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

March 27, 2020

POWERPLANTS GROUP CHAIRMAN'S FACTUAL REPORT
NTSB ID: CEN19MA190

A. ACCIDENT

Location:	Addison, Texas
Date:	June 30, 2019
Time:	0911 Central Daylight Time (CDT)
Aircraft:	Textron Aviation B300, N534FF, operated by EE Operations LLC

B. POWERPLANTS GROUP

Chairman:	Carol M. Horgan National Transportation Safety Board Washington, DC
Member:	Matthew Rigsby Federal Aviation Administration Ft. Worth, Texas
Member:	Jennifer Barclay Textron Aviation Wichita, Kansas
Member:	Les Doud Hartzell Propeller Inc. Piqua, Ohio
Member:	Chris Behling Woodward Rockford, Illinois

Technical Advisors to the Canadian Accredited Representative:

Marc Gratton Pratt & Whitney Canada Longueil, Quebec	Jean-Marc Limoges Pratt & Whitney Canada Longueil, Quebec

C. SUMMARY

On June 30, 2019, about 0911 central daylight time, a Textron Aviation B300, N534FF, collided with a hangar and terrain after takeoff from Addison Airport (KADS), Addison, Texas. The airline

transport pilot, the commercial co-pilot, and eight passengers sustained fatal injuries. A post-impact fire ensued, and the airplane was destroyed. The airplane was registered to EE Operations LLC and being operated under the provisions of *Title 14 Code of Federal Regulations* Part 91. Visual meteorological conditions prevailed, and a Federal Aviation Administration (FAA) instrument flight rules flight plan had been filed for the flight. The airplane was commencing a cross-country flight from KADS to Albert Whitted Airport (KSPG), St. Petersburg, Florida.

A powerplants group was formed on June 30, 2019. The group investigated the wreckage July 1-4, 2019. Disassembly examinations were performed on the propellers at KADS. The engines were documented and then shipped to the manufacturer for teardown examinations. Members of the powerplants group witnessed the engine teardowns and powerplant accessories evaluations at P&WC, Longueuil, Quebec, July 22-26, 2019, and materials analysis of the reduction gearbox second stage (S2) planet gear carrier fracture surfaces at a P&WC materials lab in Longueuil November 13, 2019. The group convened at Woodward, Inc. in Rockford, Illinois January 14-16, 2020 for engine and propeller controls examinations.

D. DETAILS OF THE INVESTIGATION

1.0 Powerplant information

The accident aircraft was powered by two Pratt & Whitney Canada (P&WC) PT6A-60A gas turbine engines driving Hartzell HC-B4MP-3C/M10476NSK propellers.

1.1 Powerplant description

The PWC PT6A-60A is a reverse-flow, turbopropeller engine featuring a four-stage axial, one-stage centrifugal compressor driven by a single-stage compressor turbine (CT), an annular combustion chamber, and a two-stage reduction gear assembly and power output drive driven by a two-stage power turbine (PT). The PT6-60A is flat-rated to 1,050 shaft horsepower.

The Hartzell Model HC-B4MP-3C is a 4-bladed, hydraulically operated, steel hub, constant-speed propeller with full feathering and reversing capabilities.[1] Oil pressure from a propeller governor is used to move the blades toward low pitch (reduced blade angle)[2]. Blade-mounted counterweights and a feathering spring act to move the blades toward high pitch/feather in the absence of governor oil pressure. The propeller incorporates a beta mechanism that actuates when blade angles are lower than the flight idle position. The blades, P/N M10476NSK, are of

[1]A constant-speed propeller system is one in which the propeller blade angle is automatically adjusted by a governor unit to maintain a selected rpm. A feathering propeller is a constant-speed propeller with the capability of rotating the propeller blades to an extreme blade angle that will eliminate aerodynamic drag in the event of an engine failure; there is no low rpm stop, and the blades can feather after engine shutdown. A reversing propeller is a constant-speed, feathering propeller that can also produce a reverse thrust by rotating the blades to a negative blade angle, forcing air forward rather than rearward.

[2]Blade pitch, or blade angle, is the angle between the blade chord line and the plane of rotation. This angle represents the theoretical distance that an aircraft will move forward in one revolution of the propeller.

aluminium construction, and the hub and clamps are steel. Propeller rotation is clockwise. [3]

As installed in a B300 King Air aircraft, selected propeller positions will result in the following blade angle settings: [4]

Reverse	-14.0 +/- 0.5°
Beta actuation/low pitch	15.4 +/- 0.1°
Flight idle	Adjusted for installed torque at 1,500 propeller rpm (Np)
Ground idle	Adjusted for 62-64% gas producer rpm (Ng) and Np =/> 1,050 rpm
Feather	80.0 +/- 0.5°

1.2 Powerplants data

component	model	serial number	date of manufacture	time since new	cycles since new	time since overhaul	cycles since overhaul
Left engine	PT6A-60A	PCE-PK2221	Oct 7, 2016	691	454	new	new
Left propeller	HC-B4MP-3C	FWA6013	Dec 14, 2016	691	NA	new	NA
Right engine	PT6A-60A	PCE-PK2222	Oct 7, 2016	691	454	new	new
Right propeller	HC-B4MP-3C	FWA6019	Jan 10, 2017	691	NA	new	NA

Table 1. Powerplants data

1.3 Powerplants service history

Review of the operator's airplane service records found that the engines and propellers were original to the airplane and had never been removed.

The airplane completed a phase maintenance at the Textron Aviation Service Center, Wichita, Kansas, on March 22, 2019. Powerplants work performed included control linkage inspections, engine oil filter and secondary screen checks, hot section borescope inspections of both engines, and general visual inspection of both propellers.

The records showed that the airplane accumulated 67 hours and 31 cycles after the March 22, 2019 release to service and that there was no record of unscheduled maintenance during that time. The left engine oil was topped off on June 20, 2019. The left engine oil level was checked and found acceptable on June 24, 2019. [5]

2.0 Site investigation

The powerplants group documented the wreckage July 1-4, 2019. An initial point of impact was evident on the north wall of the Sky B&B hangar, a steel beam and sheet metal structure. See Figure 1.

[3] References to position are as viewed from the rear of the engine looking forward, unless otherwise noted.

[4] Blade angles are referenced from the 42-inch radius (Hartzell installation data sheet No. 279). Ng refers to gas producer speed. Np refers to propeller speed.

[5] See Maintenance Group Chairman's Factual Report

Figure 1. Sky B&B hangar, Addison Airport

The left engine and propeller assembly were found inside the hangar near the impact hole. The right propeller was found inside the hangar to the right of the rollup door in the east wall. The right engine was found outside the east wall, with the fuselage. See Figure 2.

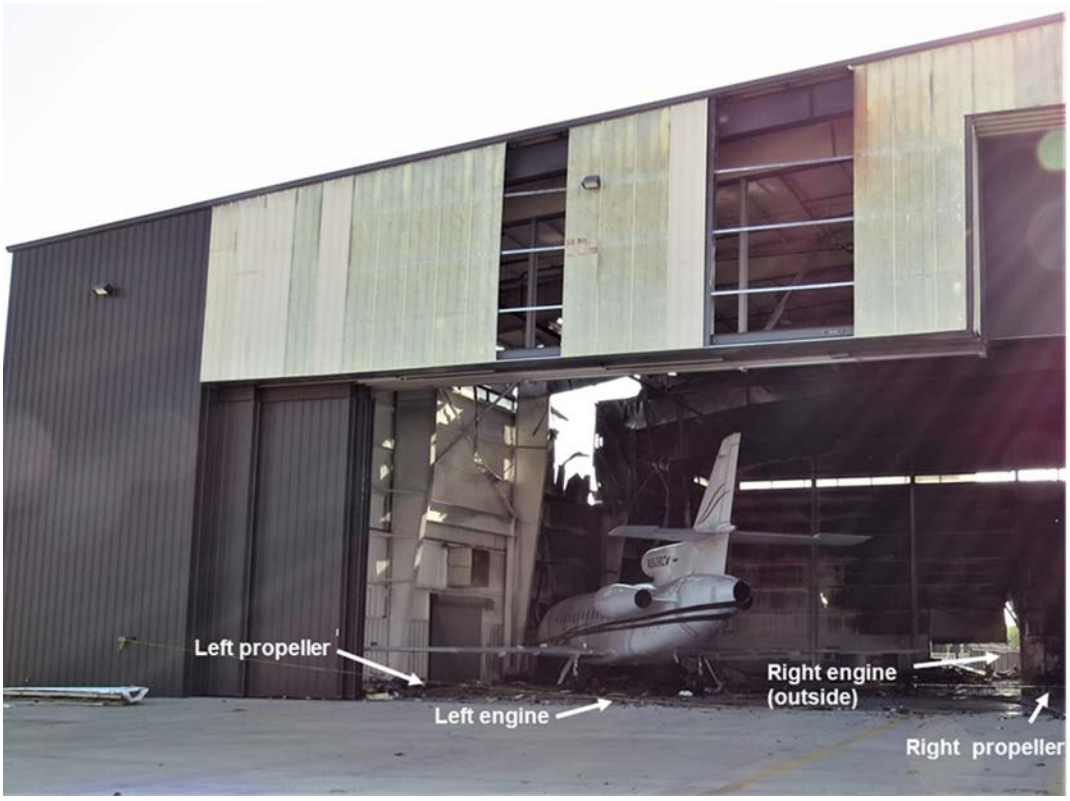

Figure 2. General locations of powerplant components as found

A propeller blade was found on the tarmac near the initial point of impact. Approximately five inches of the tip were missing. Chordwise white paint transfer marks were noted on its camber side. See Figure 3.

