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

September 30, 2015

POWERPLANTS GROUP CHAIRMAN'S FACTUAL REPORT
NTSB ID: CEN15FA034

A. ACCIDENT

Location:	Wichita, Kansas
Date:	October 30, 2014
Time:	0948 Central Daylight Time (CDT)
Aircraft:	Raytheon Aircraft Company Super King Air B200, Reg. N52SZ

B. POWERPLANTS GROUP

Chairman:	Carol M. Horgan National Transportation Safety Board Washington, DC
Member:	Rick Terrell Federal Aviation Administration Wichita, Kansas
Member:	Ernest C. Hall Textron Aviation Wichita, Kansas
Member:	Daniel P. Boggs Hartzell Propeller Inc. Orlando, Florida
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C. SUMMARY

On October 30, 2014, at 0948 CDT, a Raytheon Aircraft Company Super King Air B200, N52SZ, collided with the Flight Safety International (FSI) building at Wichita Mid-Continent Airport (KICT), Wichita, Kansas. The pilot, who was the sole occupant, was fatally injured and the airplane was destroyed. Three building occupants were fatally injured, two occupants sustained serious injuries and four occupants sustained minor injuries. The airplane was registered to and operated by Gilleland Aviation, Inc., Georgetown, Texas. It was operating as a business flight under the provisions of 14 Code of Federal Regulations Part 91. Visual meteorological conditions prevailed. An instrument flight rules (IFR) flight plan was filed. The flight originated at 0947 CDT and was en route to Mena Intermountain Municipal Airport (KMEZ), Mena, Arkansas.

According to air traffic control (ATC) recordings, at 0947:06, the airplane departed runway 1R and was instructed by the controller to fly runway heading. At 0948:17, the pilot declared an emergency and stated that he had "lost the left engine." According to witnesses on the ground, after the airplane departed runway 1R, a left turn was initiated and the airplane's altitude was estimated at less than 150 feet above the ground. One witness observed the airplane shortly after it became airborne and stated that he heard a reduction in power on one engine before it entered the left turn. Another witness saw the airplane from about 20 yards away. He said the airplane was in a left turn and approached the hangars east of FSI, then the wings were level as it flew west toward FSI. He stated that the airplane's landing gear were "down and locked", the flaps were extended, the rudder was neutral, and the right engine was at full power. The witness did not see the left engine. The airplane then disappeared from his view and he heard the sound of an impact. Another witness observed the airplane in its final seconds before it impacted the FSI building. He said the airplane was on a heading of 240 degrees and was in a "gradual" descending left turn. He thought the airplane was going to land on the west runway, but then it collided with the northeast corner of the FSI building. The witness said the landing gear was extended and both propellers were rotating, but he could not determine at what power setting. He said the airplane's left engine struck the building first just below the roof line, followed by the outboard section of the left wing. When the wing impacted the building it separated and the airplane rolled to about 70 degrees bank angle. The nose of the airplane struck the roof of the building and the airplane slid for about 20-30 feet before the tail section came over the top of the airplane followed by a large explosion.

A Powerplants Group was formed at Wichita on October 31, 2014. The group reviewed the airplane service and maintenance records and documented the engines and propellers as recovered. Review of the engine and propeller logbooks and records found no deficiencies that would affect the operation or performance of the aircraft. The engines and propellers were brought to a secured hangar where airframe components attached to the engines were removed and the propellers were separated from the engines. Propeller teardown inspections were performed at the hangar November 1–3, 2014 and at Hartzell Propellers, Inc, Piqua, Ohio September 9–10, 2015. No evidence of pre-impact failure was found. Evaluation of the propeller damage determined that neither propeller was feathered at impact. Witness marks provided data from which estimated propeller blade angles at the time of impact could be derived.[1] The marks indicated that the left powerplant was producing low to moderate power and the right propeller was producing moderate power at the time of impact. The engines were taken to a Pratt & Whitney service center at KICT. Engine teardown examinations were performed November 3–5, 2014. No evidence of pre-impact core engine failure was found. Both engines displayed evidence of engine rotation at the time of impact. Evaluations of the engine fuel and power control systems were limited by extensive thermal damage; the remaining parts exhibited no anomalies inconsistent

[1]Blade angles derived from witness marks have error tolerance both in measurement and in the accuracy of the reference point used for measurement.

with impact or thermal damage.

D. DETAILS OF THE INVESTIGATION

1.0 Powerplant information

The accident aircraft was powered by two Pratt & Whitney Model PT6A-42 turboprop engines with Hartzell Model HC-E4N-3G propellers.

1.1 Powerplant description

The Pratt & Whitney PT6A-42 is a reverse-flow turboprop engine featuring a 3-stage axial, 1-stage centrifugal compressor driven by a single-stage compressor turbine (CT) and a reduction gearbox (RGB) driven by a 2-stage power turbine (PT). The PT6A-42 is flat-rated to 850 shaft horsepower.

The Hartzell HC-E4N-3G is a 4-bladed, single-acting, hydraulically operated, constant-speed propeller with full feathering and reversing capabilities. Oil pressure from a propeller governor is used to move the blades toward low pitch. Blade-mounted counterweight forces and a feathering spring act to move the blades toward high pitch/feather in the absence of governor oil pressure. The hub and blades are aluminum and rotation is clockwise.[2] The blade part number is D9390SK-1R. The Hartzell installation data sheet No. 1075 blade angle settings for this propeller are:

Reverse:	-11.0° ± 0.5° BA	(mechanical hard stop)
Low:	18.2° ± 0.1° BA	(beta ring pickup)
Feather:	85.8° ± 0.5° BA	(mechanical hard stop)

1.2 Powerplant data

position	component	model	serial number	time since new (TSN)	cycles since new (CSN)	time since overhaul (TSO)	time since hot section (TSHSI)	cycles since hot section (CSHSI)
No. 1 (left)	engine	PT6A-42	PJ0342	6,180.9	7,109	2,774.8	1.4	2
	propeller	HC-E4N-3G	HH-1551	4,688.4	NA	1,015.9	NA	NA
No. 2 (right)	engine	PT6A-42	PJ0343	6,240.0	7,146	2,700.0	1.4	2
	propeller	HC-E4N-3G	HH-3523	1,465.0	NA	1.4	NA	NA

Table 1. Powerplants data

1.3 Service history

Review of the airplane service records found that the airplane had completed major scheduled maintenance at Hawker Beechcraft Services, Wichita, Kansas, on October 22, 2014.[3] Powerplants work performed under this work order included left and right engine hot section inspections and an overhaul of the right propeller. At the time of the accident, the airplane had accumulated 1.4 hours and 2 cycles since the October 22, 2014 release to service.

[2] References to position are as viewed from the rear of the aircraft looking forward unless otherwise noted.

[3] Phase 1 through Phase 4 maintenance, Hawker Beechcraft Services work order ICT4I000503.

Review of the airplane logbooks found no pertinent engine or propeller-related discrepancies.[4]

2.0 Evidence recovery

2.1 Left engine recovery

An initial point of impact was evident at the northeast corner roofline of the FSI building, a brick structure housing flight simulators. See Figure 1. The left engine and propeller were found inside the building, separated from the airframe and partially buried in rubble just beyond the roofline impact. See Figure 2.

Figure 1. Initial point of impact

Figure 2. Rear view of left engine as found

The propeller remained attached to the engine. See Figure 3. The blades were retained in the hub but were loose in their clamps. The outboard ends of two adjacent blades were fractured off.

Figure 3. Left engine recover

[4]Engine operating temperature indications mentioned in an October 29, 2014 airplane logbook entry made by Hawker Beechcraft concerned the airplane cabin bleed air system.

2.0 Right engine recovery

The right engine was recovered from the FSI building roof. It was lying in its airframe mount structure and facing east. The propeller was found in its expected position relative to the engine but was no longer attached to the engine due to thermal damage. All of the propeller blades were installed in the hub. The blades and pitch change mechanism were largely destroyed by fire. See Figure 4.

