

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

**POWERPLANTS GROUP CHAIR'S FACTUAL REPORT
NTSB ID: CEN20LA352**

July 6, 2021

A. ACCIDENT

Location: Rockford, Illinois
Date: August 20, 2020
Time: 1543 Central Daylight Time
Aircraft: Raytheon Aircraft Company Super King Air B200, Reg. N198DM

B. POWERPLANTS GROUP

Chair: Carol M. Horgan
National Transportation Safety Board
Washington, DC

Member: Stephen Yee
National Transportation Safety Board
Washington, DC

Member: Henry Soderlund
Textron Aviation
Wichita, Kansas

Member: Les Doud
Hartzell Propeller Inc.
Piqua, Ohio

Technical Advisor to the
Canadian Accredited Representative:

Jeff Davis
Pratt & Whitney Canada
Bridgeport, West Virginia

C. SUMMARY

A Powerplants Group was formed on May 18, 2021, to evaluate the condition of powerplant components recovered from an August 20, 2020, accident of Beech 200 airplane N198DM near Rockford, Illinois. Disassembly inspections were performed at AMF Aviation LLC in Springfield, Tennessee July 19-21, 2021.

D. DETAILS OF THE INVESTIGATION

1.0 Powerplants information

The accident aircraft was powered by two Pratt & Whitney Canada (P&WC) Model PT6A-42 engines equipped with Hartzell Model HC-D4N-3A propellers.

1.1 Powerplants description

The P&WC PT6A-42 is a reverse-flow free turbine turbopropeller engine featuring a three-stage axial, one-stage centrifugal compressor driven by a single-stage compressor turbine (CT), an annular combustor, and a two-stage reduction gear assembly and power output drive driven by a two-stage power turbine (PT). CT shaft rotation is counterclockwise as viewed from the rear. The PT6A-42 is takeoff rated at 850 shaft horsepower.

The Hartzell HC-D4N-3A is a four-bladed, single-acting, 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 counterweights and a feathering spring act to move the blades toward high pitch in the absence of governor oil pressure. The hub and blades are aluminum. The propeller and the engine PT rotate clockwise. The blade angle settings for this installation¹ are:

reverse:	$-10.5 \pm 0.5^\circ$
low:	$19.0 \pm 0.1^\circ$
high/feather:	$86.0 \pm 0.5^\circ$

1.2 Powerplants data

See Table 1.

position	component	model	serial number (S/N)	date of manufacture	time since new (TSN)	cycles since new (CSN)	time since overhaul (TSO)
left	engine	PT6A-42	93774	08/1983	8,009	6,369	5,143
	propeller	HC-D4N-3A P/N D9383K blades	FY3746	05/2012	1,302	NA	324
right	engine	PT6A-42	93773	08/1983	8,076	6,436	5,143
	propeller	HC-D4N-3A P/N D9383K blades	FY3747	05/2012	1,302	NA	324

Table 1. Powerplants data

¹ Hartzell Installation Datasheet No. 276.

1.3 Powerplants maintenance history

The airplane service records showed that engine S/N 93774 and propeller S/N FY3746 were installed in the airplane's left engine position and engine S/N 93773 and propeller S/N FY3747 were installed in the right engine position.² Both propellers incorporated STC No. SA2698NM-S, a Raisbeck performance enhancement modification.

Review of the propeller logbooks found that the left and the right propellers were overhauled in May 2018 at 977 TSN and 977 TSN, respectively. The most recent maintenance entries³ were May 28-29, 2020 100-hour inspection and propeller balance work as part of Phase 3/Phase 4 airplane maintenance.⁴

Review of left engine logbook entries found that the engine was original to the airplane. The last engine shop visit was a 1994 overhaul at P&WC, Bridgeport, West Virginia at 2,866 TSN and 2,866 CSN. A hot section inspection was performed in July 2012 at engine 6,775 TSN and 5,699 CSN. The final entry was a May 28, 2020 signoff for work performed during the Phase 3/Phase 4 airplane maintenance. That work included 24-month, routine Table 601 200-hour and 12-month inspections, a 12-month chip detector bridge check and a compressor wash. At the time of the May 28, 2020 signoff the engine had accumulated 7,926 hours and 6,277 cycles since new and 5,060 hours since overhaul.

Review of the right engine logbook entries found that the engine was original to the airplane. The last engine shop visit was a 1994 overhaul at P&WC, Bridgeport, West Virginia at 2,933 TSN and 2,933 CSN. A hot section inspection was performed in July 2012 at 6,308 TSN and 5,428 CSN. The final entry was a May 28, 2020 signoff for engine work performed during the Phase 3 and Phase 4 airplane maintenance. This work included 24-month inspections, a 12-month chip detector bridge check, routine Table 601 200-hour and 12-month inspections, a compressor wash, and a fuel flow divider replacement. The engine had accumulated 7,993 hours and 6,344 cycles since new and 5,060 hours since overhaul at the time of that entry.

2.0 Left propeller examination

The blades were reference marked L1, L2, L3 and L4 in the sequence of rotation.