Figure 3. Liberated propeller blade showing transfer of white paint

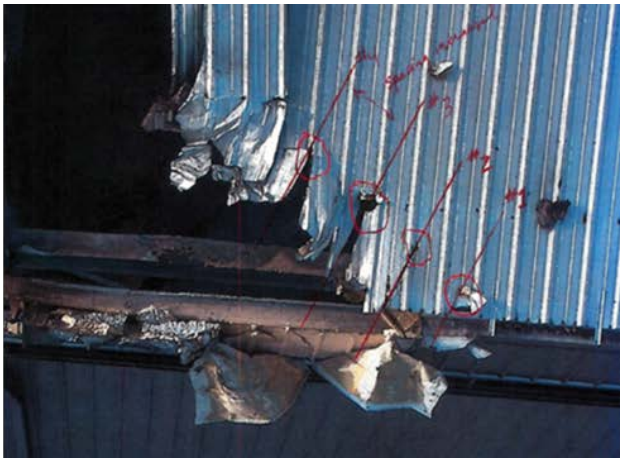

Figure 4. Propeller blade strikes at entry hole

2.1 Propeller blade strikes

Propeller blade strikes were observed at the point of entry. See Figure 4. There was another blade strike in the truss web. The truss had a white coating. See Figure 5.

Figure 5. View of the entry hole orienting the location of the crease in the roof truss

2.2 Left propeller

Propeller S/N FWA6013 was found on the floor next to the north wall. A blade was missing from the hub. A section of engine propeller shaft flange was attached. The pitch-change mechanism was separated. The spinner dome was crushed and fragmented. Two counterweights were liberated from their clamps. See Figures 6 and 7.

Figure 6. Left propeller

Figure 7. Liberated pitch change mechanism

Propeller blade tip material was found nearby. See Figure 8.

Figure 8. Propeller blade tip recovered inside hangar

Liberated propeller pieces, including the pitch-change mechanism, spinner dome fragments, the two counterweights, and the blade tip section, were recovered from the hangar floor. The blade was recovered from the tarmac.

2.3 Left engine

Engine S/N PCE-PK2221 was found approximately 50 feet southeast of the propeller. See Figure 9. Its fractured propeller flange matched the propeller flange section found attached to the nearby propeller. See Figure 10. There was some minor thermal damage. Engine cases and external components were deformed and fractured consistent with impact. The power control and reversing linkage was fractured and was disconnected at the fuel control unit (FCU). The compressor discharge pressure (P3) air filter was missing. The accessory gearbox fuel pump drive pad studs were sheared. The top of the propeller governor was fractured off. The first stage (S1) compressor rotor was intact[6] as viewed through the inlet case. The S2 PT blades were intact as viewed through the exhaust ducts. Both engine rotors were seized. Liberated components, including the P3 filter, propeller governor flyweights, and the fuel heater were recovered in the vicinity of the engine.

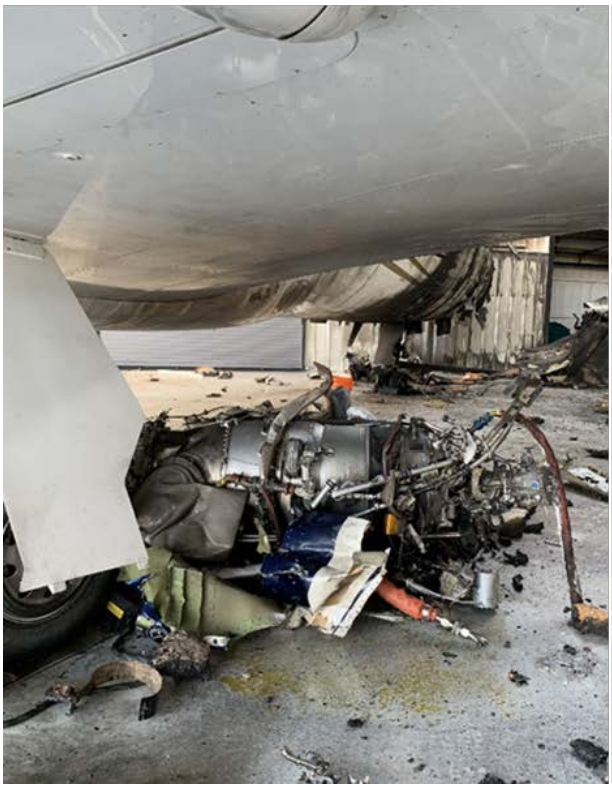

Figure 9. Left engine as found right side view

Figure 10. Left engine as found front view

2.4 Right propeller

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

Propeller S/N FWA6019 was found lying near the east wall, just south of the roll-up door. It was charred and sooted. The spinner was in place but crushed. Two blades exhibited forward bending and two exhibited aft bending. The front case of the engine reduction gearbox was attached. See Figures 11 and 12.

Figure 11. Right propeller

Figure 12. Right propeller being recovered

2.5 Right engine

Engine S/N PCE-PK2222 was found with the airplane fuselage, in the main wreckage area. It was covered with soot and debris, and residue from fire extinguishing chemicals. See Figure 13. The reduction gearbox front housing was separated at the A flange. [7] See Figure 14. The ignition exciter box was thermally destroyed. Other thermal damage appeared limited to engine externals. The S2 reduction gearbox planet gear carrier was separated at the web and was found nearby; it was fractured in the web area. The S1 compressor rotor was intact as viewed through the inlet case. The S2 PT blades were intact as viewed through the exhaust exit ducts. Both engine rotors were seized. The power control and reversing linkage was fractured. The P3 line was damaged but continuous. The governor pressure (Py) line was fractured at the A flange. The propeller governor speed lever was missing. Liberated components, including the S2 reduction gearbox planet carrier and the propeller governor speed lever were found nearby.

[7] The A flange attaches the front and rear reduction gearbox housings to the engine exhaust case.

Figure 13. Right engine as found

Figure 14. Right engine, showing A-flange separation

3.0 Wreckage retrieval

The powerplant components were removed from the wreckage site and brought to a secured hangar on the airport.

The engines were further documented and prepared for shipment.

The propellers were disassembled and examined July 2-4, 2019.

4.0 Left propeller disassembly

4.1 General

The blades were numbered L1, L2, L3, L4. [8]

A counterweight penetration was noted in one of the spinner dome fragments. The fragment could not be positively indexed to the hub to identify the counterweight that made the impression, and no useful blade angle information was obtained. [9]

[8] In describing propeller components, orientation is referenced from a single point, with blades rotating clockwise past this point as viewed from the rear of the propeller.

[9] Damage resulting from abnormal propeller loading can be used to fix a blade angle setting for the time the loading occurred.

4.2 Blade/clamp rotation

The blade clamp split lines were reference marked. See Figure 16.

Figure 15. Left propeller

Figure 16. Blade-clamp interface showing slippage

The blade-to-clamp angles and degree of blade rotation in the clamps were measured. See Table 2.

blade	as-received blade-to-clamp angle	blade slip in clamp?	clamp rotation possible?
L1	Beyond low pitch	YES - 80° toward high pitch	YES
L2	N/A (liberated)		
L3	Beyond low pitch counterweights missing	YES - 10° toward low pitch	YES
L4	Beyond low pitch	Not remarkable	YES

Table 2. Left propeller blade-to-clamp slippage

4.3 Link arms

The L1 link arm was bent laterally. The L2 link arm was bent laterally and there was a compression bend near the pin connection. The L3 and L4 link arms were not noticeably deformed. The L1, L3 and L4 link arm screw holes were elongated.