Figure 4. Right engine and propeller recovery

2.1 Recovery of separated blade sections

An outboard section of propeller blade approximately 11 inches long was found about 200 feet northeast of the initial point of impact. The piece was scraped chordwise and the leading edge (LE) was torn approximately 10 inches from the blade tip. See Figure 5. Another outboard propeller blade section, approximately 23.5 inches long, was recovered from the FSI building roof. See Figure 6.

Figure 5. Views of blade tip section recovered from parking lot

Figure 6. Blade section recovered from roof

3.0 Left propeller

The left propeller blades were reference marked A-B-C-D in the direction opposite of rotation.

Figure 7. Left propeller S/N HH-1551

A disassembly inspection was performed November 2-3, 2014. No evidence of pre-impact failure was found. The parts were further evaluated at Hartzell Propellers Inc, in Piqua, Ohio, September 9-10, 2015.

3.1 Component inspections

3.1.1 Spinner assembly

The spinner bulkhead was sooted and bent. Crushed fragments of the spinner dome were attached at the bulkhead.

3.1.2 Cylinder

The cylinder was not recovered.

3.1.3 Piston

The piston was not recovered.

3.1.4 Pitch change rod

The pitch change rod was separated forward of the hub. See Figure 8. The hub end fracture surface exhibited 45° angles typical of overload fracture.

Figure 8. Pitch change rod and fork

3.1.5 Fork

See Figure 8. The fork beta rod guide arms were randomly bent. There were minor dents and gouges in the fork knob slots and normal wear on the slot faces. One of the fork bumpers was broken off.

3.1.6 Feathering spring/guides

The feathering spring and guides were not recovered.

3.1.7 Low pitch stop

The low pitch stop was not recovered.

3.1.8 Beta mechanism

The beta ring was crushed. The return springs and rods were sooted.

3.1.9 Feather stop

The feather stop was not recovered.

3.1.10 Hub assembly

The hub assembly was soot-covered and thermally damaged. The forward hub half was damaged at the D blade retention socket and at the cylinder mounting threads, which had separated. The aft hub half D blade retention socket wall was fractured in the vicinity of the mounting bolt holes and at the D blade hub socket. See Figures 9 and 10. The propeller serial number was marked between the B and C blade sockets.

Figure 9. Aft hub fractured at D blade socket

Figure 10. Fractured aft hub with D blade preload plate

3.1.11 Blades

The propeller blade pieces recovered at the site were matched to blades A and D based on blade length and fracture characteristics. Blade damage is described in Table 2. See Figures 11 through 13.

Figure 11. Propeller blades

Figure 12. Propeller blades

Figure 13. Propeller blades

blade	damage	
A	camber side	inboard section: soot, de-ice boot burned,chordwise scoring midblade, chordwise separation 11-inch outboard section: no thermal damage or soot, chordwise scrapes entire span
	face side	inboard section: soot, thermal damage, chordwise scoring 7” from tip, chordwise separation outboard section: no thermal damage or soot, chordwise scraping, both camber and face
	bend	bent aft 21” from the tip
	twist	twisted LE down, midblade to tip
	LE	torn 10” from the tip and fractured/separated 11” from tip
	TE	undamaged
	knob	separated, recovered near the propeller
	counterweight	fractured off, not recovered
B	camber side	sooted, burned. De-ice boot thermally damaged, some thermal damage near the tip. spanwise scoring 29” from tip.
	face side	sooted, thermal damage
	bend	bent aft 90°at mid blade
	twist	undamaged
	LE	dented 8-13” from tip
	TE	locally deformed 18” from tip
	knob	attached; the bearing was missing
	counterweight	fractured off, not recovered
C	camber side	sooted, thermal damage, de-ice boot abraded/charred off. Chordwise scoring mid blade
	face side	charred, soot
	bend	bent aft 28” from tip and forward 20” from tip.
	twist	twisted, LE down
	LE	locally deformed 21” from tip
	TE	nicked and gouged mid blade to tip
	knob	separated, recovered near the propeller
	counterweight	fractured off, not recovered
D	camber side	charred, sooted, span wise and chordwise scoring. Chordwise separation 21.5” from tip
	face side	charred, sooted, heavily gouged in the shank area. Chordwise separation 21.5” from tip
	bend	bent aft at midblade and forward 4” from tip
	twist	twisted down at LE
	LE	scraped chordwise. Tear at camber side with missing material: about 4” (l) x 1.5” (w)
	TE	dented and gouged from midblade outboard
	knob	attached; fractured bearing
	counterweight	fractured off, not recovered

Table 2. Blade inspection results

3.1.11.1 Pitch change knobs

The pitch change knobs and dowel pins/dowel pin holes were deformed. See Figure 14. The A blade pitch change knob, which was recovered near the propeller, had one mounting foot broken off; the dowel pin hole on this side was deformed and two gouges/grooves extended from the deformed area across the blade butt. The path and direction of the gouges were consistent with a forcible pitch change knob separation in the high pitch direction.

The B blade pitch change knob remained attached to the blade butt.

The C blade knob, recovered near the propeller, was bent at the mounting flange; its dowel pin was sheared off; the flange, dowel pin hole, bolt holes and butt face were deformed in the low pitch direction.

The D blade pitch change knob remained attached to the blade butt. The knob bearing was fractured. The attaching bolt was partially pulled out and the mounting foot was bent on the high pitch side.

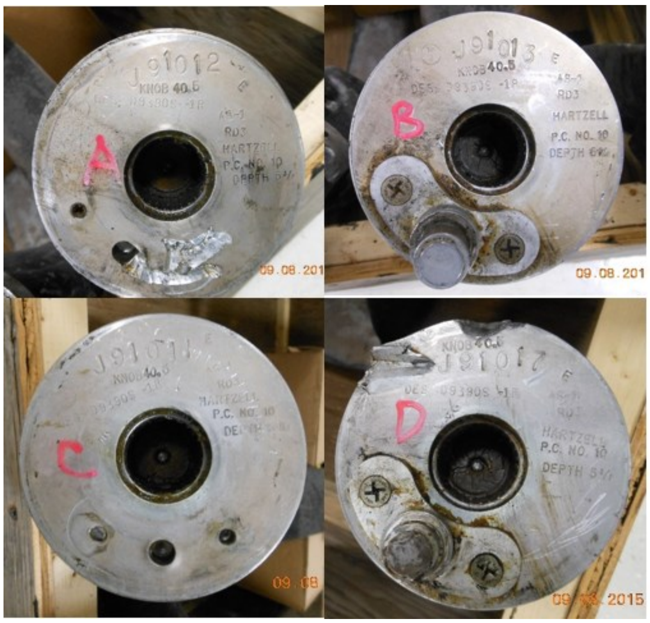


Figure 14. Blade butts with pitch change knob assemblies

Figure 15. Counterweight block mating surfaces

3.1.11.2 Counterweights

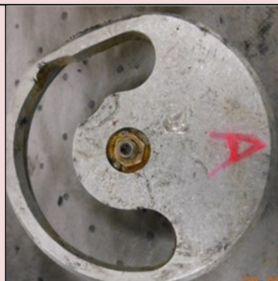
The blade counterweights had fractured/separated and were not recovered. Hole elongation and other deformities were noted at the counterweight retention boss mating surface. The A blade counterweight boss threaded holes were deformed inward, toward the hub. The B blade counterweight boss threaded holes were deformed inward, toward the hub. The C blade counterweight boss threaded holes were deformed toward the hub and in the direction opposite of rotation. The D blade counterweight boss threaded holes were deformed in the direction opposite of rotation. See Figure 15.

3.1.11.3 Blade retention bearings

Inspection of the blade retention bearing races found fractures consistent with impact damage.