2.1 General inspection

The hydraulic unit was separated from the propeller. The blades were all bent aft to varying degrees and all displayed chordwise rotational scoring, predominantly on the camber side. All propeller blades could be partially rotated by hand force. The L1 counterweight was liberated. See Figure 1.

² Positional references are as viewed from the rear of the aircraft looking forward unless otherwise noted.

³ The August 19, 2020 Chronos LLC maintenance visit that preceded the accident flight included a patch repair to the left propeller center de-ice boot.

⁴ The airplane was being maintained under a Beech King Air 200 Series phased inspection program.



Figure 1. Front view of left propeller



Figure 2. Engine propeller shaft, forward fracture surface

The engine propeller shaft was separated just aft of the propeller attachment flange. The flange remained attached to the propeller aft hub half with all attachment bolts lockwired. The shaft fracture surface exhibited features consistent with torsional overload. See Figure 2.

2.2 Disassembly observations

2.2.1 Spinner assembly

The spinner bulkhead was locally bent and distorted. The spinner dome was torn from the bulkhead; a fragment remained attached.⁵

2.2.2 Hydraulic unit

The left propeller hydraulic unit was identified as the unit liberated from FY3746 by matching cylinder thread and hub attachment flange damage. The cylinder was intact.⁶ Approximately three inches of the cylinder mounting flange was bent. The piston was inside the cylinder. The piston was dented in line with the cylinder edge damage. The pitch change rod was fractured at the oil transfer hole. The forward section of the pitch change rod remained attached at the piston; the aft section of the pitch change rod was bent and was assembled to the fork. The bent section of the cylinder mounting flange was cut out to facilitate removal of the piston. See Figure 3.

⁵ Some additional spinner fragments were recovered. They were crushed and deformed and provided no relevant evidence.

⁶ The use of “intact” when describing the condition of hardware indicates that a part or assembly is entire, complete.



Figure 3. Cylinder and piston with pitch change rod



Figure 4. Feather stop

2.2.3 Feather stop

The feather stop nuts were positioned 1.63 inches from the pitch change rod end. They were tight and undamaged. Dirt was packed into approximately one inch of threads aft of the feather stop. See Figure 4.

2.2.4 Fork

The fork assembly surfaces were corroded. Two fork bumpers were fractured off. Three of the beta plate forward finger tangs were fractured off; the fourth forward finger tang was not completely separated but it was bent forward. See Figure 5.

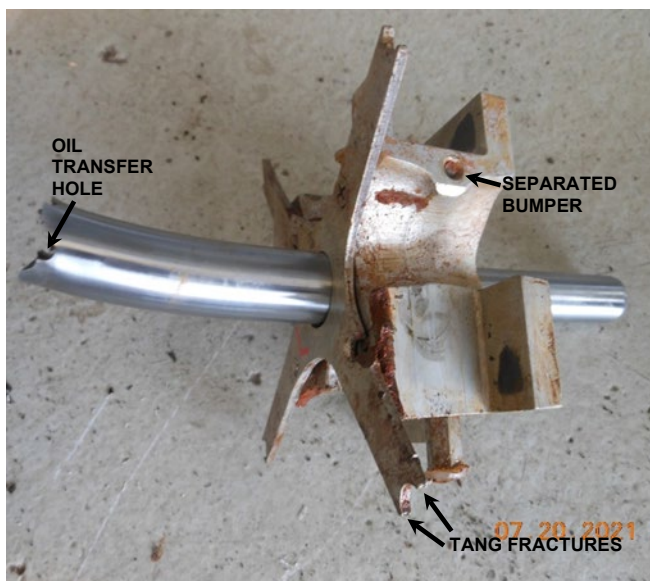


Figure 5. Fork and pitch change rod

The bumpers and three of the tang pieces were found inside the hub.

2.2.5 Reverse stop

The reverse stop sleeve was intact and undamaged.

2.2.6 Feathering spring/guides

The feathering spring was undamaged. The guides were intact. The spring retainer was fractured.

2.2.7 Beta mechanism

The beta ring was fractured and bent; it was attached to the beta rods. The return springs were intact. Two of the beta rods and beta adjustment sleeves were bent; these were cut to facilitate hub disassembly.

2.2.8 Hub assembly

The hub castings were intact. The forward hub half cylinder attachment flange was marred and distorted. The forward pitch change rod bushing was fractured. The aft pitch change rod bushing was intact. The preload plate mounting features were marred or fractured. See Figures 6 and 7.