4.4 Pitch stops

The low pitch stop sleeve was not removed/observed. The feather stop screws were in good condition. The beta rods were bent and were pulled from the beta ring. The beta rod guide collar rod and the beta ring were fractured.

4.5 Piston

The L2 link arm attachment was fractured. The L3 link arm attach pin was loose. The L4 link arm attach point was cut to facilitate removal of the link arm. Clean residual oil was found in the piston cavity when the piston and cylinder were separated.

Multiple cylinder-to-piston impact marks were observed on the internal piston surface. See Figure 17.

Figure 17 . Left propeller internal piston witness marks

The distances from the witness marks to the aft piston edge were measured. See Table 3.

distance from aft piston edge (inches)
3.00
2.75
2.60
2.10
1.00

Table 3. Left propeller piston witness marks

4.6 Cylinder

The cylinder was creased approximately 0.5 inch from the aft shoulder. There was light scuffing on the cylinder external surface and bands of more prominent marks at several locations within the band, between 0.7 and 2.125 inches, as measured from the forward cylinder shoulder. According to Hartzell, the band of light scuffing showed the normal range of wear and the localized bands were indications of forceful contact.

The feathering spring assembly was held by the spring retainers and appeared undamaged. The pitch change rod appeared undamaged and was not removed.

4.7 Clamps and counterweights

The condition of the blade clamps and counterweights was recorded. See Table 4.

clamp pos	clamp and attachment hardware condition	counterweight condition
L1	Link screw bent toward low pitch; counterweight attachment bolts fractured	separated from clamp
L2	Both TE clamp bolts fractured; clamp halves were separated	intact
L3	Link screw pulled and separated; counterweight attachment bolts liberated	separated from clamp
L4	Link screw pulled, separated from clamp	loosely attached

Table 4. Condition of left propeller clamps and counterweights

4.8 Hub unit

The L2 pilot tube was pulled from the hub unit. One of the four propeller flange dowel pins remained lodged in the propeller flange. Two of the eight propeller mounting bolts also remained in the propeller flange with a segment of the propeller shaft flange attached. See Figure 18.

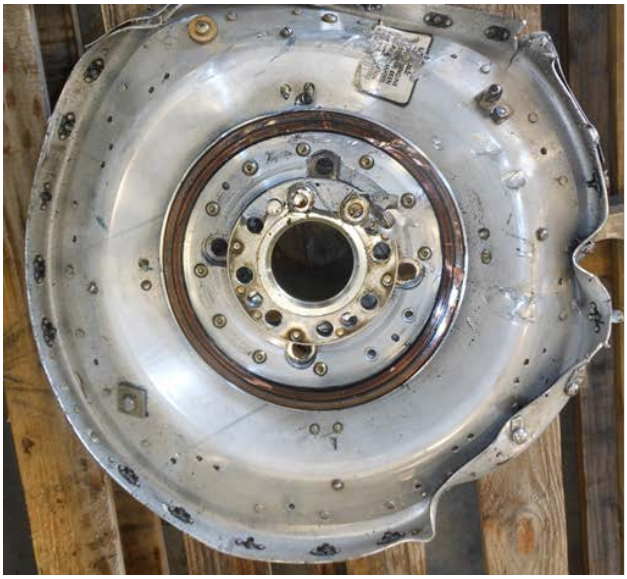

Figure 18. Left propeller flange

Figure 19. Cylinder separation from hub

4.9 Cylinder attachment

Remnants (whiskers) of cylinder threads typical of forcible separation of the cylinder were noted on the hub. See Figure 19.

4.10 Blades

The blade damage was documented. This assessment included inspection of the blade butts and hub arm ends for evidence of forcible impact (blade butt/hub arm witness marks.) [10] See Figure

[10] Blade butt/hub arm witness marks typically show as shiny arcs/crescents, and as impressions of raised markings on the blade butt that transfer to the hub arm.

20.

Figure 20. Left propeller blades

The L1 blade was bent aft, opposite the direction of rotation, and was twisted toward low pitch. Both camber and face sides exhibited chordwise scoring. The leading edge (LE) of the blade was gouged, with material deformed toward both high and low pitch. The blade TE was not remarkable. The de-ice boot was torn. There was impact damage to the needle bearing face area. Two crescent witness marks were noted:

4° aft, TE quadrant	Blade butt
35° aft, TE quadrant	Hub arm

The L2 blade was bent aft, opposite the direction of rotation. Approximately 5 inches of the blade tip was separated. The tip fracture surface showed overload features. Chordwise white paint transfer was noted on the camber side and there was chordwise scoring on the face side. The LE was gouged. The de-ice boot was torn. There was impact damage to the needle bearing face area. The L2 blade pilot tube was liberated with the blade. Two crescent impact marks were noted:

15° aft, TE quadrant	Blade butt
36° aft, TE quadrant	Hub arm

The L3 blade was bent aft with some S-bend characteristics. The camber side exhibited chordwise and random scoring. The face side exhibited spanwise scoring. The LE was gouged and there was a distinct crease 19 inches from the tip. The TE was bent TE-down, typical of impact forces. The de-ice boot was torn. There was impact damage to the needle bearing face area. An impression from raised lettering on the butt of the blade could be observed in the L3 hub arm. There were two crescents on the hub arm and two on the butt:

77° aft, TE quadrant	Blade butt
31° fwd TE quadrant	Blade butt
62° aft, LE quadrant	Blade butt corresponding to pen-stamp mark
10° aft, TE quadrant	Hub arm
74° aft, TE quadrant	Hub arm
75° (near mark)	Hub arm pen stamp impression

The L4 blade was bent aft at the tip and was twisted toward low pitch. There was chordwise scoring near the tip, on the camber side. Approximately 1.5 inches of the blade tip were missing. There was a distinct crease in the LE approximately 4 inches from the tip end. The TE displayed TE-down impact bending. The de-ice boot was torn. There were no discernible blade butt/hub arm witness marks.

Figure 21. Blade butts showing impact marks (L4 had no marks)

5.0 Right propeller disassembly

5.1 General

The blades were marked R1, R2, R3, R4.

The right propeller remained attached to the engine reduction gearbox with all mounting hardware secured. The beta ring was intact, and the beta arm was under the guide pin. The propeller was charred and sooted.

Figure 22. Two views of the right propeller as recovered

The spinner dome was torn and partially crushed. There was a counterweight penetration. The penetration angle was measured as approximately 31°. See Figure 23.

Figure 23. Right propeller spinner dome measurement

5.2 Blade/clamp rotation

The blade clamp split lines were marked for reference. See Figure 24. The degree of blade rotation within the clamps was measured. See Table 5.

blade	as-recovered blade-to-clamp angle	Blade slip in clamp?	Clamp rotation possible?
R1	Beyond low pitch	YES - 180° toward high pitch	YES
R2	Not determined	YES - 35° toward high pitch	YES
R3	Beyond low pitch Counterweights liberated	Not remarkable	YES
R4	Beyond low pitch	Not remarkable	YES

Table 5. Right propeller blade-to-clamp slippage

5.3 Link arms

All link arms were disconnected from the link screws. The R1 link arm was somewhat bent, and the R4 link arm exhibited a slight bend in compression. The R2 and R3 link arms were stretched. All link screw holes were elongated.

5.4 Pitch stops

The low pitch stop sleeve was not removed. The feather stop screws were in good condition. The beta rods and beta ring were intact and appeared undamaged; they were not removed.

5.5 Piston

The piston was locally sooted. There was an external dent/crease under the beta rod guide ring, adjacent to the R4 link arm attach point. The piston position was approximately 0.75 inch from the feathered position. All link arm attachments and link pins were intact and safetied.

Multiple cylinder-to-piston impact marks were observed on the internal piston surface. See Figure 25.

Figure 25. Internal piston impact marks

Measurements were taken from the witness marks to the aft piston edge. See Table 6.

distance from aft piston edge (inches)
3.0
2.75
2.25
0.8125
0.0625

Table 6. Piston internal surface impact marks

5.6 Clamps and counterweights (c/w)

The condition of the blade clamps and their counterweights were recorded. See Table 7.

clamp pos	clamp condition	counterweight condition
R1	Link screw sheared	gouged on inboard side
R2	Link screw liberated, hole deformed opposite of high pitch	no anomalies
R3	Link screw sheared	gouged on inboard side
R4	Link screw bent, fractured opposite of high pitch	gouged on inboard side

Table 7. Condition of the left propeller blade clamps and counterweights

5.7 Hub unit

The hub unit mounting flange remained attached to the engine with all mounting hardware present and secured.

5.8 Blades

The condition of the blades was documented. See Figure 26.