3.1.11.4 Preload plates

All of the preload plates were mechanically damaged. All displayed witness marks consistent with contact from adjacent blade fork bumpers.[5] Equivalent propeller blade angles were derived from the locations of the marks. See Table 3.

preload plate		split line confidence level**	fork bumper impact mark* *F: forward A: aft*	estimated equivalent BA	comments
A		high	24° F 25° A	17° 54°	The aft chamfer was deformed; the aft chamfer was cracked at the feather side of the knob slot; the lip was sheared and deformed
B		medium	several averaging 25° F	16°	The lip was sheared and deformed
C		high	30° F 'chattering' decreasing to ~22° F	12° to 19°	The lip was sheared and deformed
D		medium	27° F	14.5°	The plate was deformed due to a broken-out section; the lip was sheared and deformed

*Mark locations are measured relative to the hub split line, with *F* indicating forward and *A* indicating aft
**The hub split line was determined from sealant and assembly marks (not marked at disassembly)

Table 3. Preload plate witness marks and estimated equivalent blade angles

[5] Angular locations of preload plate impact marks can provide information about the position of the blade at the time impact occurs.

4.0 Left engine examination

4.1 External condition

The left engine inlet case, AGB housing, and AGB diaphragm were thermally destroyed. The rear section of the gas generator case (GGC) was deformed and there was a crack in the deformed area at 10 to 11 o'clock. The aft end of the exhaust duct was compressively deformed with the most pronounced deformation between 4 and 8 o'clock and a circumferentially-oriented crack in the compressed area between 1 and 2 o'clock. The engine showed no indications of uncontainment. See Figures 16 and 17.

Figure 16. Top view of engine S/N PJ0342

Figure 17. Bottom view of engine S/N PJ0342

The engine tubes, accessories, and electrical components exhibited moderate to severe thermal and mechanical damage. The high pressure bleed valve was thermally destroyed. The low pressure bleed valve was heat-deformed. There was no significant thermal damage to the reduction gearbox (RGB) and the constant speed governor (CSU), or the overspeed governor (OSG). The center fire seal mount ring assembly had displaced and was mechanically deformed. The rear mount ring assembly was fragmented. See Figure 18.

The fuel pump and much of the fuel control unit (FCU) were thermally destroyed. The integrity of the fuel line from the FCU to the rear fire seal mount ring assembly fuel line could not be assessed due to fire damage. The fuel line from the rear fire seal mount ring to the fuel flow divider fuel line was whole and the connections secured. The fuel nozzle assemblies, transfer tubes and the flow divider remained installed or were recovered from the wreckage debris. No indications of pre-impact fire were found. Viewed through the exhaust, the PT rotor was intact. See Figure 19.

Figure 18. Rear mount ring, tubes and inlet screen

Figure 19. PT rotor viewed through the exhaust

The power control and reversing linkage was mechanically deformed but was continuous from the propeller governor beta block to the FCU.

The compressor discharge air pneumatic signal (P_3) was continuous from the FCU fitting to just aft of the 90° bend in the FCU-to-aft mount ring bracket tube; thermally destroyed from this point to P_3 filter-to-aft mount ring bracket tube aft fitting, and intact from the aft fitting to the GGC boss. The P_3 filter assembly was thermally destroyed; the P_3 filter element was recovered but could not be assessed due to thermal damage.

The power turbine control (P_y) signal tubing was continuous from the FCU to the CSU and OSG connections. Thermal damage did not allow assessment of the P_y connection at the FCU. The safeties at the propeller governor, torquemeter, and fire seal mount ring P_y fittings were intact.

The presence of ferrous debris on the RGB chip detector could not be assessed due to thermal damage.

The oil filter element was recovered. No metal particles were found in its folds.

The fuel filter element metal screen was recovered. It was coated with burned material and could not be assessed.

4.2 Disassembly observations

4.2.1 Compressor section

4.2.1.1 Compressor rotor

The compressor rotor turned freely in its housing following removal from the GGC. The stage 1 (S1) compressor blades were dented and torn, with random leading edge (LE) curling. The blade tips were rubbed with associated burring. The S1 compressor spacer was lightly rubbed 360°. The stage 2 (S2) blade LEs were lightly dented and the blade tips were rubbed and burred. See Figure 20. The stage 3 (S3) compressor blades were lightly impact damaged and the blade tips were rubbed and burred. See Figure 21. The S2 and S3 spacers were undamaged.

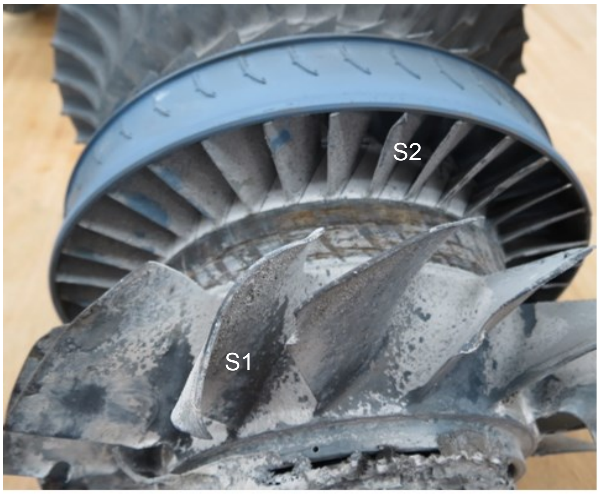


Figure 20. S1 and S2 compressor blades (viewed from forward of engine looking aft)

Figure 21. S3 compressor blades

The impeller inducer area was undamaged. All of the impeller vane tips were scored and burred. See Figures 21 and 22. Several exducers were lightly rubbed. See Figure 22.

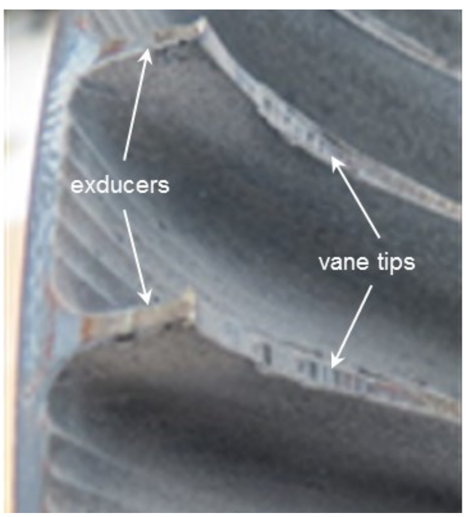


Figure 22. Impeller exducers and vane tips

Figure 23. S1 compressor stator vanes

The impeller back face and front stub shaft were undamaged.

4.2.1.2 Compressor stator

The LE roots of the S1 stator vanes were randomly torn and curled. See Figure 23. The S1 stator vanes exhibited tip rub and associated burring. See Figure 23. No S2 stator vane damage was noted.

The S3 vanes were rotationally damaged at the TE roots. The impeller shroud showed normal wear.

4.2.1.3 Compressor bearings and air seals

No distress was observed to the No. 1 or the No. 2 bearings or air seals.

4.2.2 Combustion section

The combustion chamber liner and the small exit duct were undamaged.

4.2.3 Turbine section

4.2.3.1 CT vane ring

The downstream[6] side of the CT vane ring exhibited rotational scoring at the inner drum. See Figure 24.

4.2.3.2 CT shroud

The CT shroud was circumferentially rubbed. See Figure 24.