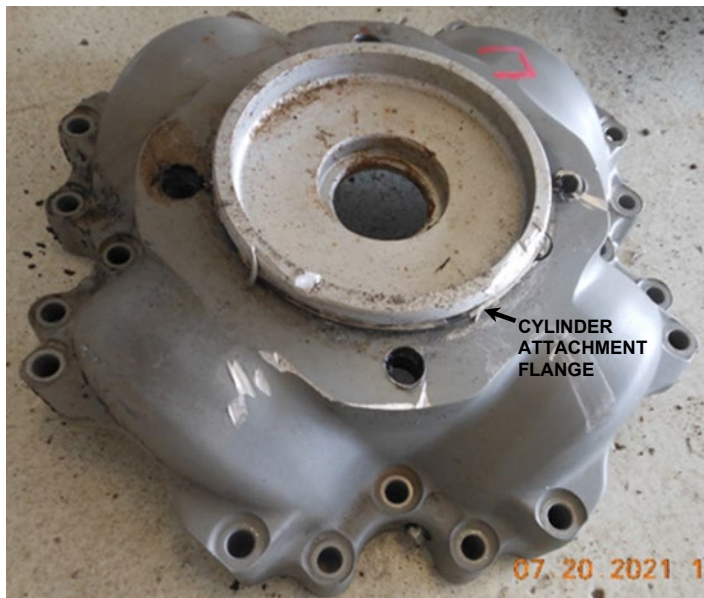


Figure 6. Forward hub half



Figure 7. Closeup view of forward hub cylinder attachment flange damage

2.2.9 Blades

The blade deice boots displayed various cuts and varying degrees of heat damage. All blade retention bearings were intact. All blade pitch change knob/bracket assemblies were damaged or liberated. See Figures 8 through 10.



Figure 8. Left propeller blades, camber sides



Figure 9. Left propeller blades, flat sides



Figure 10. Left propeller blade butts, showing pitch change knob/bracket damage

The L1 blade was bent aft, opposite the direction of rotation, and was twisted toward low pitch. The blade camber side was scored chordwise from the tip to 20 inches inboard. The face side was scored chordwise near the tip along the leading edge (LE). There was a two-inch wide impact/bend at the tip LE that was deformed toward low pitch. The blade trailing edge (TE) was not remarkable. The pitch change knob bracket was missing from the blade butt; the dowel pin hole and one screw hole were deformed in the direction opposite low pitch.⁷ The counterweight was missing; the counterweight mount boss hole was distorted, and the boss was damaged in the direction of propeller rotation. The counterweight was not recovered.

The L2 blade was bent aft, opposite the direction of rotation. The blade camber side was abraded chordwise from the tip to 12 inches inboard. The face of the blade was scored chordwise near the tip along the LE. The LE was nicked and gouged in the deice boot area. The TE was nicked and exhibited local bending. The pitch change knob bracket assembly was missing the cam follower/bearing, which was recovered inside the hub. The counterweight was intact.

The L3 blade was bent aft. The blade camber side was scored chordwise from the tip to 16 inches inboard. The face of the blade was scored chordwise near the tip along the LE. The LE was nicked. The TE was nicked and exhibited local bending. The pitch change knob cam follower was fractured, and one bracket screw head was pulled/missing. The counterweight was intact.

The L4 blade exhibited “S” bending. The tip was bent aft and was twisted toward low pitch. The camber side of the blade was scored chordwise from the tip to 21 inches inboard. The face of the blade was scored chordwise near the tip along the LE. The leading and trailing edges were nicked. One pitch change knob bracket screw was missing, and the cam follower was frozen. The counterweight was intact.

2.2.10 Preload plates

The left propeller blade preload plates were examined for witness marks.⁸

All left propeller preload plate retention lips were sheared off. All of the left propeller pitch change slots were damaged at the low pitch end of the pitch change knob slot consistent with forceful

⁷ The knob/bracket assembly was found inside the hub.

⁸ Damage resulting from abnormal propeller loading can be used to fix a blade angle for the time loading occurred.

blade rotation toward low pitch. The L1 plate also exhibited knob contact marks along the inboard edge of the slot forward of the hub split line beginning at 27° with the last recognizable knob mark at 72° degrees. See Figure 11.



Figure 11. Left propeller preload plates showing knob impact marks at the low pitch slot ends and L1 fork/bracket impact marks

3.0 Left engine examination

The engine dataplate identified the engine as ESN 93774. See Figure 12.



Figure 12. ESN 93774 data plate

3.1 External condition

The engine was covered with soot. The components aft of the center fire seal mount ring exhibited light to moderate thermal damage, including the rear mount ring assembly. See Figure 13.



Figure 13. Left engine center firewall and aft



Figure 14. Engine propeller shaft fracture surface

The accessory gearbox (AGB) showed light thermal damage. The rubber on the inlet case was thermally damaged. The inlet case and the gas generator case (GGC) were intact. The rubber inlet case seals and the engine mount rubber were thermally distressed. The exhaust duct front flange and the left exhaust port were compressively deformed. There was no indication of uncontainment.

The forward end of the propeller driveshaft was fractured off. The fracture surface features were consistent with torsional overload. See Figure 14.

The first stage (S1) compressor blades were inspected through the engine inlet with no damage noted.

The Nos 3 and 4 bearing and reduction gearbox (RGB) scavenge tubes were missing forward of the engine C-flange.⁹ The low pressure (LP) and high pressure bleed valves were intact.