Figure 26. Right propeller blades

The R1 blade was bent in the forward/thrust direction and was untwisted toward high pitch. Both camber and face sides exhibited chordwise scoring. The LE was gouged. The TE was gouged and torn at the tip, and there was a triangular puncture at mid-blade. The de-ice boot was torn. Crescent witness marks were noted on the blade butt and the hub arm:

Blade butt:	31° fwd, TE quadrant
Hub arm:	64° aft, TE quadrant

The R2 blade was bent in the forward/thrust direction. The camber side was scored chordwise and was charred and sooted in the tip area. The face side was scored chordwise and there was spanwise scoring at mid-blade. The de-ice boot was scored. Crescent witness marks were noted on the blade butt and the hub arm:

Blade butt:	37° fwd, TE quadrant
Hub arm:	37° aft, TE quadrant

The R3 blade was bent aft and twisted LE-down. The camber side was scored chordwise and was charred and sooted mid-blade, with the paint burned off from the outboard surface mid-blade to the tip. The face side was scored chordwise near mid-blade, and the TE tip was fractured off. The LE was gouged. The TE was gouged and nicked. There was a small puncture at the outboard end of the de-ice boot. No blade butt or hub arm impact marks were found.

The R4 blade was bent aft. Both camber and face sides exhibited chordwise scoring. The LE was gouged and there was a local bend in the TE eight inches from the tip. The de-ice boot was torn, and heat damaged. There were no discernible blade butt or hub arm impact marks.

Figure 27. Blade butts with witness marks noted

6.0 Parts disposition

The propellers and the airframe components removed from the engines were released to secured storage on July 3, 2019.

On July 5, 2019 the engines were transferred to a Dallas Airmotive storage facility from where they were shipped to Pratt & Whitney Canada (P&WC), Longueuil, Quebec, for further investigation.

Members of the powerplants group participated in engine teardown examinations and accessory assessments at P&WC Longueuil July 22-26, 2019.

7.0 Left engine teardown

7.1 External condition

The left engine exhibited some case deformation and local impact damage. It was coated with soot and with chemical residue from the hangar fire suppression system. See Figures 28-31.

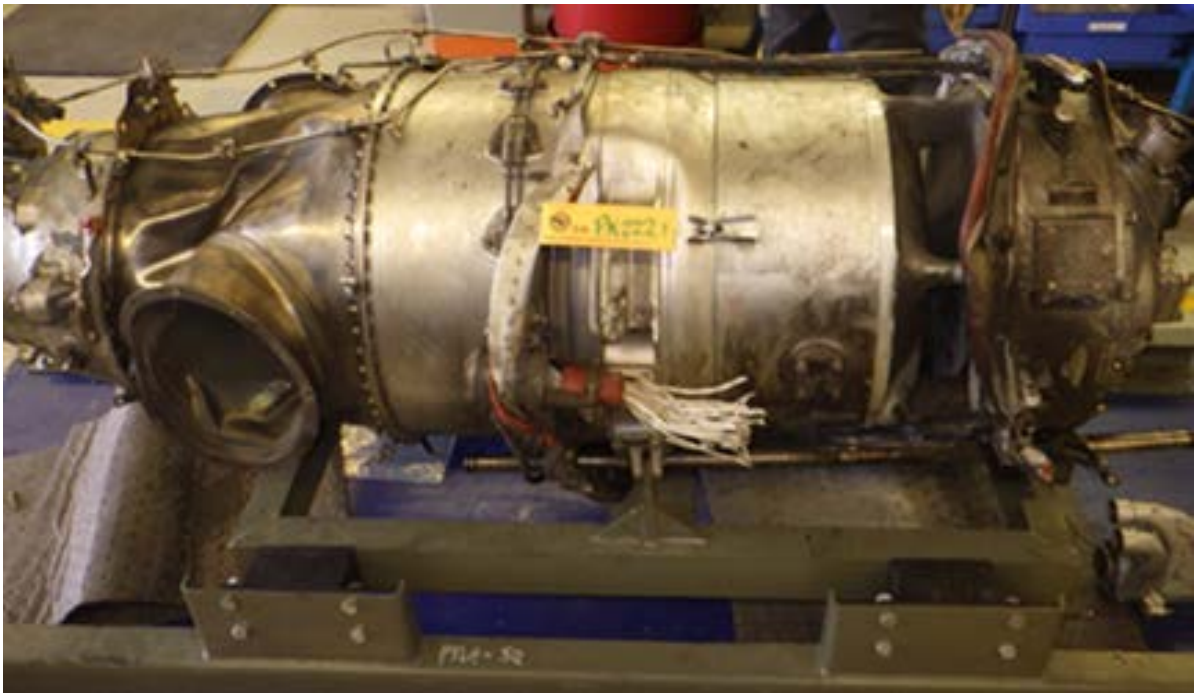

Figure 28. Left side view of engine S/N PCE-PK2221

Figure 29. Right side view of engine S/N PCE-PK2221

Figure 30. Front view of engine S/N PCE-PK2221

Figure 31. Rear view of engine S/N PCE-PK2221

Thermal damage to line insulation and attachment hardware indicated some local exposure to fire. See Figure 32.

Figure 32. Typical left engine thermal damage

The front of the engine was twisted out of axis and displaced 5°-10° off centerline. See Figure 33.

Figure 33. Bottom view of engine showing distortion

7.1.1 Reduction gearbox

Much of the reduction gearbox forward housing scavenge sump was fractured off, along with the oil strainer, chip detector, and a section of the S2 ring gear support. See Figure 34.

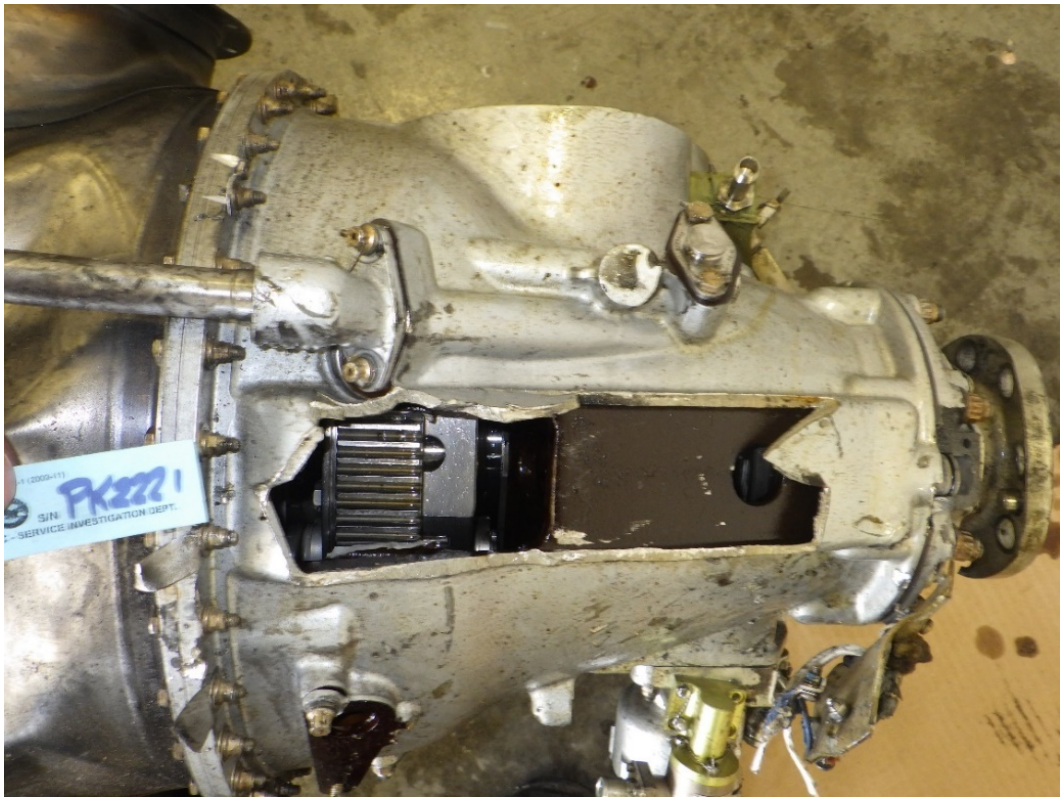

Figure 34. Reduction gearbox front housing sump area

7.1.2 Exhaust duct

The exhaust duct was compressively deformed. There was a 2-inch fracture along a fold at 6 o'clock [11].

7.1.3 Gas generator

The gas generator case was creased aft of the fuel nozzle bosses between 9 and 12 o'clock. The upper left engine mount displayed compressive impact damage at 10 o'clock. The compressor inlet case was compressively deformed along its full circumference.