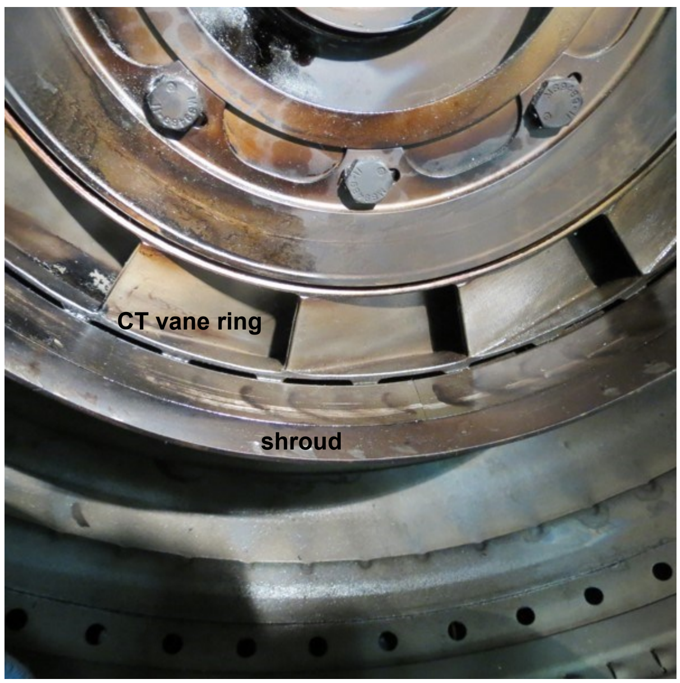


Figure 24. CT vane ring and shroud

4.2.3.3 CT disk assembly

The downstream side of the CT disk assembly was circumferentially scored along the fir trees and the hub. The disk hub spigot was deformed and thermally discolored. There was discoloration along the blade roots. See Figure 25.

[6] 'Upstream' and 'downstream' refer to gas path flow through the engine from the compressor inlet to the exhaust.

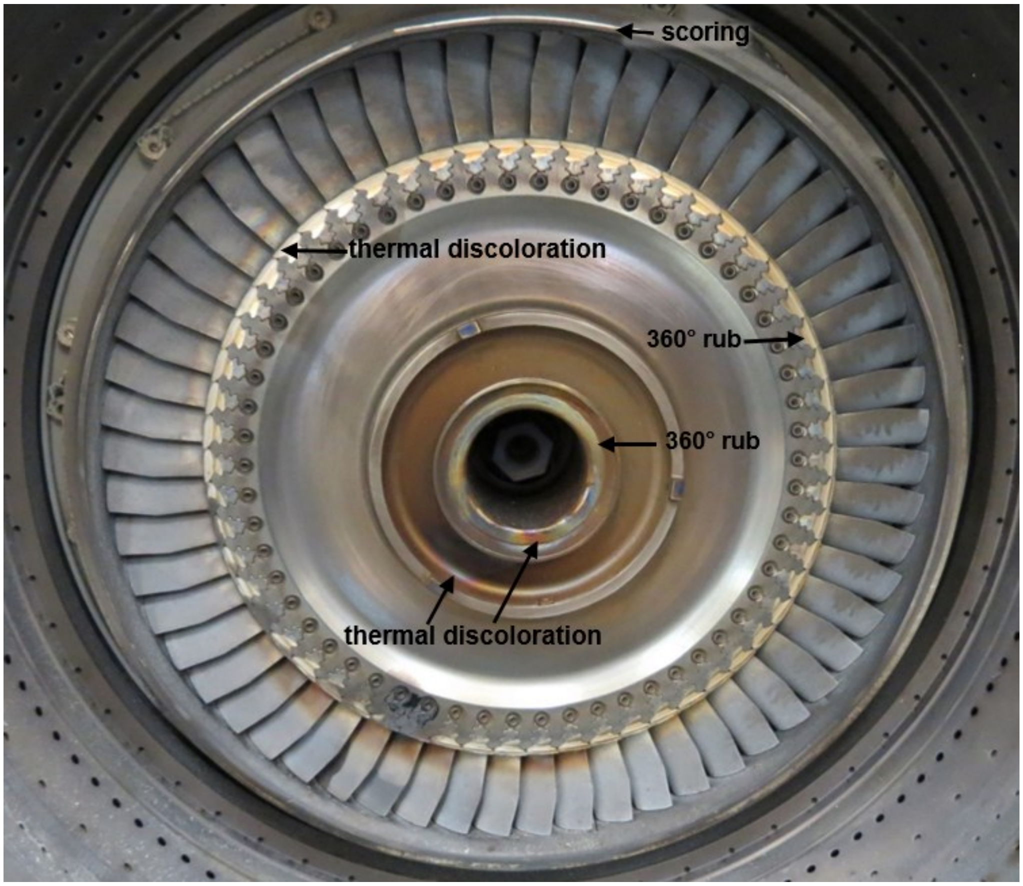


Figure 25. CT disk assembly downstream side

All of the CT blades exhibited tip rub and one blade was torn at the TE. The blade retention rivets and platforms on the upstream side of the CT disk were scored 360°. See Figure 26.

Figure 26. CT disk assembly upstream side showing rotational scoring along blade retention rivets and platforms

4.2.3.4 ITT probes, busbar, and harness

The interturbine temperature (ITT) busbar was undamaged. Two adjacent ITT harness probes located at 6 to 7 o'clock were fractured off. See Figure 27.

4.2.3.5 PT housing

The PT housing was intact. Ten of the 12 PT vane housing-to-exhaust case bolts were fractured. See Figure 28.

Figure 27. PT housing showing missing ITT probes

Figure 28. Failed PT housing flange attachment

4.2.3.6 S1 PT shroud

The S1 PT shroud was undamaged.

4.2.3.7 S1 PT vane ring

The upstream side of the S1 PT vane ring exhibited 360° scoring and thermal discoloration on three surfaces, including machining separation of the center of the baffle. See Figure 29. The downstream side of the vane ring exhibited a 190° arc of rotational damage and thermal discoloration on the inside baffle and rotational scoring along the outside baffle. There were two axial cracks in the vane ring inner drum. See Figure 30.

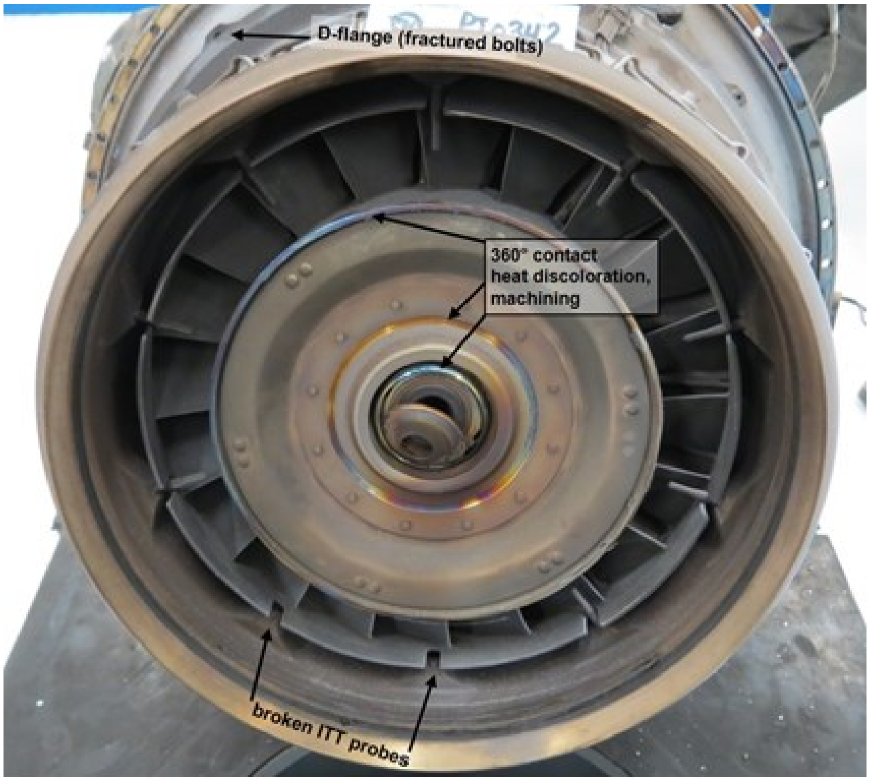


Figure 29. PT S2 vane ring assembly, upstream face

4.2.3.8 S1 PT disk assembly

The upstream surface of the S1 PT disk assembly was rubbed and burred along the blade roots and root platforms and at the blade shroud knife edges. See Figure 31.