A forward section of the propeller governor upper housing was impact damaged. The overspeed governor (OSG) was fractured off near its base flange; the flange remained attached to its drive pad, but the remainder of the OSG was missing. The fuel pump had fractured at the flange, which remained attached to the AGB. The separated fuel pump and fuel control unit (FCU) assembly remained attached by tube connections. The fuel nozzles, transfer tubes and the flow divider showed no obvious mechanical damage. A fuel nozzle was removed for examination with no anomalies noted. No indications of preimpact fire were found.

One ignitor was removed for inspection; no anomalies were found. The power control and reversing linkage was mechanically deformed and cracked. The terminal adjacent to the cambox was

⁹ The C-flange is the gas generator case front flange-to-exhaust case aft flange joint.

fractured. The linkage was continuous from the FCU to the cambox and from the fractured terminal to the propeller governor reversing lever.

The compressor discharge air pneumatic signal (P3) and PT control (Py) signal line insulation were thermally damaged. The P3 was continuous, and the connections were tight and were properly lockwired. The P3 filter was clean; its O-ring was thermally damaged. The Py tubing was complete; the connections were tight and properly lockwired. The oil filter element and housing were found clean. The fuel filter housing was thermally damaged; the (paper type) fuel filter was thermally consumed. The last chance fuel filter was clean.

3.2 Disassembly observations

3.2.1 Compressor

The LP bleed valve was removed, allowing a limited but 360° inspection of the compressor impeller airfoil profiles through the port. No damage was found. The LP bleed valve was capable of actuation. The compressor rotated freely. Continuity was established from the compressor to an AGB drive pad. The compressor was not disassembled.

The PT rotor could not be turned with hand force.

3.2.2 Combustor

The engine was separated at the C-flange. The combustion chamber liner appeared in good condition. The small exit duct was not accessed. See Figure 15.

3.2.3 Compressor turbine

3.2.3.1 CT vane assembly

The CT vane ring was in typical in-service condition. The vane ring shroud (CT disk blade path) exhibited light rub with material transfer. See Figure 16.

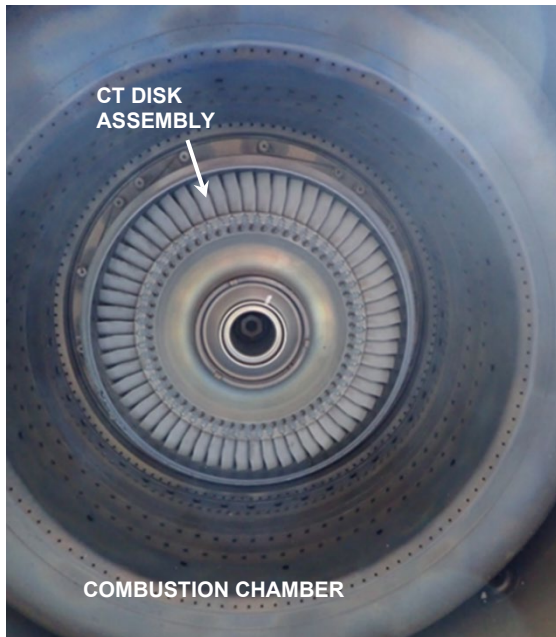


Figure 15. Engine forward of the C flange separation showing engine hot section



Figure 16. View of CT vane assembly downstream side after CT disk removal

3.2.3.2 CT disk assembly

The CT disk upstream face showed intermittent, light polishing across the blade platform edges. The CT blades displayed light tip and LE rub. See Figure 17.

The downstream face of the CT disk was circumferentially scored along the disk retaining bolt bore lip outside surface. See Figure 18.

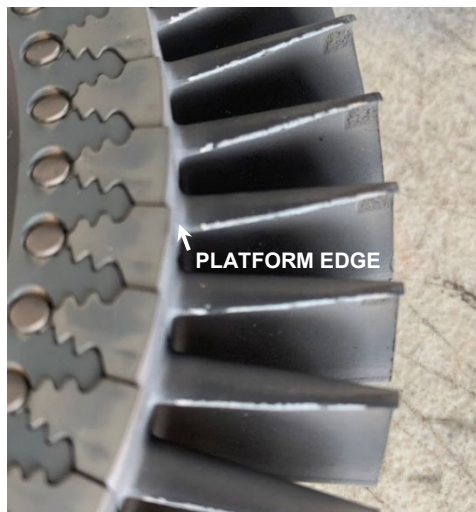


Figure 17. CT disk assembly upstream face showing LE blade contact



Figure 18. CT disk downstream face showing circumferential scoring to retaining bolt bore lip

A CT blade was damaged to facilitate removal of the CT disk assembly.

3.2.4 Power turbine (PT)

The PT vane housing and the interstage turbine temperature (ITT) harness and (eight) ITT probes were in good condition. See Figure 19.

3.2.4.1 PT S1 vane ring assembly

The PT S1 vane airfoil LEs exhibited operational/ thermal distress cracks. The center baffle lip was scored 360°. See Figure 20.



Figure 19. Upstream side of PT S1 vane assembly in PT stator housing. ITT probes are shown.