7.1.4 Accessory gearbox

There was local scraping damage to the accessory gearbox case. One fuel heater mounting lug was

[11] O'clock positions refer to approximate circumferential locations in a clockwise direction as viewed from the rear of the engine looking forward, unless otherwise noted.

fractured off. The fuel pump mounting pad studs were sheared.

7.1.5 Externals

The engine externals showed random impact damage. The fuel pump/FCU cluster remained attached to the engine by fuel and signal lines. The top of the propeller governor was fractured off and was attached to the reduction gearbox by the Py line and beta linkage. The overspeed governor (OSG) feathering solenoid was loose. The OSG test solenoid was bent and fractured. The power control and reversing linkage was bent and was fractured at the FCU attachment.

There was some local thermal distress to the P3 line insulation.

The B-nut connections at both ends of the P3 line between the P3 filter housing and the FCU were found loose. The line was capped off and pressure tested; it passed the check with no leakage.

The P3 line between the P3 filter housing and the gas generator case was pressure checked as installed; there was a leak at the P3 filter housing in a damaged (bent) area.

There was some local thermal distress to the Py line insulation. Pressure test identified small leaks at the rear gas generator case firewall fitting and at a loose propeller governor fitting. A torque check of these fittings and the front firewall fittings found lower than specified torque values.

The center and rear fire seal mount ring assemblies were displaced and mechanically deformed.

The P3 filter and housing were found clean. The fuel filter and housing were found clean.

The oil filter and housing were found clean. The magnetic chip detector was not recovered. The propeller governor oil return line to the reduction gearbox was found finger tight with the safety cable missing.

7.2 Disassembly observations

The compressor bleed valve and fuel system components were removed for further evaluation. There was difficulty removing the fuel nozzles from the gas generator case between 9 and 12 o’clock due to the case deformation in this area.

7.2.1 Compressor section

The Nos. 1 and 2 bearing rotated freely. Bearing disassembly found no damage. The air seals of both bearings exhibited light rub damage.

The S1 axial compressor blade tips were lightly rubbed, with corresponding rub along the S1 axial blade path. There was no evidence of rotor-to-stator contact at the other axial stages. The centrifugal impeller vanes were rubbed, with rollover burring, in the exducer area. See Figure 35. The impeller shroud exhibited 360° rub damage, consistent with the damage observed on the impeller. See Figure 36.

Figure 35. Compressor impeller

Figure 36. Compressor impeller shroud

7.2.2 Combustion section

The combustion chamber showed no evidence of abnormal operation. The outer liner was deformed at 10 o'clock, axially in line with the gas generator case damage.

7.2.2.1 CT vane ring

No damage was noted to the CT vane ring.

7.2.2.2 CT shroud

There was an arc of rub damage across three CT shroud segments at 4 o'clock.

7.2.2.3 CT disk assembly

The upstream face [12] of the CT disk assembly was undamaged. The downstream face was scored 360° along the blade retention fir tree roots and rivets, the center hub, and across the tooling lugs. [13] See Figures 37 through 39. The compressor turbine blades tips were rubbed.

Figure 37. Downstream face of CT showing 360° scoring in the fir tree root area and tooling lugs

[12] 'Upstream' and 'downstream' refer to the direction of gas flow from the compressor air inlet to the exhaust duct.

[13] Rotational scoring can occur when clearances between stationary and rotating components are lost while the engine is operating.

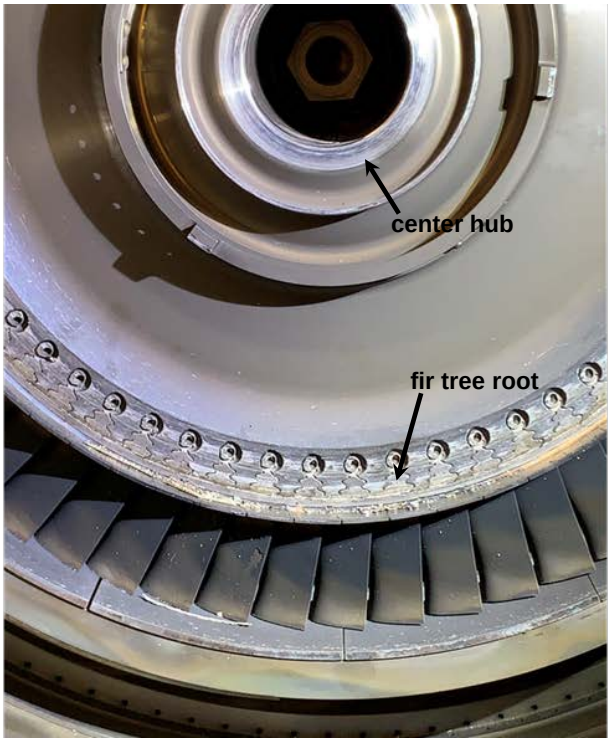

Figure 38. CT downstream face, showing fir tree root and center hub scoring

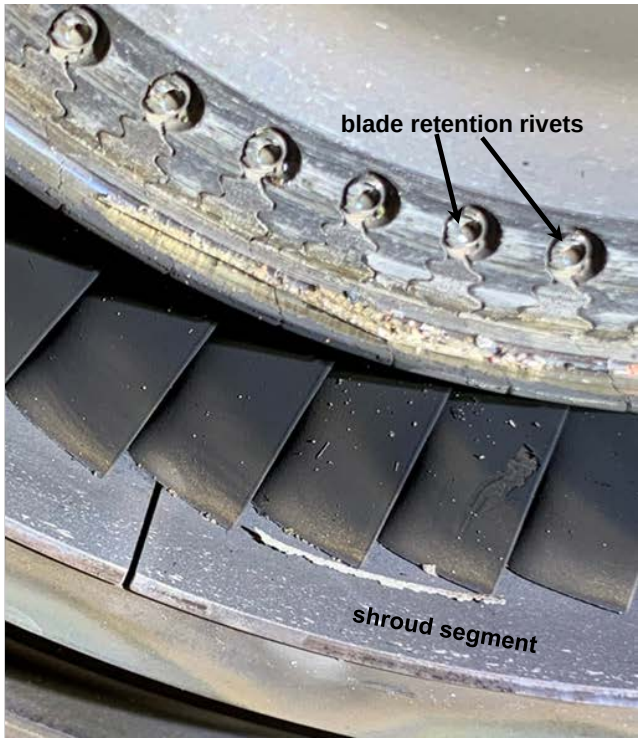

Figure 39. Detail of fir tree area and shroud segment scoring

7.2.2.4 S1 PT guide vane ring and interstage baffle

The upstream face of the S1 PT guide vane ring and interstage baffle was scored 360° near the center of the baffle and along the retaining rivets; all retaining rivets were missing material. There was circumferentially oriented scoring on the face of the baffle and at its outer edge, with heavy rub between 6 and 11 o'clock. See Figures 40 and 41.

Figure 40. Upstream face of S1 PT guide vane ring and interstage baffle showing 360° scoring/material loss across retaining rivets

Figure 41. Detail of Figure 40 showing rotational damage signatures

The downstream face of the S1 PT guide vane ring and interstage baffle was scored 360° along the inner and outer shroud edges and scored at the center baffle surface. See Figure 42.

Figure 42. Downstream face of S1 PT guide vane ring and interstage baffle showing 360° inner and outer baffle shroud edge scoring

7.2.2.6 S1 PT shroud

The S1 PT shroud was scored 360°. The scoring was pronounced between 3 and 6 o'clock.

7.2.2.5 S1 PT disk assembly

The upstream face of the S1 PT disk assembly was heavily scored 360° along the fir tree roots and blade platform edges, and at the blade tip shrouds. See Figure 43.

Figure 43. Upstream face of S1 PT disk assembly showing 360° scoring along the fir tree roots and blade platform edges, and at the blade tip shrouds

The S1 PT blades were displaced in the downstream direction. The scoring on the disk face between fir trees lined up with the scoring on the displaced blades, evidence that this damage occurred before the blades displaced. Metallization was noted on the blade LEs.[14] See Figure 43.The blade shroud knife edges were rubbed. See Figure 44.