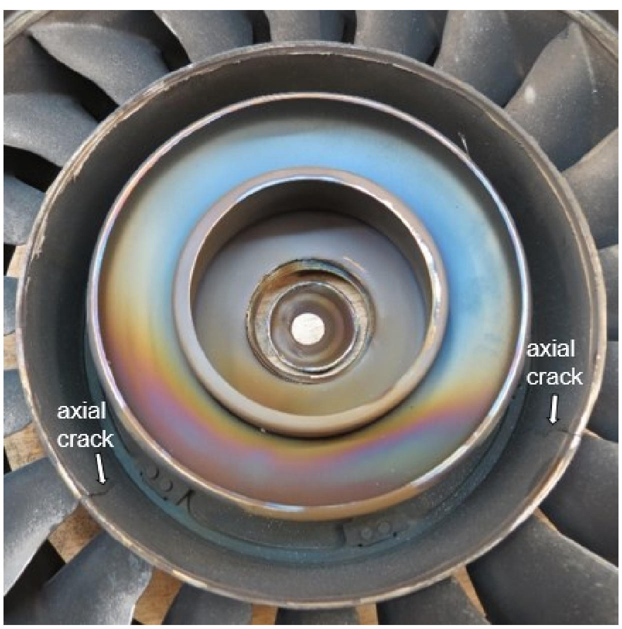


Figure 30. Downstream face of PT S1 vane ring

Figure 31. Upstream face of PT S1 disk assembly

The S1 PT disk assembly downstream face was rubbed in the fir tree area. A small amount of burring was noted at the S1 PT blade shroud knife-edges.

4.2.3.9 S2 PT vane ring

The PT rotor assembly was not disassembled; visual inspection of the S2 PT vane ring showed no anomalies.

4.2.3.10 S2 PT disk assembly

The upstream surface of the PT S2 disk assembly was circumferentially scored. The downstream surface exhibited circumferential rub at the fir tree area, the balance rim, and on the disk hub spigot. See Figure 32. The blade shroud knife edges exhibited slightly more rub than is typical for in-service operation.

Figure 32. PT S2 disk assembly, downstream face

4.2.3.11 S2 PT shroud housing

The S2 PT shroud housing was rotationally scored.

4.2.3.12 PT shaft and shaft housing

The PT shaft housing was compressively deformed. The PT shaft was separated into 2 pieces upstream of the No. 3 bearing. The aft end of the PT shaft remained attached to the PT rotor assembly. The forward end of the aft section of the shaft was worn and burnished consistent with rotational contact between the shaft fracture surfaces. An undamaged portion of the fracture surface on the aft end of the forward section of the shaft exhibited torsional tensile overload features. See Figure 33. The S1 sun gear showed no distress. See Figure 33.

The No. 3 bearing outer race (OR) retaining bolt heads were broken off. The bearing flange was fractured through the weight reduction holes over a 270° arc, centered at 12 o'clock. The OR flange was deformed and had fractured in overload. The raceway showed no distress. The bearing cage was seized and microwelded to the bearing inner race (IR). See Figure 34.

Figure 33. S1 sun gear and forward section of fractured PT shaft; detail of fracture surface

Inspection of the assembled No.4 bearing found no distress other than a 90° arc of light rub on the OR. See Figure 35. The No. 4 bearing was prevented from turning smoothly by the deformed PT shaft.

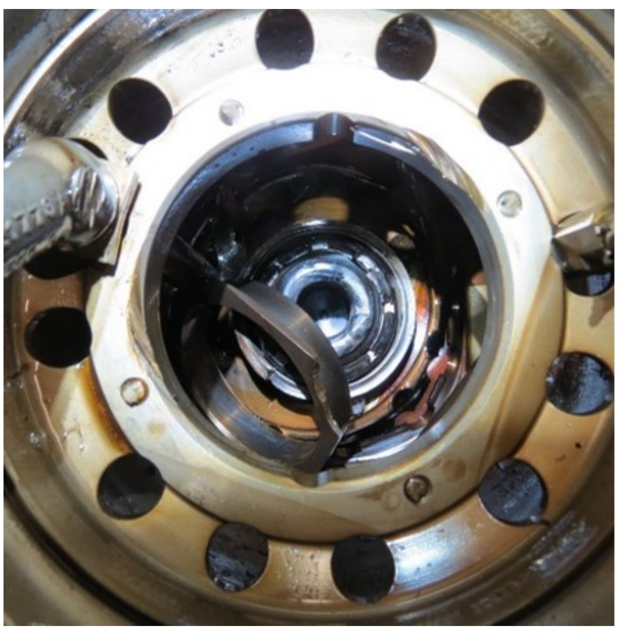


Figure 34. No. 3 bearing distress

Figure 35. No. 4 bearing face

All of the No. 4 bearing OR retaining bolt heads were broken off, including those retaining the 3/4 bearing oil nozzle retaining bracket; the 3/4 bearing oil nozzle retaining bracket and bearing roller elements were found loose in the RGB rear housing. See Figure 38. The 3/4 bearing oil nozzle assembly was bent 90° and was fractured at its supply end. The aft surface of the 3/4 bearing housing was deformed and ovalized, and was intermittently scored.

4.2.4 Reduction gearbox

The RGB S1 planet gears, carrier assembly, ring gear, and bearings were inspected as assembled. The flexible shaft retaining ring was displaced. The S2 sun gear was rotationally scored. No other anomalies were noted. See Figure 37.

Figure 37. S1 reduction gear carrier

Figure 38. S2 reduction gear carrier

The RGB S2 planet gears, carrier assembly, ring gear and bearings were inspected as assembled. No gear distress was found. The No. 4 bearing oil nozzle exhibited machining damage and displaced material. The gear retention plug heads were slightly worn on the inboard sides consistent with contact by the S2 planetary housing during operation. See Figure 38. Inspection of the aft side of the No. 5 bearing found no obvious damage. The front gearbox assembly was not disassembled and the condition of the No. 6 bearing, the propeller oil transfer sleeve, and the propeller control system drive train was not assessed.

4.2.5 Accessory gearbox

The AGB housing and diaphragm were thermally destroyed. Steel components recovered from the crash site included the input coupling shaft and most of the accessory gears. They were coated with soot and thermally-destroyed material. Examination of the recovered components found no evidence of pre-impact failure.

4.3 Controls and accessories evaluations

The fuel pump and FCU were thermally destroyed. Steel pump and FCU components were identified in the AGB debris. All were whole and unremarkable. The CSU and an airframe-supplied overspeed governor were evaluated at Woodward, Rockford, Illinois with NTSB oversight.

As-received inspection of CSU P/N 8210-024, S/N 1223678 found it capable of functional test. The unit operated normally on production acceptance test, meeting all requirements except several speed settings that were slightly out of production specification. The discrepancies were accounted for by typical field rigging adjustments and post-crash fire damage. A teardown inspection was then performed. No evidence of pre-impact failure was found. See Figure 39.

Figure 39. CSU components

Raytheon overspeed governor P/N 210638, S/N 12211796 was initially installed on a test bench but functional test was stopped due to unusual noise. Disassembly found that the plunger and driveshaft were seized together as a result of corrosion. The corrosion and mechanical damage were consistent with post-crash fire and the fire extinguishing effort. No evidence of pre-impact failure was found. See Figure 40.

Figure 40. Raytheon overspeed governor components

5.0 Right propeller

The right propeller blades and the pitch change mechanism were largely consumed by fire. See Figure 40.

