stage power turbine driving an RGB and power takeoff shaft. See Figure 1. The gas generator rotates in the clockwise direction and the power turbine rotates in the counterclockwise direction. The PT6B-36A is takeoff rated at 981 shaft horsepower.

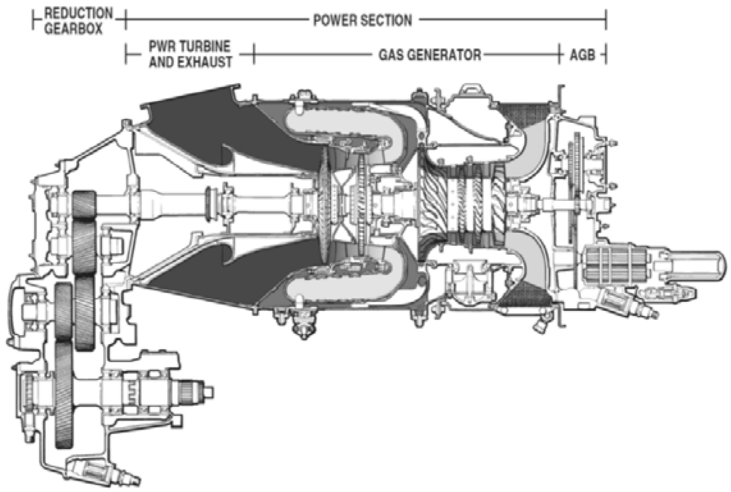


Figure 1. PT6B-36 cross-sectional drawing *courtesy of Pratt & Whitney Canada*

1.2 Engine data

position	model	serial number (S/N)	date of manufacture	time since new (hours)	cycles since new	time since overhaul (hours)	cycles since overhaul
left engine	PT6B-36A	PCE 36149	Sept 1990	4,506	9,513	1,009	1,133
right engine	PT6B-36A	PCE 36144	May 1990	4,681	9,678	1,226	2,445

Table 1. Powerplants data

1.3 Engine service history

Review of the operator's service records found that the engines were original to the helicopter, installed at production in May 1991. The left[1] engine was last removed for an April 2007 shop visit. The right engine was last removed for a July 2005 shop visit. The records showed January 1, 2020 signoffs for 50-hour inspections on both engines. A review of the past year's routine monthly items found no engine discrepancies.

A daily log entry on September 2, 2019 indicated there was minor unscheduled maintenance for a right engine chip detect fault. The fault was cleared in accordance with the PT6B-36 Engine Maintenance Manual. Minor deposits were found on the reduction gearbox (RGB) chip detector.[2]

2.0 On site observations

The engines were found approximately 153 feet from the initial point of impact, in the main wreckage area. See Figure 2. The main wreckage was substantially destroyed by fire. See Figure 3.

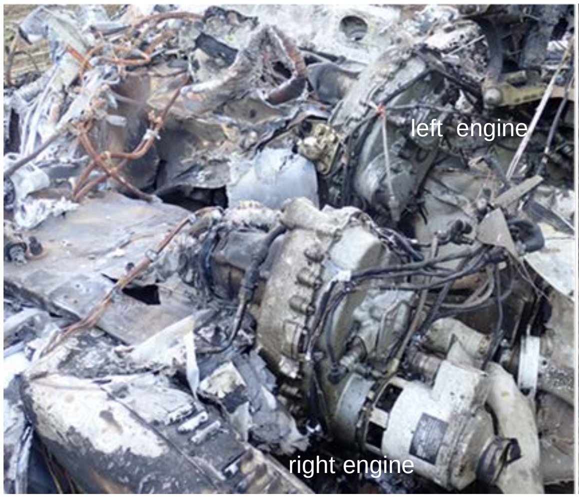
[1] References to position are as viewed from the rear of the engine looking forward.

[2] See Maintenance Group Chairman's Factual Report.

Figure 2. Wreckage path

Figure 3. Main wreckage site

The engines were inverted and engine deck material limited inspection. Both engine RGBs appeared intact. The viewable gas generator and exhaust cases showed no evidence of uncontainment. See Figure 4. The accessory gearbox (AGB) casings, the AGB-mounted accessory housings, and the inlet cases of both engines were thermally consumed.[3] See Figure 5.