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

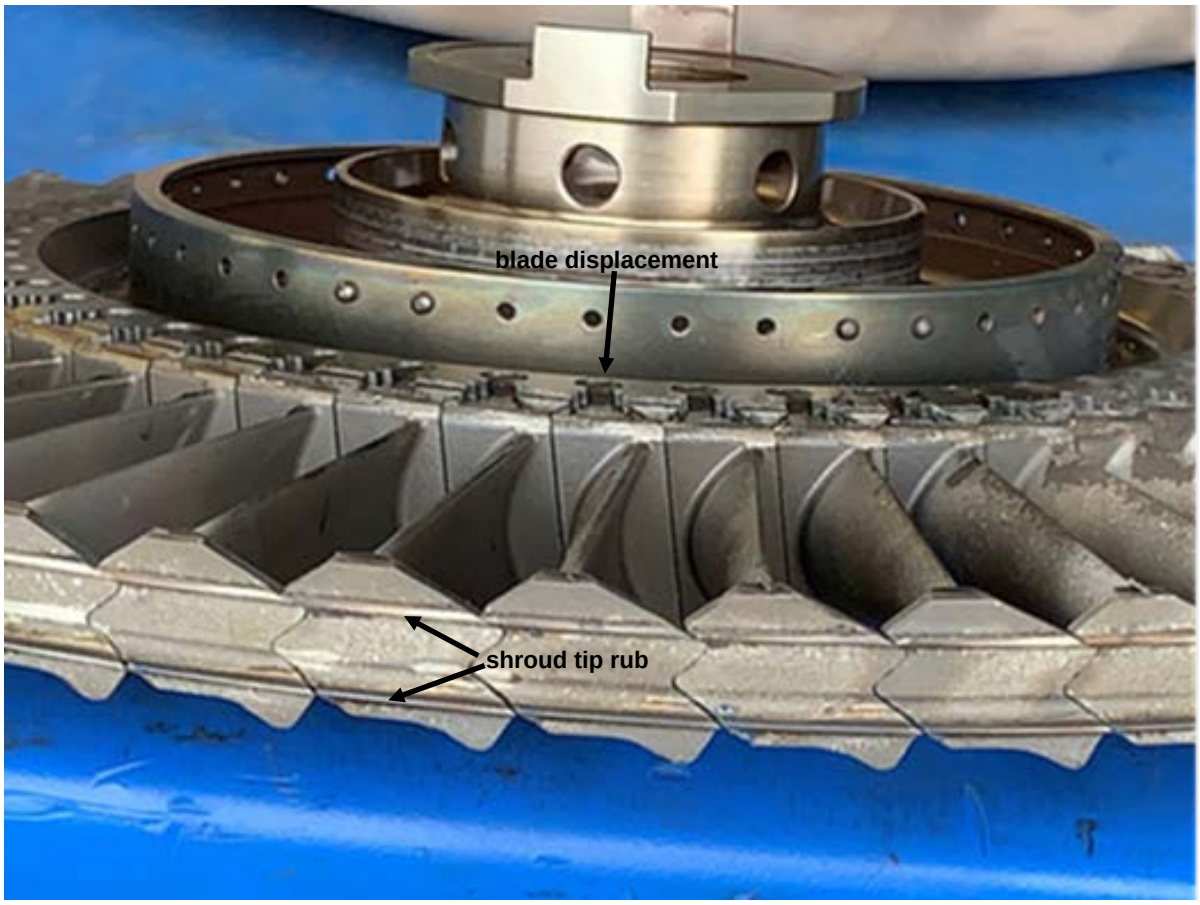

Figure 44. S1 PT disk assembly showing blade displacement and shroud tip rub

The downstream face of the S2 disk assembly was showed no obvious contact damage.

7.2.2.7 S2 PT guide vane ring and interstage baffle

The S2 PT vane ring and interstage baffle upstream face was unremarkable. The downstream face was scored along the inner and outer shroud edges. Some abradable seal material was displaced. No vane damage was observed.

7.2.2.8 S2 PT shroud

The S2 PT shroud was rubbed 360°.

7.2.2.9 S2 PT disk assembly

Fragments of interstage seal material were found on the upstream face of the S2 PT disk assembly. The blade tip shrouds were rubbed 360° on the upstream face. See Figure 45.

Figure 45. S2 PT disk assembly upstream face showing 360° blade tip rub

The S2 PT disk downstream face was scored 360° at the balance rim edge and along the blade retaining rivet diameter. See Figure 46.

The S2 PT blade tip shroud knife edges were worn.

Figure 46. S2 PT disk assembly downstream face showing 360° scoring along retaining rivets and edge of balance rim

7.2.2.10 PT Housing

The PT stator housing-to-exhaust case flange was gapped, and the retention bolts were bent. There was no obvious damage to the ITT system.

7.3 PT shaft and shaft housing

The PT shaft and shaft housing assembly was compressively deformed. The No. 3 bearing cover was separated, and the rollers were liberated. All rollers were recovered. They exhibited end face impact damage consistent with outer race contact. The cage was intact. No spalling was noted on the rollers or inner and outer race bearing surfaces. The No. 4 bearing retaining bolts were sheared. The bearing could be freely rotated.

7.4 Reduction gearbox

The S1 sun gear teeth were damaged along the front edge. The S1 planet gear assembly rotated freely, and the gears appeared undamaged. The planet gear carrier was not disassembled.

The S2 sun gear and flex coupling gear teeth were undamaged. The sun gear rear face was

circumferentially scored. See Figure 47.

The S2 planet gear carrier was fractured at the webs. The web material at the separations was deformed in the direction opposite propeller rotation. The gear shaft retaining nuts were distorted and scraped. See Figure 48. The aft sides of the fractured planet gear carrier webs were scored consistent with the circumferential scoring damage observed on the aft face of the S2 sun gear.

P&WC evaluation of representative fracture surfaces found ductile torsional overload features. The material was as specified. There was no evidence of fatigue.

Figure 47. S2 sun gear showing scoring damage

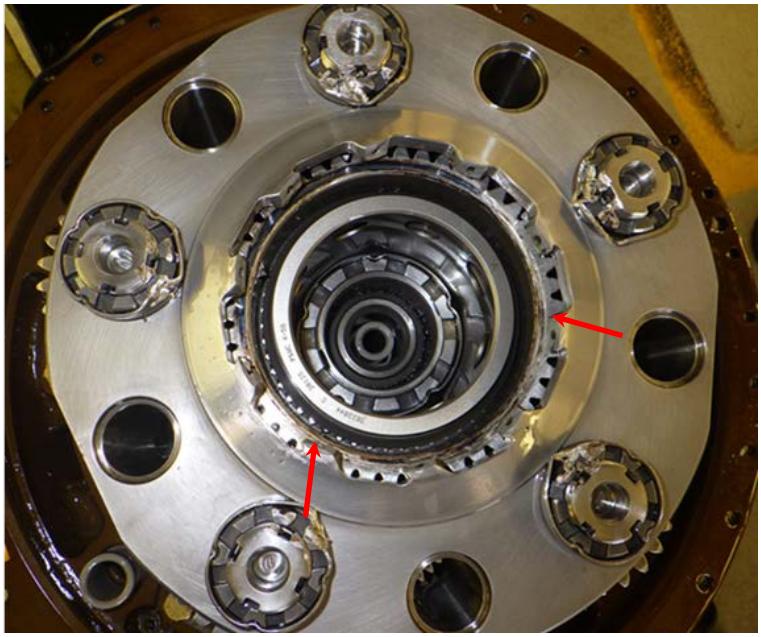

Figure 48. S2 planet gear carrier fracture surfaces, 2 of 10 indicated

No gear damage was noted. The S2 planetary gears turned freely. The S2 planet assembly was not disassembled.

Five of the six No. 5 bearing outer race retaining bolts were fractured consistent with the damage observed to the S2 planet gear shaft nuts.

The propeller flange was bent. An approximate 90° arc of the flange was fractured off.[15] The fracture surfaces showed overload features. The propeller shaft seal cover plate was dented. The shaft seal underneath was found protruding from its cavity. The protruding seal lip showed static imprints of the runner edge and no evidence of wear. The propeller shaft was not disassembled from the reduction gearbox rear case. The Nos. 6 and 7 bearings were not accessed.

7.5 Accessory gearbox

[15] The missing piece of propeller flange was found attached to the left propeller assembly.

The accessory gearbox gears and bearings rotated freely. The gearbox casings were split, and the main oil pump was disassembled. The gears and main oil pump were visually inspected with no anomalies noted.

8.0 Right engine disassembly

8.1 External condition

The engine exhibited light thermal damage. The gas path was coated with dirt/soot. Both rotors were seized. The reduction gearbox was fractured at the A flange and the forward section of the reduction gearbox was found attached to the right propeller. See Figures 49 through 52.