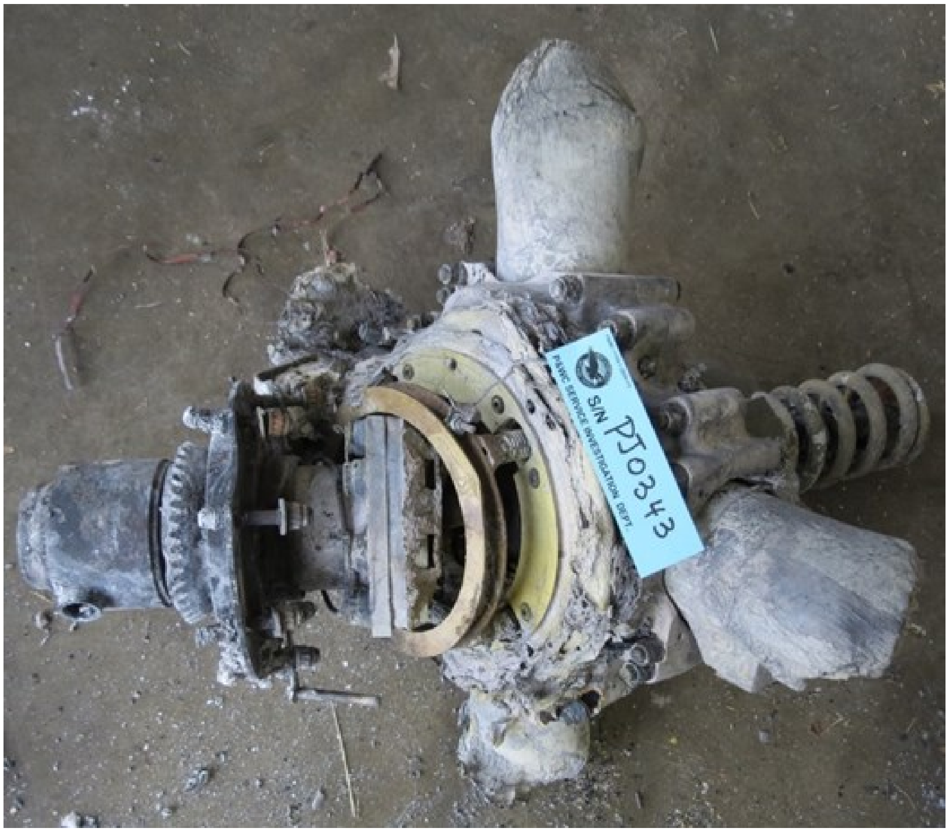


Figure 40. Propeller S/N HH-3523

The propeller blades were marked A-B-C-D.

5.1 Component inspection

5.1.1 Spinner assembly

The spinner dome was not recovered. Most of the spinner bulkhead was consumed by fire. An approximately 6 inch (in radius) bulkhead section remained attached to the hub.

5.1.2 Engine/propeller mounting

The engine-to-propeller mounting interface was thermally consumed.

5.1.3 Cylinder

Two small pieces of the cylinder were recovered.

5.1.4 Piston

The piston was melted/thermally deformed. See Figure 41.

5.1.5 Pitch change rod

The pitch change rod was cut just aft of the piston to aid in disassembly. It was slightly bent aft of the fork.

5.1.6 Fork

The fork assembly was corroded and was not perpendicular to the pitch change rod. Two forward tangs were fractured off. The beta rod guide arms were bent. See Figure 42.

Figure 41. Piston and pitch change rod

Figure 42. Fork

5.1.7 Feathering spring/guides

The feathering spring was bent. The guides were not recovered.

5.1.8 Low pitch stop

The low pitch stop was captive on the pitch change rod.

5.1.9 Beta mechanism

The beta ring and rods were bent and thermally damaged.

5.1.10 Feather stop

The feather stop nuts remained on the pitch change rod. The linear distance between the reverse stop and the feather stop were within assembly tolerance.

5.1.11 Hub assembly

Both the forward and aft hub halves was partially melted and thermally deformed. See Figure 43. The mounting flange was thermally consumed. Blade pockets C and D were melted/consumed. The propeller serial number mark was between the A and B blade sockets.

Figure 43. Hub housings

5.1.12 Blades

The blades were thermally destroyed. Blade damage is listed in Table 4. See Figure 44.

Figure 44. Blades

BLADE		DAMAGE
A	surface bend twist LE TE	The blade was thermally destroyed except for a 6- to 8-inch stub There was a 3 inch circumferential crack on the face side bearing radius
	knob	The pitch change knob was fractured off and was recovered
	counterweight	The counterweight was fractured off and was not recovered
B	surface bend twist LE TE	The blade was thermally destroyed except for a 6- to 8-inch stub
	knob	The pitch change knob remained attached; the bearing was missing
	counterweight	The counterweight was fractured off and was not recovered
C	surface bend Twist LE TE	The blade was thermally destroyed except for a 6- to 8-inch stub
	knob	The pitch change knob was fractured off and was recovered
	counterweight	The counterweight was fractured off and was not recovered
D	surface bend twist LE TE	The blade was thermally destroyed except for a 6- to 8-inch stub The blade bearings remain attached with the bearing retention ring in place The preload plate could not be removed from the blade butt
	knob	The pitch change knob was fractured off; the bearing was missing
	counterweight	The counterweight was fractured off and was not recovered

*Mark locations are measured relative to the hub split line, with *F* indicating forward and *A* indicating aft
**The hub split line was determined from sealant and assembly marks (not marked at disassembly)

Table 4. Blade inspection results

5.1.12.1 Pitch change knobs

The pitch change knobs and dowel pin holes were deformed. The A blade pitch change knob, recovered near the propeller, was missing one mounting foot; the A blade dowel pin hole was deformed toward high pitch. The B blade pitch change knob remained attached, the bearing was missing. See Figure 45 (a) and (b).

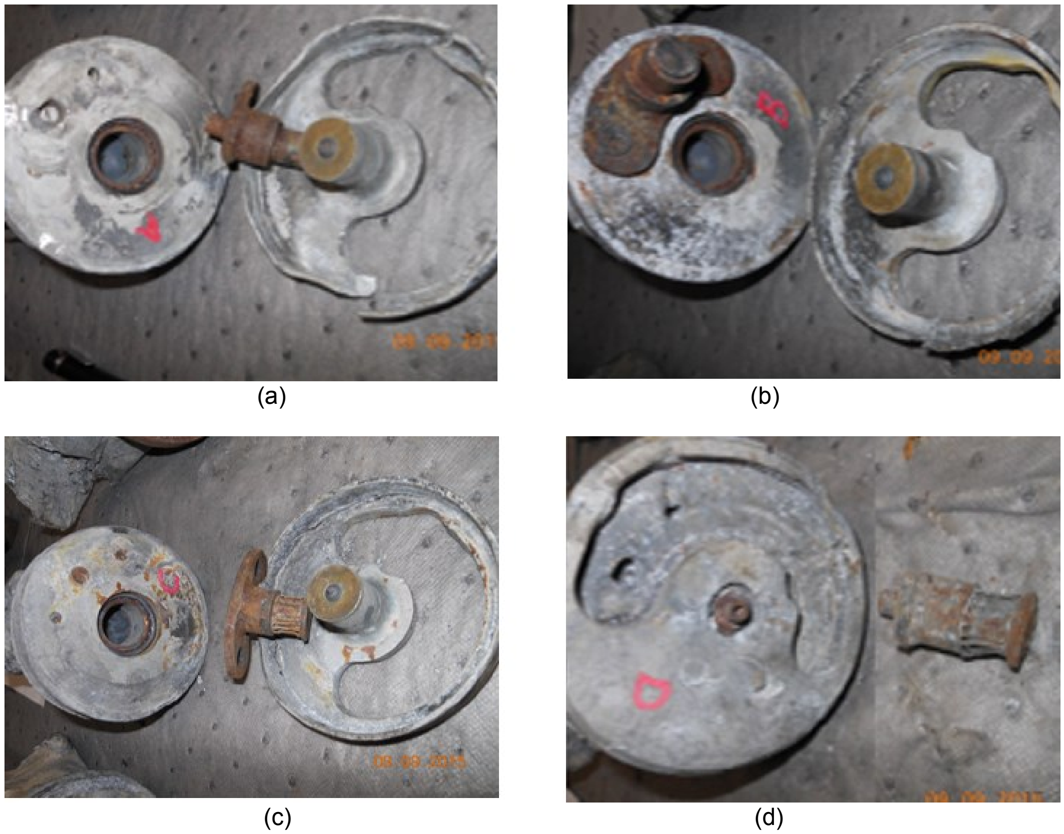


Figure 45. Pitch change knobs

The C blade pitch change knob had separated and was recovered near the propeller; the C blade dowel pin hole was deformed toward high pitch. The D blade pitch change knob, recovered near the propeller, was missing its bearing. The D blade dowel pin hole was deformed toward high pitch.