Figure 20. Upstream PT S1 vane ring 360° center baffle lip scoring

The downstream side of the PT S1 vane ring was rubbed 360° along the center baffle inner lip with local burring at the inboard edge. There were two axial cracks in the vane ring inner shroud. The PT S1 shroud (blade path surface) lands were scored over most of their circumference (310° or more). See Figure 21.

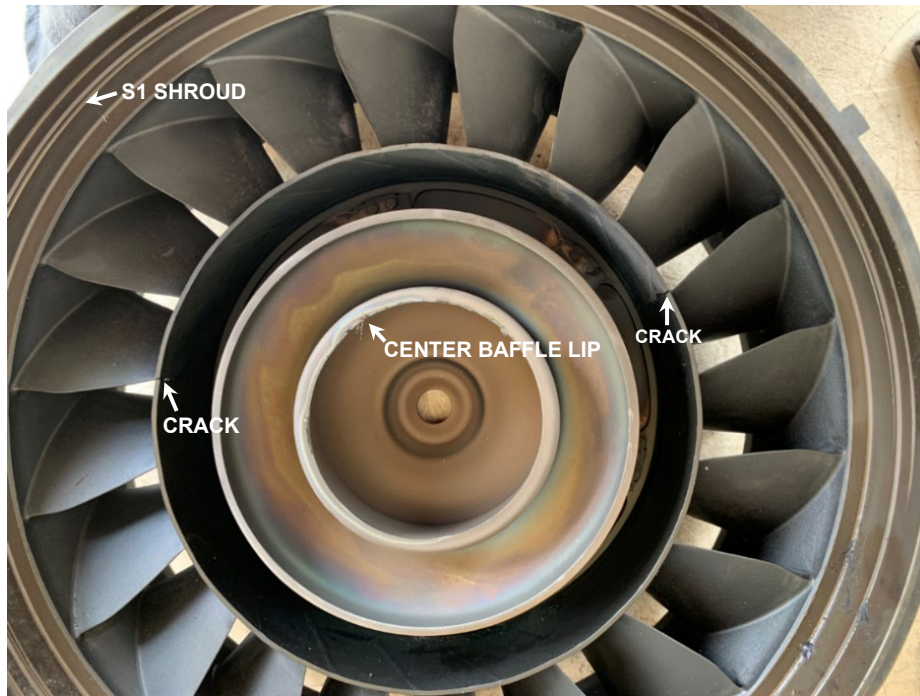


Figure 21. PT S1 vane ring assembly downstream side showing 360° scoring along center baffle lip, inner shroud cracks, and blade path scoring

The PT rotor turned freely after the S1 PT vane ring was removed. Mechanical continuity between the PT rotor and the propeller shaft was established.

The PT retaining nut was machined off to facilitate PT rotor disassembly.

3.2.5 PT S1 disk assembly

The PT S1 disk upstream face exhibited 360° scoring along the lip adjacent to the retaining nut. See Figure 22. Sulfidation-type damage was observed at the blade platform roots. The PT S1 blade tip knife edges seals were worn. See Figure 23.

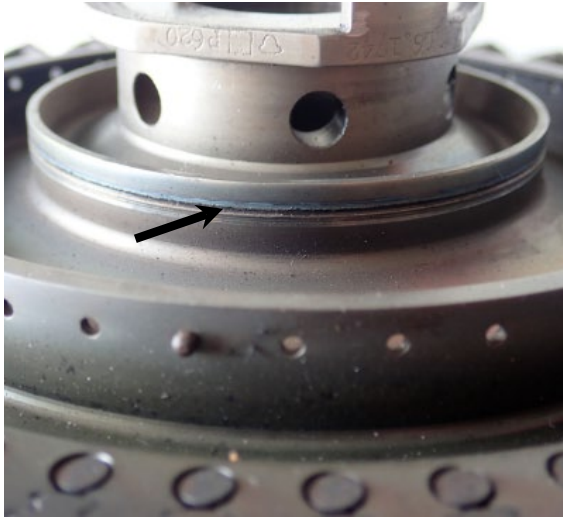


Figure 22. PT S1 disk assembly upstream face showing 360° scoring



Figure 23. PT S1 blade tip knife edge wear

No damage was noted to the PT S1 disk downstream face.

3.2.5.1 PT S2 vane ring

The PT S2 vane ring abradable air seal displayed an arc of rub and local areas of chipped and deteriorated material. The shroud housing blade path was heavily scored/machined 360°.

3.2.6 PT S2 disk assembly

The PT S2 disk assembly blade tip knife edges were heavily rubbed (flattened). The disk was otherwise undamaged.

3.2.7 PT shaft and shaft housing

The visible portion of the PT shaft was unremarkable. The PT shaft housing was not accessed. PT shaft threads were damaged to facilitate disassembly.

3.2.8 RGB

The RGB gear train rotated freely. The RGB chip detector was removed and inspected. No ferrous debris was found. The RGB was not disassembled.

4.0 Right propeller examination

Propeller S/N FY3747 was received attached to the right engine. The propeller attachment hardware was secure and lockwired. The propeller governor and beta linkage was properly attached. See Figures 24 and 25.