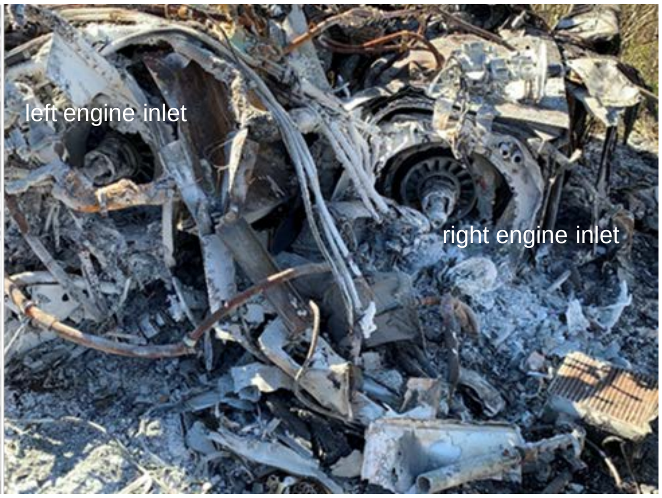


Figure 4. View of engines as found

Figure 5. AGB and inlet cases destroyed, exposed inlets

The left engine gas generator rotor was seized. Inspection of compressor components through the inlet found no obvious damage. Internal AGB and AGB-mounted accessory components were found

[3] The AGB cases are magnesium castings. The engine inlet case and the gearbox-mounted accessory housings are aluminum castings.

in the debris just forward of the compressor inlet. See Figure 6.

The right engine gas generator rotor was seized. All of the S1 compressor rotor blade tips were curled in the direction opposite of rotation. See Figure 7. Visible compressor components appeared otherwise undamaged. Internal AGB and AGB-mounted accessory internal components were found in debris just forward of the compressor inlet.

Figure 6. Left engine inlet

Figure 7. Right engine inlet

One electronic engine control (EEC) channel assembly was identified; it was compressively deformed and fractured, with the exposed electronic boards contaminated with fire debris.[4]

The wreckage was extracted from the site on January 28, 2020. It was trucked to Phoenix, Arizona, for further investigation. Engine disassembly examinations were performed at Air Transport, an aircraft recovery facility in Phoenix, January 30-31, 2020.

3.0 Left engine disassembly examination

3.1 External inspection

The engines were documented as received. See Figures 8 – 10.

The engine data plate S/N (PCE 36149) was confirmed to the left engine installation records. The cowling and airframe components were removed.

[4] The EEC is dual channel. The channels are separately housed. A second EEC channel assembly was identified in the wreckage in Phoenix; this assembly was also breached and contaminated with fire debris. Neither unit could be identified by S/N. The other two channels assemblies were not recovered.

Figure 8. Engine S/N PCE 36149, as recovered

Figure 9. Engine S/N PCE 36149, front view

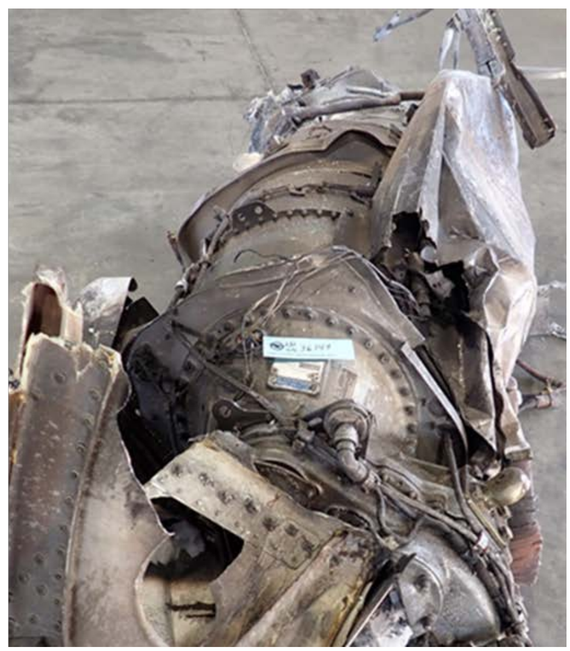


Figure 10. Engine S/N PCE 36149, back view

3.1.1 External components

The fire seals were deformed. Hose insulation, electrical harness wiring and attachment hardware not protected by the engine deck material showed some thermal damage. The AGB-mounted accessories were destroyed by fire. A visual check of the accessory components located in the debris found no evidence of failure.[5] A oil filter element found in a location that indicated it was from the