5.1.12.1

5.1.12.2 Blade counterweights

The blade counterweights had fractured/separated and were not recovered. Hole elongation and other deformities were noted at the counterweight retention boss mating surfaces. See Figure 44. The A blade counterweight boss threaded holes were deformed opposite the direction of rotation. The B blade counterweight boss threaded holes were unremarkable. The C blade counterweight boss threaded holes were deformed opposite the direction of rotation; the dowel pin was sheared off. The D blade counterweight boss threaded holes were deformed slightly in the direction of rotation.

5.1.12.3 Blade retention bearings

The propeller blade retention bearing races were fractured. The fractures were consistent with impact damage.

5.1.12.4 Preload plates

The preload plates were mechanically and thermally damaged. All plates exhibited witness marks consistent with contact from adjacent blade fork bumpers. See Table 5.

plate		*split line confidence level**	*fork bumper impact mark***		*comments*
A		low	19° F 19° A deepest mark centered at 0°	22° 49° 36°	top fractured during disassembly; the lip was sheared and deformed
B		low	18°F; mark indicating rotation to low pitch and/or plate rotation/slippage	23°	axial fractured during disassembly; the lip was sheared and deformed
C		high	25°F most forward 17°F deepest 3°A most aft	15.5° 23.5° 38°	the lip was sheared and deformed
D		high	19° F (heaviest) 0° 35° A (far out of operating range)	22° 36°	the lip was sheared and deformed

Table 5. Preload plates and equivalent blade angles

6.0 Right engine examination

6.1 External condition

The right engine inlet case, AGB housing, and AGB diaphragm were thermally destroyed. See Figures 46 and 47. The gas generator case was slightly deformed at the rear; the forward section showed no distress. The engine tubes, accessories and electrical components were severely fire

Figure 46. Right engine S/N PJ0343

damaged. The high pressure bleed valve was thermally destroyed. The low pressure bleed valve was thermally destroyed. The aft fire seal mount ring was fragmented and the center fire seal mount ring assembly was mechanically deformed. The exhaust duct was slightly deformed at 12 and 6 o'clock. There was no dimpling damage to the inner flowpath surface. There were no case uncontainments. The RGB aft and forward cases and the propeller accessories were thermally destroyed. See Figure 48.

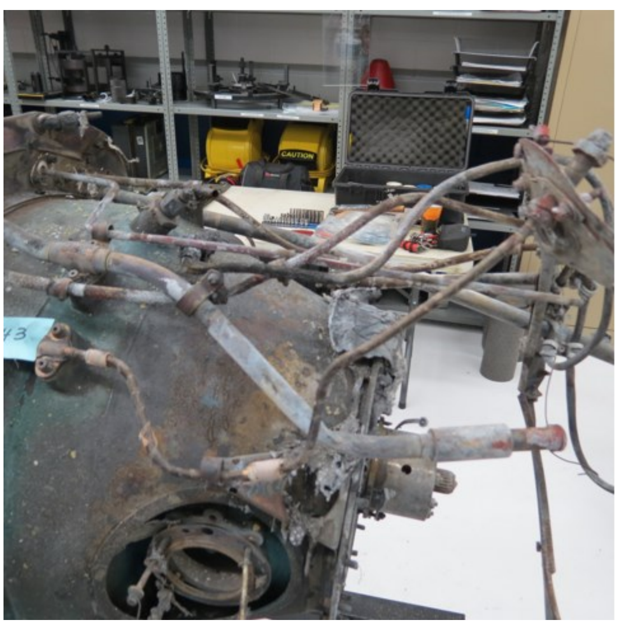


Figure 47. Missing inlet case, AGB diaphragm, housing

Figure 48. RGB cases destroyed by fire

The fuel pump and FCU were thermally destroyed. The integrity of the fuel line between the FCU and the fire seal mount ring assembly could not be assessed due to thermal and mechanical damage. The fuel line from the aft fire seal mount ring to the fuel flow divider fuel line was continuous with the safeties intact. The fuel manifolds were coated with debris but were undamaged. The transfer tubes were thermally damaged and could not be assessed. All of the fuel nozzles and the flow divider were recovered. There were no indications of pre-impact fire. See Figure 49. Viewed through the exhaust, the PT rotor was intact. See Figure 50.

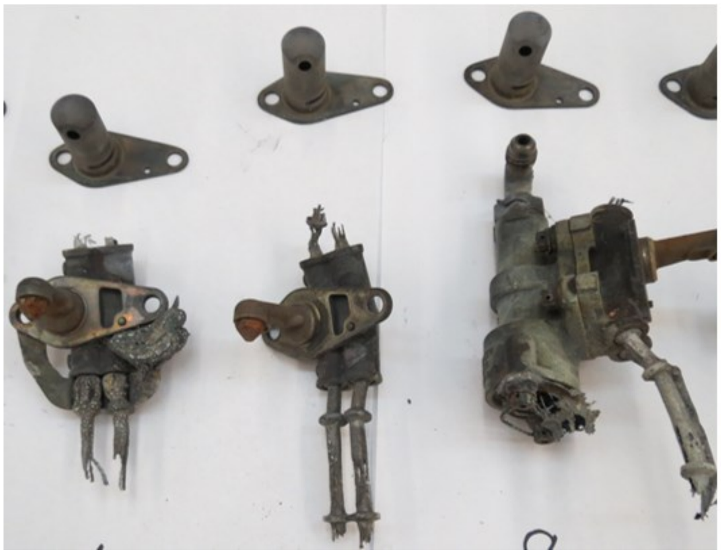


Figure 49. Fuel system components

Figure 50. PT rotor viewed through the exhaust

The power control and reversing linkage was continuous along the GGC. The aft extremity was not recovered and the forward extremity was found attached with residual pieces of the CSU.

The P_3 signal tubing was continuous from the gas generator case boss to the rear fire seal mount ring with the connections secured. The FCU and the P_3 filter housing were thermally destroyed but the B-nuts from the rear fire seal mount ring to the FCU were secured to fittings.

The P_y signal tubing was continuous along the GGC. The rear and front extremities were thermally destroyed.

The RGB chip detector was not recovered.

The oil filter was not recovered.

The fuel filter was not recovered.

6.2 Disassembly observations

6.1

6.2

6.2.1 Compressor section

6.2.1.1 Compressor rotor

The S1 compressor rotor blade tips were rubbed and burred and several blades were bent. Some dents were observed on the S2 and S3 rotor LEs. The blades of all compressor stages were dented near the blade platform and exhibited blade tip rub and burring. All of the compressor spacers were rubbed 360°. See Figure 51.

Figure 51 Compressor rotor

Figure 52. Impeller vanes

The impeller was lightly rubbed 360° and was burred at the exducers. See Figure 52. No distress was observed at the impeller inducer area, back face, or stub shaft.

6.2.1.2 Compressor stator

All stator stages exhibited vane LE and TE tip curl, tip rub, and burring. Several S1 vanes exhibited light LE impact damage. The S3 vanes exhibited light rotational damage at the TE roots. All compressor spacers were lightly rubbed 360°. The impeller shroud showed signs of circumferential rubbing. See Figure 53.