Figure 49. Right side view of engine S/N PCE-PK2222

Figure 50. Left side view engine of S/N PCE-PK2222

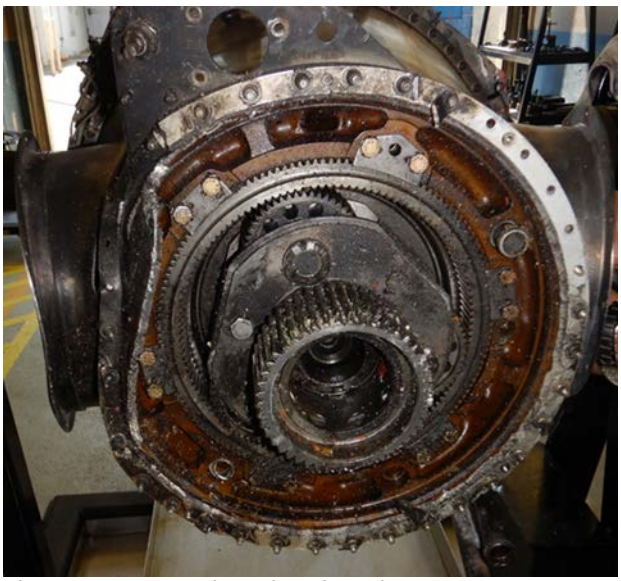

Figure 51. Front view of engine S/N PCE-PK2222

Figure 52. RGB section that separated with propeller

The S2 planet gear carrier was separated at the web and was found nearby.

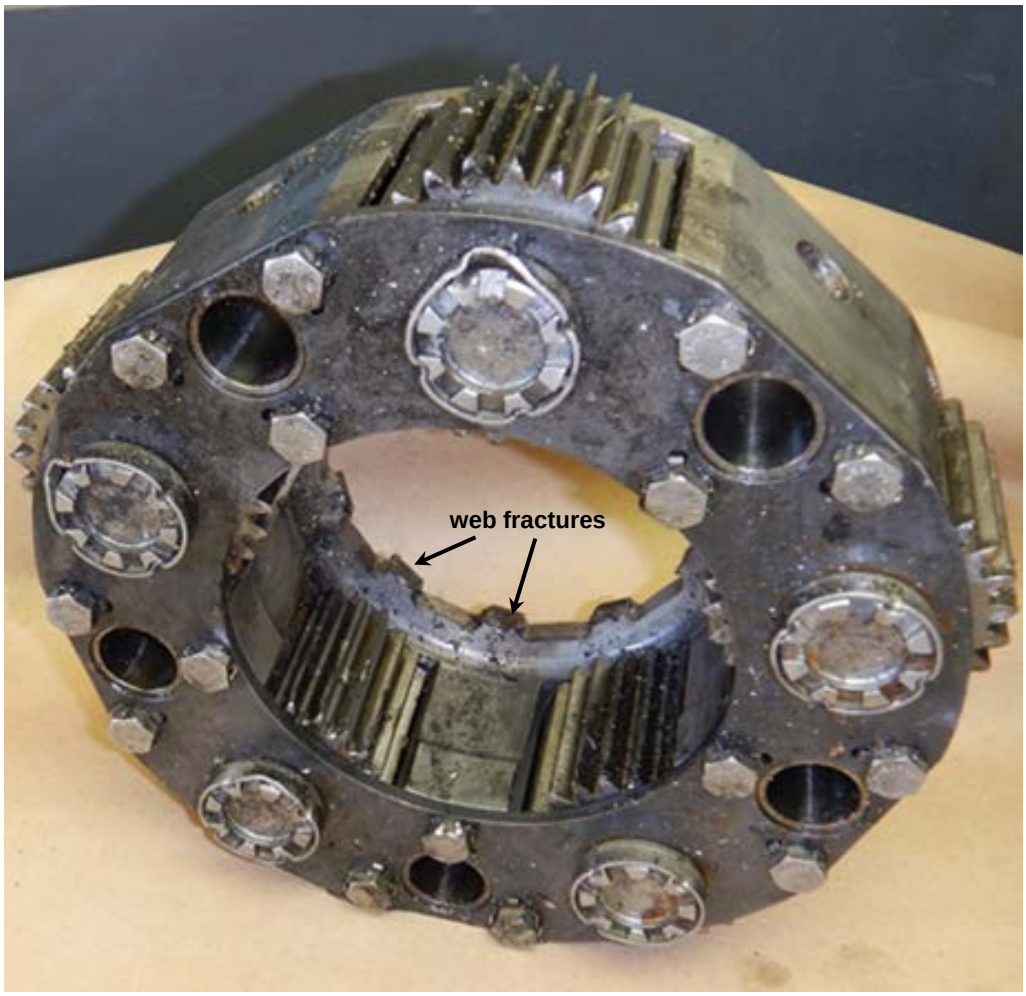

Figure 53. Liberated S2 planet gear carrier with several of the 10 web fractures noted

8.1.1 Reduction gearbox

The reduction gearbox rear housing was fractured and separated at the A flange. The flange was crushed between 1 and 4 o'clock, including an oil transfer line boss (Figure 51).

8.1.2 Exhaust duct

The exhaust duct was compressively deformed around the right stack. The forward flange was damaged between 1 and 2 o'clock, consistent with impact.

8.1.3 Gas generator

The gas generator case had a slight deformation near the bleed valve port.

8.1.4 Accessory gearbox

The accessory gearbox appeared undamaged.

8.1.5 Externals

The engine externals were randomly damaged by the impact sequence and were coated with soot, fire debris, and fire extinguishing chemicals. See Figure 54. The exciter box was thermally destroyed. There was local thermal damage to line insulation and attachment hardware. The center and rear fire seal mount ring assemblies were displaced and deformed. See Figure 55.

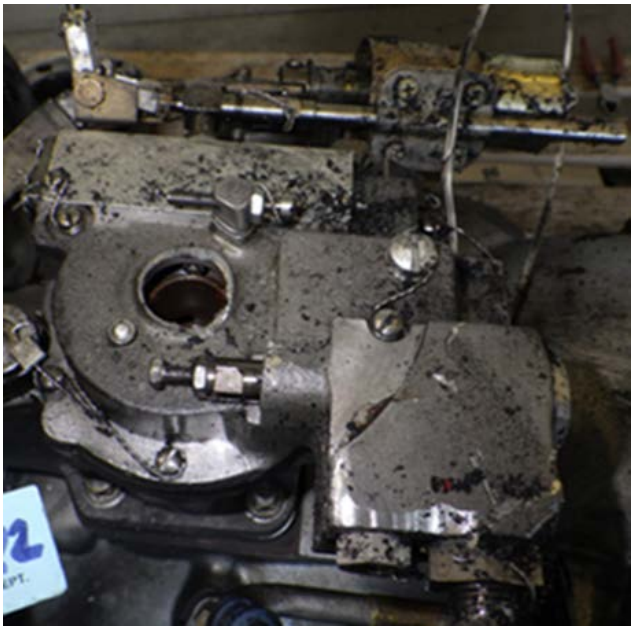

Figure 54. Propeller governor, showing impact damage

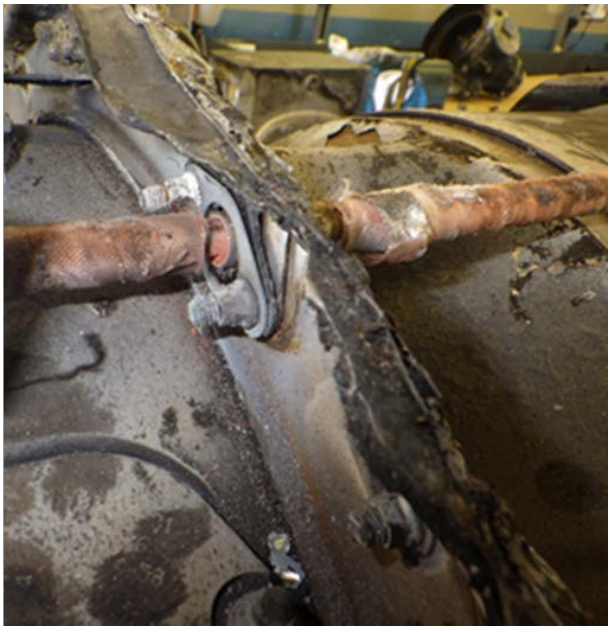

Figure 55. Typical right engine thermal damage

The power control and reversing linkage was corroded but capable of movement. The reversing cam slot was fractured, with a small piece missing.

The P3 line insulation was thermally damaged. The P3 line was pressure tested and did not leak. The P3 filter and housing were clean, with no evidence of corrosion.

The Py line was severed at the A flange, crushed against the FCU, and bent at the firewall. Pressure testing by sealing off the severed end revealed a small leak at the fitting forward of the firewall.

The fuel filter and housing were clean. The magnetic chip detector was clean. The oil filter and housing were clean.