[5] Inspections of the accessory internal components and the AGB internal components of both engines were performed on site.

left engine was contaminated with fire debris. The fuel filter element was contaminated with fire debris. Other engine externals displayed random impact damage. The P3 line was impact damaged but the connections were intact from the gas generator case to the hydromechanical fuel control fitting and were secured with safety wire. The fuel nozzles and fuel flow divider sustained direct impacts but appeared intact. The external portion of the power turbine speed sensor was missing. The sensor was not removed. Both torque probes appeared intact; the torque probes were not removed. The AGB chip detector was not recovered. The external portion of the RGB chip detector was missing. A visual check of the RGB chip detector and screen found no anomalies.[6]

3.1.2 Accessory gearbox

The AGB cases were thermally consumed. A visual check of AGB internal components found no evidence of failure.

3.1.3 Compressor inlet case

Thermal destruction of the AGB and inlet case structure had displaced the compressor inlet screen and exposed the No. 1 bearing flexible housing. The screen was distorted and coated with fire debris.

3.1.4 Gas generator case

There was a large dent in the gas generator case at the flow divider (6 o'clock[7]). See Figure 11. There was a circumferential fracture along a seam weld between 5 and 11 o'clock, just forward of the large dent. See Figure 12.

Figure 11. Dent in gas generator case

Figure 12. Seam weld fracture in gas generator case

[6] The RGB screens and chip detectors of both engines were inspected on site.

[7] O'clock refers to approximate circumferential positions in a clockwise direction as viewed from the rear of the engine looking forward.

3.1.5 Exhaust duct

The exhaust duct was bent and displaced upward at its forward flange. See Figure 13.

Figure 13. Exhaust duct distortion

There was an approximately 0.5-inch case penetration near the C flange at 6 o'clock. See Figure 14.

3.1.6 RGB

The RGB casting was fractured at the base of the output shaft detail. See Figure 15.

Figure 14. Exhaust duct penetration

Figure 15. RGB casting fracture

3.2 Disassembly observations

The C flange was separated to expose the compressor turbine and the power turbine stator housing assembly. See Figures 16 and 17.

Figure 16. Compressor turbine and combustor exposed by C flange separation

Figure 17. Power turbine stator housing after separation from the gas generator section

3.2.1 Gas generator

Limited gas generator rotation was accomplished following C flange separation,[8] and continuity was established from the compressor turbine to the S1 compressor.

3.2.1.1 Compressor assembly

The No. 1 bearing and stator air seal were thermally damaged and heavily contaminated with fire debris. See Figure 18. The bearing was seized. The S1 and second stage (S2) compressor airfoils were intact. The compressor was not disassembled.

[8] The front of the rotor was unsupported due to the thermal damage to the inlet case and No. 1 bearing assembly.

Figure 18. S1 compressor and front support bearing

3.2.1.2 Combustor

The combustion liner was crushed and distorted between 5 and 9 o'clock; this damage was in line with the damage to the gas generator case and with the power turbine plane of rotation. There was heavy scoring between 6 and 7 o'clock, with rub-through up to 1.1 inches axially through the liner wall. See Figure 19.

Figure 19. Combustor liner distortion, scoring and metal deposited on shroud segments and blade TEs

3.2.1.3 Compressor turbine

The compressor turbine downstream face[9] was scored 360° in the blade fir tree root/retention rivet (blade retention) area.[10] There was circumferential scoring at the disk bore radius and along the bore edge, and at the tooling lugs. See Figure 20. Metal deposits (metallization) was observed on the blade trailing edges (TEs) and on the visible sections of the compressor turbine shroud segments.[11] The shroud segments appeared intact. See Figure 21.