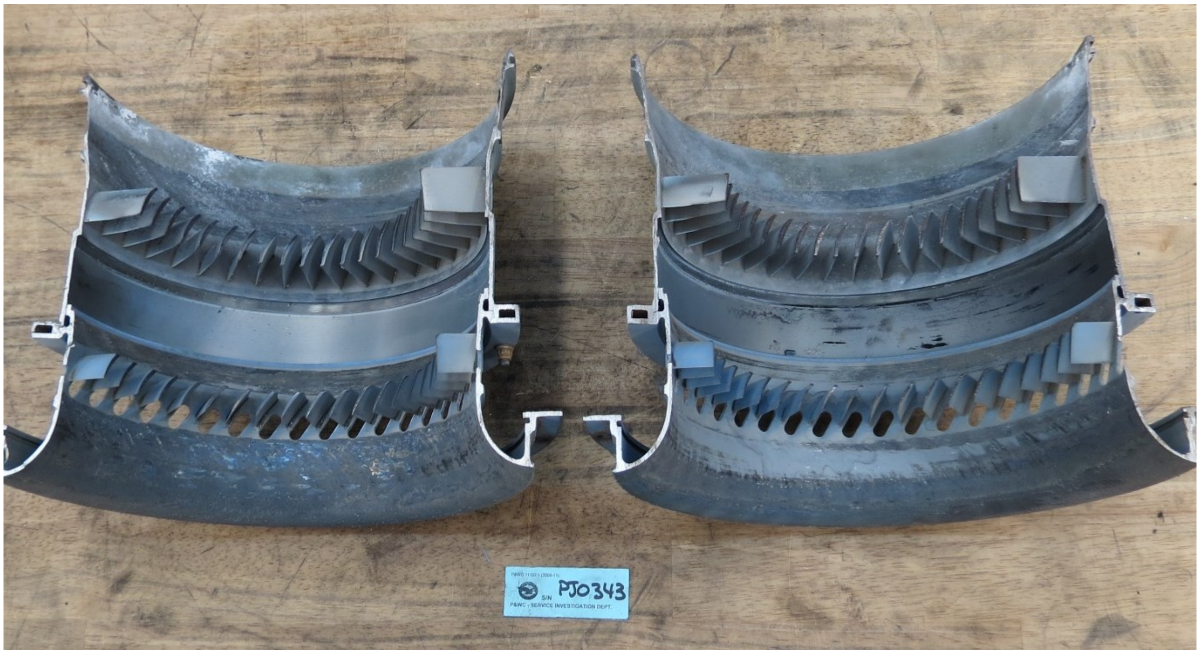


Figure 53. Compressor stator vane halves

6.2.1.3 Compressor bearings and air seals

No distress was observed to the No. 1 or the No. 2 bearings or air seals.

6.2.2 Combustion section

The combustion liner and small exit duct were undamaged.

6.2.3 Turbine section

6.2.3.1 CT vane ring

The downstream side of the CT vane ring inner drum showed a slight 120° arc of rub. See Figure 54.

Figure 54. CT vane ring downstream side

Figure 55. CT disk assembly upstream side

6.2.3.2 CT shroud

The CT shroud showed normal contact rub, with no distress observed.

6.2.3.3 CT disk assembly

The upstream side of the CT disk assembly exhibited 360° circumferential rub along the blade platforms and retention rivets. See Figure 56. A light circumferential rub was observed on the disk hub downstream side.

6.2.3.4 ITT probes, busbar, and harness

The ITT bus bar was undamaged. The two ITT harness probes at 6 to 7 o'clock were fractured off. See Figures 57 and 58.

6.2.3.5 PT housing

The PT housing was intact. See Figure 57.

6.2.3.6 S1 PT vane ring

There was a very light circumferential rub on the upstream side of the S1 PT vane ring baffle. See Figure 58.

Figure 56. PT S1 vane ring

Figure 57. PT housing

6.2.3.7 S1 PT shroud

The S1 PT shroud showed normal circumferential marks.

6.2.3.8 S1 PT disk assembly

The PT rotor was not disassembled. The Sl disk assembly showed only normal shroud tip wear.

6.2.3.9 S2 PT vane ring

The S2 PT vane ring showed no distress.

6.2.3.10 S2 PT shroud

The S2 PT shroud showed normal circumferential marks.

6.2.3.11 S2 PT disk assembly

The S2 PT disk assembly showed normal shroud tip wear.

6.2.3.12 PT shaft and shaft housing

The PT shaft housing showed no distress. The shaft and Nos. 3 and 4 bearings were covered with soot and thermally destroyed material. No anomalies were noted. The housing was not disassembled.

6.2.4 Reduction gearbox

The RGB was thermally destroyed. Inspection of the S1 and S2 sun gears, carrier assemblies, ring gears, and the torquemeter piston found no evidence of pre-impact failure. See Figure 58.The propeller shaft was fractured adjacent to the propeller oil transfer sleeve and remained attached to the propeller system.

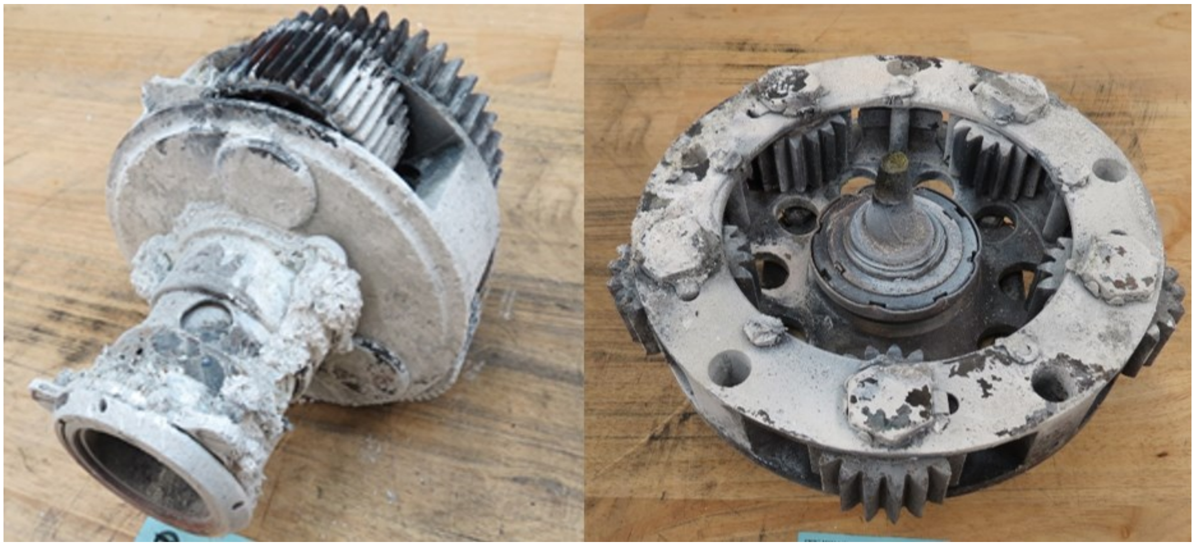


Figure 58. RGB planetary gearing recovered from wreckage debris

6.2.5 Accessory gearbox

Accessory gears and other internal AGB components were recovered from debris where the AGB housing and diaphragm were consumed by fire. They were coated with soot/thermally destroyed material, and some were embedded in re-solidified molten material. All of these gears were intact and cursory visual inspection found no other obvious distress.See Figure 59.

Figure 59. AGB components with thermally destroyed diaphragm and housing

6.2.6 Controls and accessories evaluations

The fuel pump and FCU housings were thermally destroyed. Steel pump and FCU components were embedded in re-solidified molten material and were largely indistinguishable. The overspeed governor housing was thermally destroyed and only a few internal parts were recovered. The propeller governor was thermally destroyed; a few internal parts and some control linkage were recovered. No evidence of pre-impact failure was found.