Figure 24. Right powerplant



Figure 25. Right engine RGB and propeller attachment

The propeller was removed from the engine. The blades were reference marked R1, R2, R3 and R4 in the sequence of rotation.

4.1 General inspection

The hydraulic unit was liberated. The hub cylinder attachment flange was fractured. Three blades were bent forward, and one blade was bent aft. All blades displayed chordwise scoring predominantly of the camber side. Two blades could be partially rotated by hand force. The R2 counterweight was fractured off.

4.2 Disassembly observations

4.2.1 Spinner assembly

All but a small section of the spinner remained attached at the bulkhead. The spinner bulkhead was intact with minor local bending.

4.2.2 Hydraulic unit

A section of cylinder attachment flange was attached to one of the recovered hydraulic units, identifying it as the hydraulic unit that separated from FY3747. See Figure 26.



Figure 26. Hydraulic unit with liberated hub attachment flange

The piston and cylinder were intact. A section of spinner material was deformed to the top of the cylinder. The pitch change rod was fractured at the oil transfer hole. The forward section of the rod was attached to the piston inside the cylinder; the aft section was bent and was assembled in the fork.

The feather stop nuts were intact and undamaged. They were positioned approximately 0.53 inch from the reverse stop sleeve. The lockwire was broken but the torque stripe was aligned. See Figure 27. The hydraulic unit was not disassembled.

4.2.3 Fork

One fork bumper was fractured off. Two beta pickup plate arm fingers were bent forward, and one screw head was fractured. See Figure 28. One forward finger tang was fractured off; all the aft tangs displayed impact dents characteristic of forceful rotation toward high pitch. The bumper and tang were recovered inside the hub.

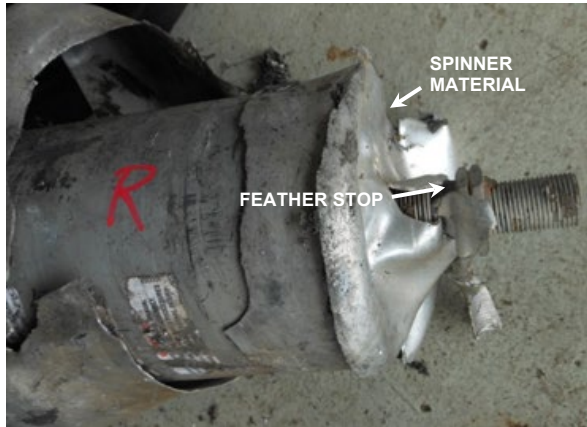


Figure 27. Hydraulic unit showing feather stop and forward section of pitch change rod



Figure 28. Fork and aft section of pitch change rod

4.2.4 Reverse stop

The reverse stop sleeve remained threaded in the cylinder. It was not removed for examination.

4.2.5 Feathering spring/guides

The pitch change rod was loaded in the feathered direction, indicating spring compression. The feathering spring and guides were not observed.

4.2.6 Beta mechanism

The beta ring was intact with some local bending, and was attached to the beta rods. A small fragment of the carbon block remained in the ring groove. One beta rod was fractured, one was bent at the forward end. The four beta rods were securely attached to the beta ring with the return springs in place.

4.2.7 Hub assembly

The outside surface of the front hub half was marred and scored. The cylinder mounting boss was fractured off. No other casting fractures or cracks were noted. Both the forward and aft pitch change rod bushings were fractured. The hub preload plate support structures exhibited fractures and marring.

4.2.8 Blades

The blade deice boots displayed various cuts and varying degrees of heat damage. All blade retention bearings were intact. See Figures 29 through 31.



Figure 29. Right propeller blades, camber side



Figure 30. Right propeller blades, face side



Figure 31. Right propeller blade butts, showing condition of pitch change knobs and bracket attachments

4.2.8.1 Blade inspections

The R1 blade was bent forward in the thrust direction and was twisted toward high pitch. Both the camber and face sides were scored chordwise along the LE; the camber side LE scoring was isolated to the mid blade-to-tip area. The LE was nicked and gouged; a chunk was missing between 7 inches from the tip to 9 inches from the tip. The LE was deformed in both the high and the low pitch directions. The TE was nicked and locally bent. The pitch change knob cam follower was fractured; the knob remained attached. The counterweight was intact.

The R2 blade was bent forward in the thrust direction, opposite the direction of rotation, and twisted toward high pitch. The camber side exhibited local chordwise scoring along the LE from mid blade to the tip. The face side was scored chordwise from 11 inches inboard to the tip. The LE was nicked and gouged with small pieces missing including an approximately 0.5-inch piece of the tip. This damage was deformed in the high pitch direction. The TE exhibited buckling and wave-type bending. The pitch change knob bracket was fractured off and the dowel pin hole was deformed in the direction opposite high pitch; both bracket screw heads were sheared off. The counterweight was fractured off (recovered on site).