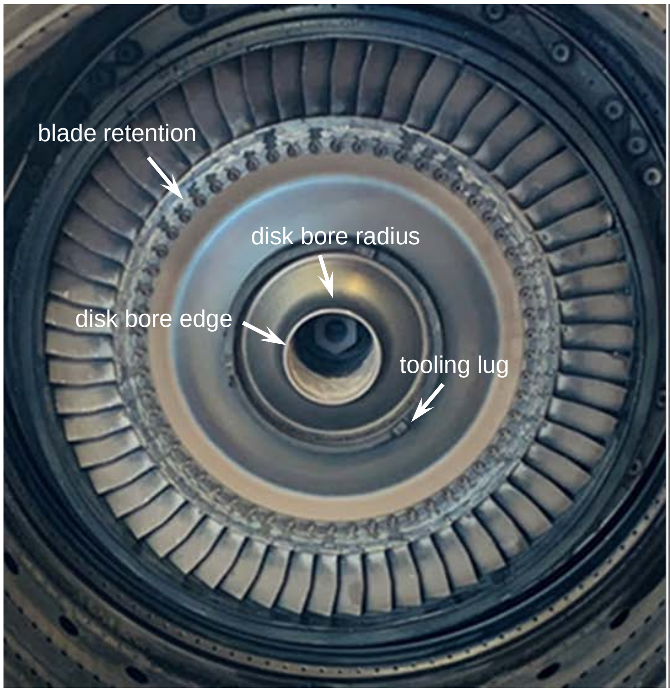


Figure 20. Compressor turbine downstream face showing 360° scoring

Figure 21. Detail of scoring along blade retention

The Powerplants Group determined that no further gas generator disassembly was required.

3.2.2 Power turbine and exhaust

The power turbine stator housing-to-exhaust duct flange retention bolts were sheared. The housing remained attached to the exhaust duct by the interturbine temperature (T5) busbar lead. See Figure 22.

The T5 harness was locally distorted. The power turbine vane ring and baffle assembly had shifted position in the power turbine stator housing. Several T5 probes were bent. See Figure 23.

[9] 'Upstream' and 'downstream' refer to the direction of gas flow from the engine air inlet at the compressor to its exit through the exhaust duct.

[10] Such scoring occurs when contact between stationary and rotating components occurs during operation, when operating clearances are lost.

[11] Metallization is an indication that engine combustion was occurring as metal particles were produced.

Figure 22. Power turbine stator housing

Figure 23. Power turbine vane ring and baffle assembly

3.2.2.1 Power turbine vane ring and baffle assembly

The power turbine vane ring and baffle assembly upstream face displayed 360° scoring and local thermal discoloration at the baffle outer diameter (OD). The vane inner ring edge was also scored. See Figure 24. Part of the inner baffle lip was distorted upward and was scored in two locations. There were two arcs of scoring contact on the inner baffle face. See Figure 25.

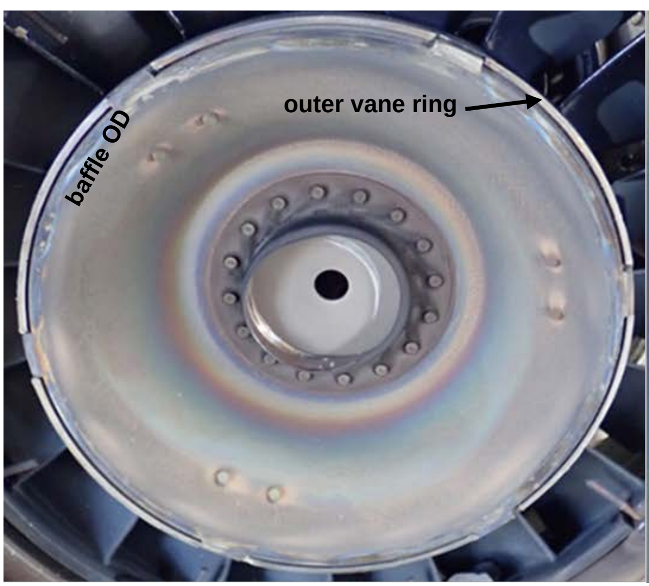


Figure 24. Rotational damage to power turbine vane and baffle assembly upstream face

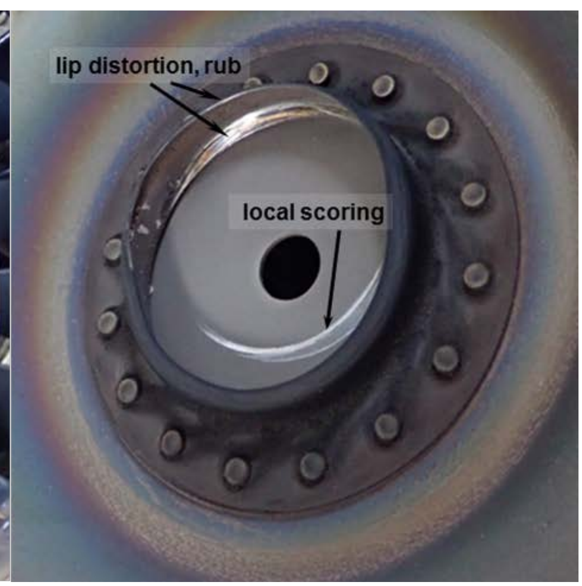


Figure 25. Inner baffle damage signatures

The downstream face of the power turbine vane ring and baffle assembly exhibited 360° scoring along the baffle OD and adjacent outer vane ring edge. This scoring signature spanned more of the baffle face (up to 0.6 inch) between 10 and 3 o'clock; the baffle was separated from the vane inner ring in this area. The baffle was also separated, and heat discolored, at 6 o'clock. The inner baffle lip was torn and was splayed outward between 3 and 10 o'clock, and inward between 10 and 12 o'clock. See Figure 26.

There were a series of circumferentially oriented marks on the baffle face between 3 and 9 o'clock. See Figures 26 and 27.

Figure 26. Power turbine vane ring and baffle assembly downstream face

The power turbine shroud was heavily rubbed; the knife edges were obliterated in some areas, and the shroud material was missing between 7 and 8 o'clock. See Figure 27. The vane TEs displayed tearing and gouging damage. Metallization was present on all vanes. See Figure 28.

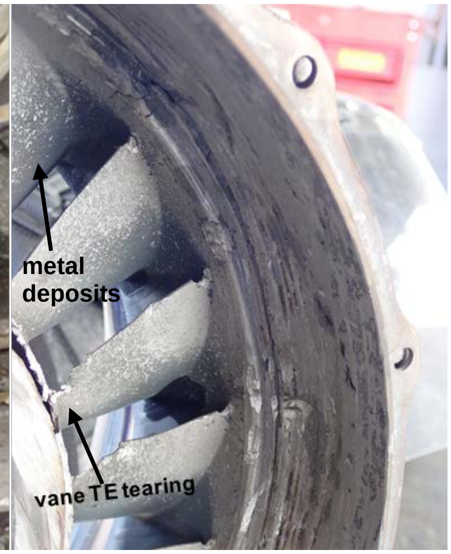


Figure 27. Detail, downstream power turbine vane ring and baffle assembly

Figure 28. Power turbine shroud

3.2.2.2 Power turbine

The power turbine rotor/gear train could not be manually rotated following removal of the power turbine stator housing assembly.

All the power turbine blade tip shrouds were liberated. The above-platform lengths of the remaining blade airfoils measured approximately 0.4 to 1.4 inches above the platform. See Figure 29.

Figure 29. Power turbine with power turbine stator housing removed

The power turbine upstream face was scored 360° along the disk outboard of the fir tree roots and at the center bore, balance ring and tooling lugs. See Figures 30 and 31.