The R3 blade was bent forward in the thrust direction, opposite the direction of rotation and twisted toward high pitch. The camber side was scored chordwise near the LE from mid-blade to the tip and the face of the blade was scored chordwise from mid-blade to the tip. The LE was gouged with chunks of material missing. The damaged areas were deformed toward both high and low pitch. The TE was locally bent with buckling wave-type characteristics. The pitch change knob bracket was fractured off, with attachment hole deformation in the direction opposite high pitch. The counterweight was intact.

The R4 blade was bent aft. The camber side was scored chordwise from mid-blade to the tip and the face of the blade was scored chordwise along the LE from mid-blade to the tip. The LE was randomly nicked; the TE was unremarkable. The pitch change knob cam follower was fractured; the bracket remained attached with screws intact. The counterweight was intact.

4.2.9 Preload plates

All right propeller preload plate retention lips were sheared off. There were no knob impact marks at the low pitch ends of the plate slots. The face of each plate exhibited groupings of multiple marks from fork bumper impacts. The R1 plate displayed a bumper mark at 33° forward of the hub split line (F) and additional marks progressing aft in the high pitch direction. The R2 plate showed a bumper mark 16° F with a smearing mark in the aft direction. The R3 plate had bumper marks near the feathered range of travel. The R4 plate displayed a bumper mark at 26° F and additional marks progressing aft toward high pitch. See Figure 32.

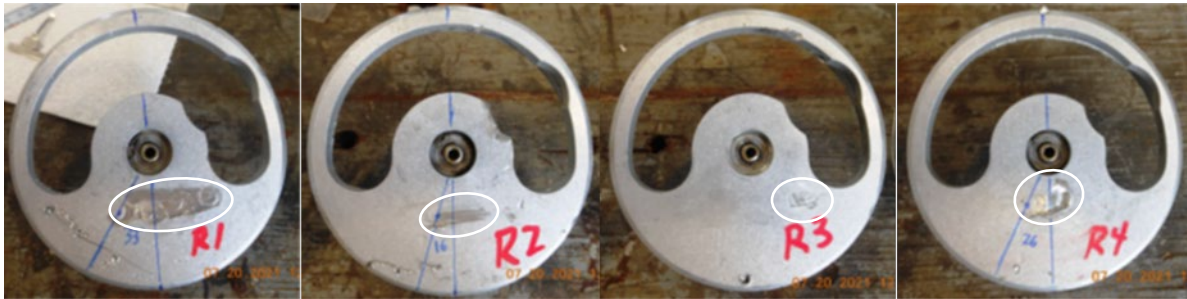


Figure 32. Right propeller preload plates showing impact marks

5.0 Right engine examination

5.1 External condition

The engine dataplate identified the engine as ESN 93773. See Figure 32.



Figure 33. ESN 93773 engine data plate

The right engine exhibited light thermal damage and was coated with soot from the C flange and aft to the AGB. The inlet case was gouged at 8 o'clock and external components in the area were crushed/displaced. See Figure 33. The No. 3/4 bearing and RGB scavenge pumps were missing. The inlet screen rubber was thermally damaged. The top of the gas generator case was buckled and deformed. See Figure 34. The mounts appeared undamaged. The first stage compressor blades were inspected through the engine inlet with no visible damage found. There were no uncontainments.



Figure 34. Damage to inlet case and engine externals



Figure 35. Gas generator case distortion

Excepting in the area of the oil tank damage, the engine external components displayed limited thermal and mechanical damage. The fuel line from the FCU to the flow divider was continuous. All fittings were tight. The threaded boss near FCU drain port was impact damaged. The fuel nozzles, transfer tubes and the flow divider showed no obvious mechanical damage. A fuel nozzle removed for inspection was in normal condition. There were no indications of pre-impact fire.

The power control and reversing linkage was mechanically deformed but was continuous from the propeller governor reversing lever to the FCU. The P3 lines were continuous, with all fittings tight and properly lockwired. The P3 boss on the FCU was fractured. The P3 air filter was clean. The Py signal tubing was continuous; the connections were all tight and properly lockwired. An ignitor was removed for inspection with no anomalies found. The fuel filter element was inspected and found clean. The oil filter element was inspected and found clean.

5.2 Disassembly observations

5.2.1 Compressor

The LP bleed valve was removed. A limited inspection of the compressor impeller airfoil profiles was performed by through the port as the compressor was rotated. No anomalies were noted. The compressor turned freely, and continuity was established from the compressor to an AGB drive pad. The compressor was not disassembled.

5.2.2 Combustor

The engine was separated at the C flange. No anomalies were noted to viewable portions of the combustion chamber liner. The small exit duct was not accessed. See Figures 36 and 37.



Figure 36. Left engine hot section showing combustor and CT disk assembly downstream face



Figure 37. CT disk removed, exposing CT vane assembly downstream side

5.2.3 Compressor turbine

5.2.3.1 CT vane ring assembly

The CT vane ring shroud/CT disk blade path exhibited a 360° light rub. The CT vane ring was otherwise unremarkable.

5.2.3.2 CT disk assembly

The CT disk assembly upstream face showed intermittent, light polishing along the blade outboard fir tree root platform edges. Light blade tip rub was noted. See Figure 38.