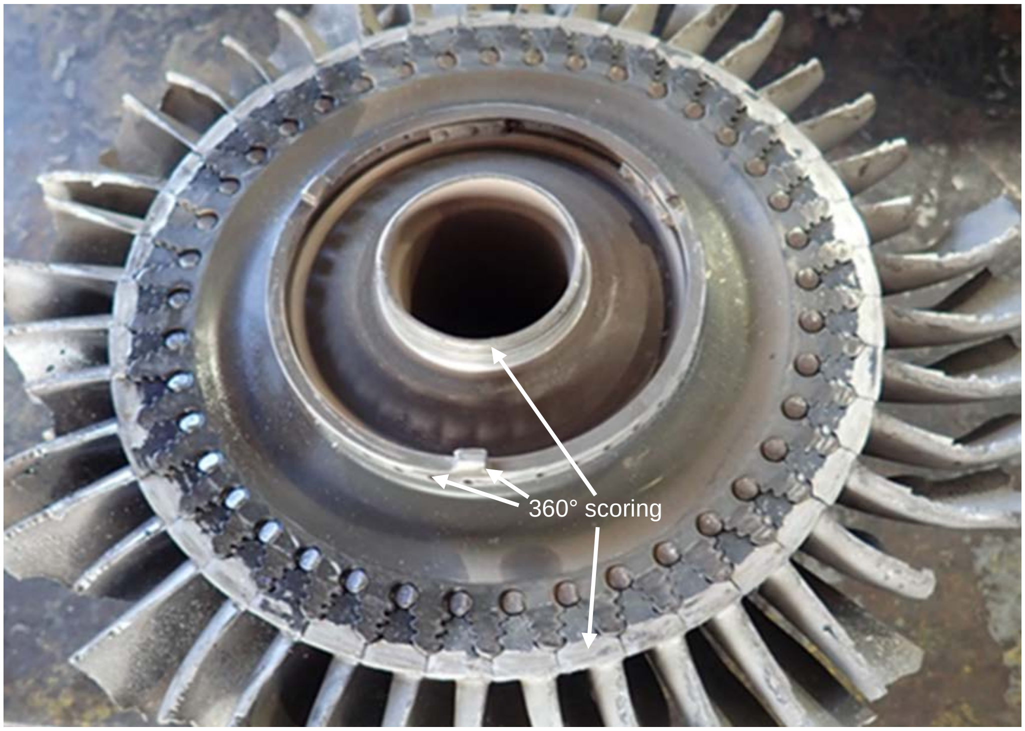


Figure 30. Power turbine upstream face showing circumferential contact damage

Undamaged areas of airfoil fracture surfaces were rough and uneven, consistent with overload. Some of the airfoil fracture surfaces were rubbed. The fracture surface of the tallest remaining airfoil exhibited thermal discoloration. The TEs of some airfoils displayed bending with a wavy appearance. See Figure 32.

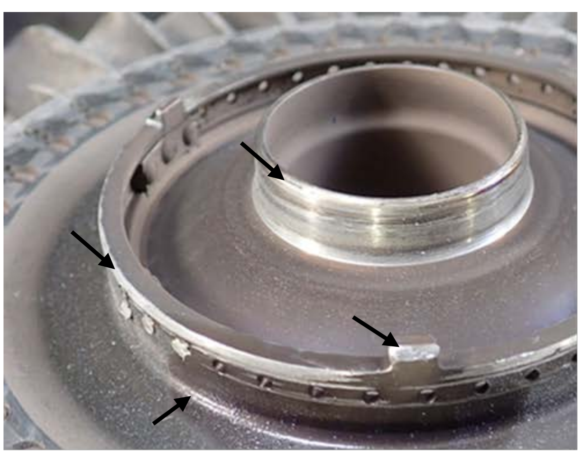


Figure 31. Circumferential damage at bore, bore edge, and tooling lugs

Figure 32. Power turbine airfoil bending

The downstream face of the power turbine was scored 360° along the base of the fir trees roots, across the rivets diameter and on the disk face inboard of the rivets. Most of the blades were displaced aft. See Figures 34 and 35.

Figure 33. Power turbine downstream face showing heavy rotational scoring and afterward blade displacement

Figure 34. Closeup of power turbine fir tree root area

3.2.2.3 Exhaust duct

The exhaust duct inner forward cone lip displayed rotational scoring. The No. 3 bearing cover inner lip was bent aft. See Figure 35. Impact marks were observed on the exhaust duct inside surfaces. Blade fragments were lying inside the duct at 6 o'clock. See Figure 36.

Figure 35. Exhaust duct rotational damage

Figure 36. Airfoil debris lying in exhaust duct

3.2.4 Output drive shaft

The visible portions of the output drive shaft and torquemeter assembly and the aircraft drive shaft retention/locking hardware were thermally damaged. Several teeth of the (airframe) flexible coupling retention nuts were bent, and the retaining ring was partially displaced.

3.2.4.1 Airframe-supplied flexible coupling

Two of the three airframe coupling drive lobes were fractured off. Circumferential scoring was observed on the coupling surface. See Figure 37.

The mating piece of the airframe flexible coupling was found nearby. It was distorted. See Figure 38.