The CT disk downstream face exhibited light circumferential scoring along the retaining bolt bore lip outer surface. See Figure 38.



Figure 38. CT disk upstream face showing intermittent rub



Figure 39. CT disk assembly downstream face bore lip scoring

One blade was damaged to facilitate disk removal.

5.2.4 Power turbine

The PT was seized.

The PT vane housing-to-exhaust case hardware was secured. The PT vane housing inner surfaces were sooted; the housing was otherwise unremarkable.

5.2.5 PT S1 vane ring assembly

The upstream side of the PT S1 vane ring assembly displayed an arc of circumferential rub on the inner baffle between 5 and 9 o'clock. See Figure 40.

The downstream side of the PT S1 vane ring exhibited 360° rub along the inboard edge of the center baffle feature, with local burring. The shroud housing was rubbed 135° (from 5 to 2 o'clock). See Figure 41.



Figure 40. PT S1 vane ring upstream side showing inner baffle rub



Figure 41. PT S1 vane ring downstream side showing rub along the center baffle edge and arc or scoring along the shroud/blade path

The PT rotor was capable of rotation once the PT section was separated from the engine and the PT S1 vane ring was removed. However, the rotor turned independent of the engine propeller shaft, indicating a break in PT drive continuity.

5.2.6 PT S1 disk assembly

The upstream surface of the PT S1 disk assembly was rubbed and burred along the blade roots and platform edges. The lip adjacent to the retaining nut was rubbed 360°. The blade shroud knife edges were worn away. See Figure 42.



Figure 42. PT S1 disk assembly showing 360° scoring



Figure 43. Ferrous debris on RGB plug

The PT rotor was not disassembled.

5.2.7 PT S2 disk assembly

The PT S2 disk downstream face showed no notable damage. The PT S1 blade shroud tip knife edges were worn away.

The viewable PT S2 vane ring shroud housing was machined 360°. The scoring was more pronounced between 2 and 7 o'clock.

5.2.8 PT shaft and shaft housing

The PT shaft housing was not accessed. PT shaft threads were damaged to facilitate disassembly.

5.3 Reduction gearbox

Ferrous debris was found on the RGB chip detector. See Figure 43.

The RGB housings were split to investigate the drive disconnect. The S1 planetary gear assembly turned smoothly when rotated, with no drive train anomalies noted. See Figure 44.

The S2 planetary gearing turned smoothly when rotated. No anomalies were noted. The S2 planetary gear retention hardware exhibited heavy rotational scoring. Figure 45.



Figure 44. S1 planetary gearing showing S1 and S2 sun gears

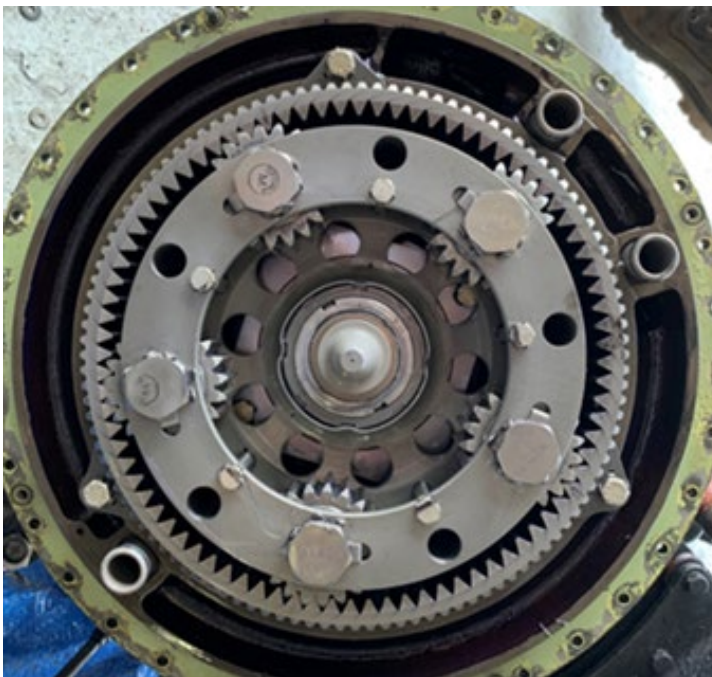


Figure 45. S2 planetary gearing showing rotational damage to gear retention hardware

A propeller shaft fracture was found. The separation was forward of the S2 sun gear. The RGB front case No. 5 bearing retention bolt holes were fractured. See Figure 46.

The S2 ring gear inner teeth were scored transverse to the tooth axis. The propeller shaft oil transfer tube outer surface was circumferentially scored in plane with the propeller shaft fracture.

The No. 5 bearing turned freely. There was light polishing on both ends of the rollers. The S2 planetary gear carrier exhibited rotational damage forward of the plane of the shaft fracture. See Figure 47.



Figure 46. RGB front case with S2 planetary gear carrier removed showing cracked bearing retention bolt holes and propeller shaft fracture



Figure 47. Forward side of S2 planetary gear carrier showing flanged bearing assembly and propeller shaft separation fracture

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