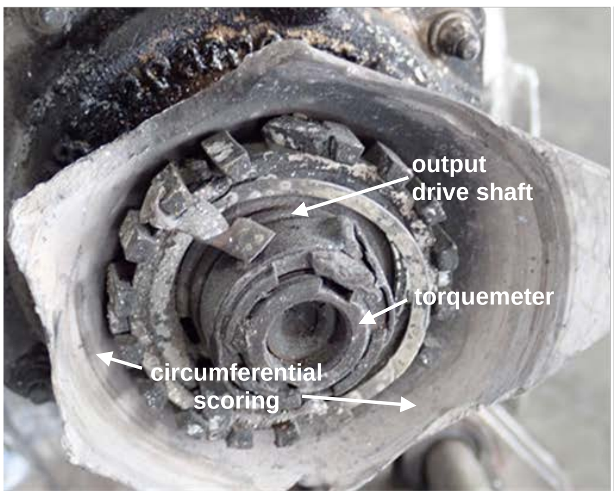


Figure 37. Circumferential scoring on the (airframe) flexible drive shaft coupling

Figure 38. Section of airframe flexible drive shaft

The Powerplants Group determined that no further disassembly of the engine was required.

4.0 Right engine disassembly examination

4.1 External inspection

The as-received condition of the engines was documented. See Figures 39 – 42.

Figure 39. Engine S/N PCE 36144, left side view

Figure 40. Engine S/N PCE 36144, right side view

Figure 41. Engine S/N PCE 36144, front view

Figure 42. Engine S/N PCE 36144, rear view

The engine data plate S/N (PCE 36144) was confirmed to the left engine installation records. The cowling and airframe components were removed.

4.1.1 External components

The fire seals were deformed. Hose insulation, electrical harness wiring and attachment hardware not protected by the engine deck material showed some thermal damage. The AGB-mounted accessories were thermally destroyed. Accessory internal components found at the site were coated with fire debris. A visual check of these components found no evidence of failure. An oil filter element believed to be from the right engine was found about 10 feet forward of the engines; it was crushed and was not contaminated by fire debris. The fuel filter element was contaminated with fire debris. Other engine externals displayed random impact damage. The P3 line was impact damaged but the connections were intact from the gas generator case to the hydromechanical fuel control fitting and were secured with safety wire. The fuel nozzles and fuel flow divider showed no obvious damage. The power turbine speed sensor was in place and no damage was noted. The sensor was not removed. The external portion of the left torque probe was missing; the remaining section of the left torque probe and the entire right torque probe were in place. The torque probes were not removed. The AGB chip detector was not recovered. The external portion of the RGB chip detector was intact. A visual check of the internal screen and chip detector found no anomalies.

4.1.2 Accessory gearbox

The AGB cases were thermally consumed. AGB internal components were coated with fire debris. Visual checks found no evidence of failure.

4.1.3 Compressor inlet case

Thermal destruction of the AGB and inlet case structure had displaced the compressor inlet screen and exposed the No. 1 bearing flexible housing. The inlet screen was distorted and coated with fire debris. See Figure 43.

4.1.4 Gas generator case

The gas generator case exhibited multiple dents adjacent to the fuel nozzles between 4 and 8 o'clock. See Figure 44.

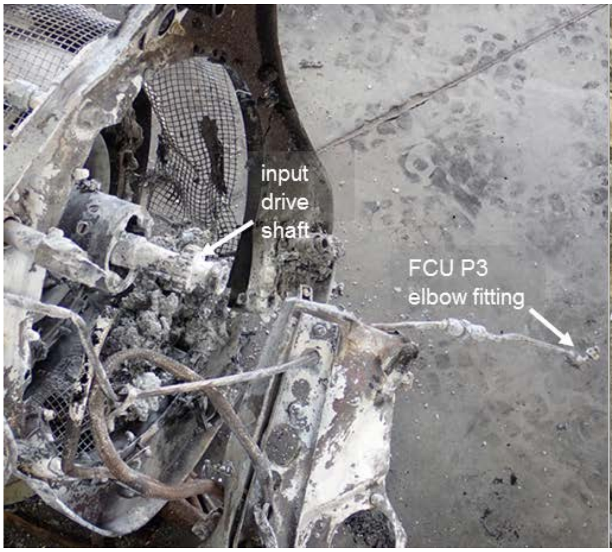


Figure 43. Compressor inlet with AGB and inlet case structure missing

Figure 44. Dented gas generator case

4.1.5 Exhaust duct

The exhaust duct was compressively deformed 360°. See Figure 45.

Figure 45. Exhaust duct compression damage

4.1.6 RGB

The lower half of the RGB exhibited localized impact damage (gouges).

4.2 Disassembly observations

The exhaust stack exit port was severely distorted and was deformed over part of the C flange. The gas generator case was sectioned in this area to facilitate engine disassembly. The engine was separated at the C flange. Metal fragments were found lying on the inside surface of the PT housing and the combustion liner at 6 o’clock. See Figures 46 and 47.

Figure 46. Compressor turbine and combustor after C flange separation

Figure 47. Power turbine stator housing after separation from the gas generator section

4.2.1 Gas generator

The compressor turbine rotor remained seized following removal from the power turbine and exhaust.

4.2.1.1 Compressor assembly

The No. 1 bearing and stator air seal were thermally damaged and heavily contaminated with fire debris. See Figure 48. The bearing was seized. The S1 compressor blade tips were all curled in the direction opposite of rotation. See Figure 49. The S2 airfoils were intact.

Figure 48. Compressor inlet showing No. 1 bearing package

Figure 49. Detail showing curled blade tips

4.2.1.2 Combustor

The combustion liner was locally deformed, consistent with the damage observed to the gas generator case.

4.2.1.3 Compressor turbine

The compressor turbine downstream face was scored 360° along the fir tree roots, blade retention rivets, and at the bore outer surface and edge. There was heat discoloration along the fir tree roots and rivets. The compressor turbine shroud segments appeared intact and their viewable areas were coated with metal. Metallization was also observed on the compressor turbine blade TEs. See Figure 50.

Figure 50. Compressor turbine downstream face showing rub 360° scoring

4.2.2 Power turbine and exhaust

4.2.2.1 Power turbine vane ring and baffle assembly

The upstream face of the power turbine vane ring and baffle assembly displayed 360° scoring along the vane inner ring and baffle OD, and on the inner and outer baffle lip surfaces. There was heavy heat discoloration along the baffle OD, and it was separated from the vane inner ring in several areas. See Figure 51.

Figure 51. Upstream face of power turbine vane ring and baffle assembly showing rotational damage

The downstream face of the power turbine vane ring and baffle assembly displayed 360° scoring along the inner vane ring edge and the baffle OD. There was heavy heat discoloration along the baffle OD, and it was partially separated from the inner vane ring. There were arcs of scoring on the baffle face between 6 and 2 o’clock and on the inner baffle face between 12 and 7 o’clock, where the material was penetrated between 2 and 5 o’clock. The vanes between 12 and 6 o’clock were missing chunks of TE material. Six of the vanes and the vane outer ring edge in this area were heavily rubbed and battered. The power turbine shroud was also battered, and the knife edges were obliterated. There were heavy metal deposits on the vane TEs. The air path showed some isolated impact marks. See Figure 52.

Figure 52. Downstream face of power turbine vane ring and baffle assembly, showing rotational damage

4.2.2.2 Power turbine

Following separation, the PT rotor turned freely by hand and continuity to the output shaft was established. The bolt bore edge was severely scored 360°, with metal displacement into the bore, decreasing the bore diameter in this area. The tooling lugs all showed local scuff/rub marks. See Figure 53. The power turbine upstream face was heavily rubbed 360° outboard of the blade retention rivets and there was heavy rub along the blade leading edges (LEs) adjacent to the platform. See Figure 54.

Figure 53. Power turbine with power turbine vane ring and baffle assembly removed

Figure 54. Detail of rotational damage to power turbine upstream face

Twenty-five blades were fractured. The remaining blade stubs were 1.0 to 1.6 inches long. The airfoil fracture surfaces were rough and uneven, consistent with overload. See Figure 55. The 16 remaining blades were intact; their shrouds exhibited heavy tip rub, and some of the shroud material was missing. See Figure 56.

Figure 55. Power turbine blade fracture surfaces

Figure 56. Power turbine blade tip shroud rub damage

Damage to the bolt bore complicated further PT disassembly. The Powerplants Group determined that examination of the PT wheel downstream face was not required.

4.2.3 Output drive shaft

EEC cooling hose material was attached at the RGB in the output shaft area.[12] See Figure 57.

[12] The (airframe) EEC hose is routed below the PTO.

Structural wire from the cooling hose was found wrapped around the output shaft. See Figure 58.

Figure 57. Engine output shaft with hose material

Figure 58. Wire wrapped around engine output shaft

4.2.3.1 Airframe-supplied flexible coupling

The airframe-supplied engine output coupling was attached to the engine. See Figure 59.

Figure 59. Distorted airframe coupling attached at engine output shaft

Carol Horgan
Powerplants Group Chairman