The accessories were removed for further investigation.

8.2 Disassembly observations

8.2.1 Compressor

The S1 axial compressor rotor exhibited light blade tip rub on S1 and circumferential scoring on the S1 axial blade path. The other axial stages showed no obvious damage.

The exducer area of the centrifugal impeller vanes were rubbed with slight rollover burring. The impeller shroud showed 360° rub in the corresponding area. The Nos. 1 and 2 bearings rotated freely. Their air seals showed moderate scoring.

8.2.2 Combustion section

The combustion chamber inner and outer liners were undamaged. The small exit duct was undamaged. There were no indications of abnormal operation.

8.2.3 Turbine section

8.2.3.1 CT vane ring

The CT vane ring was undamaged.

8.2.3.2 CT shroud

The CT shroud was undamaged.

8.2.3.4 CT disk assembly

The downstream face of the CT disk assembly was scored 360° in the blade fir tree root area adjacent to the platforms. See Figure 56.

Figure 56. CT disk assembly downstream face showing 360° scoring in the fir tree root area

8.2.3.5 S1 PT guide vane ring and interstage baffle

The upstream face of the S1 PT guide vane ring and interstage baffle was lightly scoring along the inner shroud edge. See Figure 57.

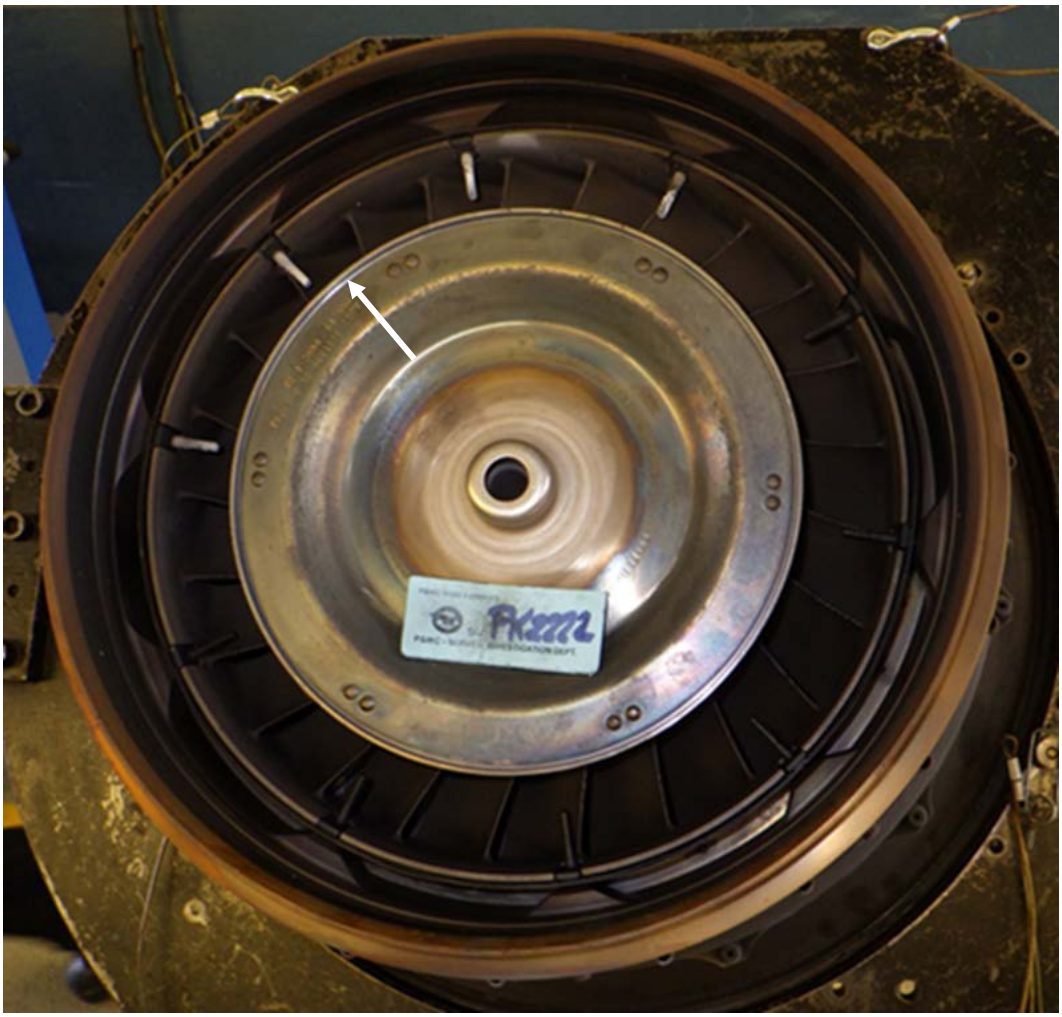

Figure 57. Upstream face of S1 PT guide vane ring and interstage baffle showing shroud edge scoring

The downstream face of the S1 PT guide vane ring and interstage baffle was scored along the inner shroud and center baffle edge. The S1 PT vanes were undamaged. See Figure 58.

Figure 58. Scoring on downstream face of S1 PT guide vane ring and interstage baffle

Figure 59. Rotational scoring S1 PT disk upstream face

8.2.3.6 S1 PT disk assembly

The upstream face of the S1 PT disk assembly displayed light 360° scoring along the blade platform and the outboard surface of the fir tree roots, and along the shrouded tip edges. See Figure 59.

The S1 PT disk blade tip knife edges were worn.

8.2.3.7 S1 PT shroud

The S1 PT shroud was scored 360°. The damage was more pronounced between 12 and 6 o'clock.

8.2.3.8 S2 PT guide vane ring and interstage baffle

The downstream face of the S2 PT guide vane ring and interstage baffle outer shroud edge exhibited rub damage with some material flaking. The interstage seal abradable material was worn. See Figure 60. The vanes were intact and undamaged.

8.2.3.9 S2 PT disk assembly

The upstream face of the S2 PT disk assembly was circumferentially scored on the tip shroud edges, and along the blade platform edges. The downstream face was unremarkable. All blades were in place.

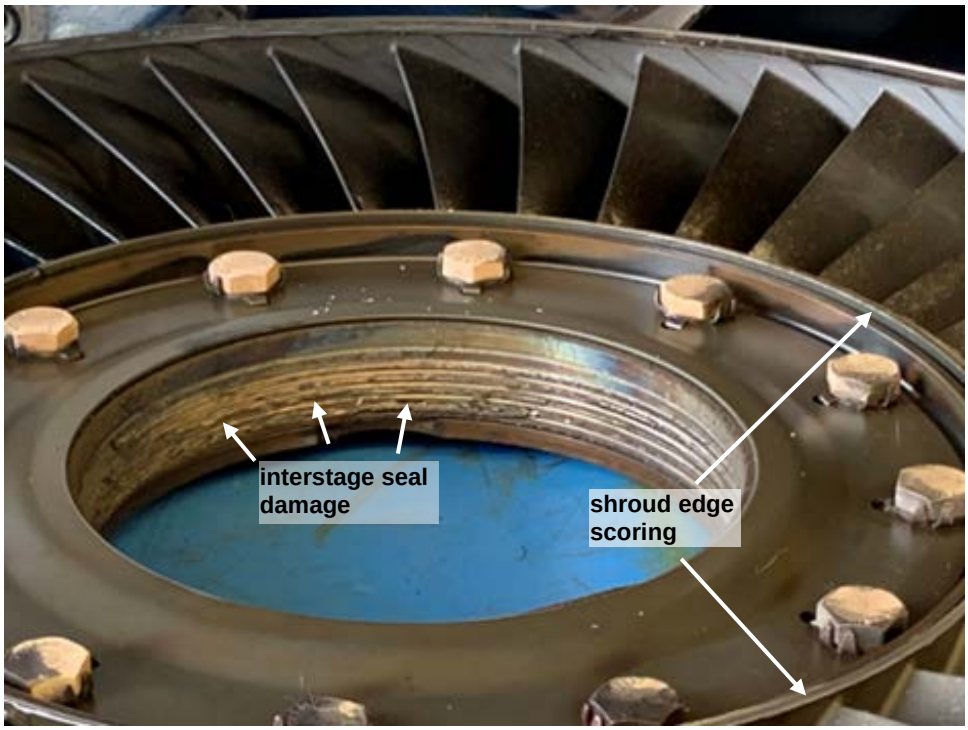

Figure 60. S2 PT guide vane ring and interstage baffle showing outer shroud edge scoring and interstage seal damage

8.2.3.10 PT stator housing

The PT stator housing was undamaged. There was no obvious damage to the ITT system.

8.2.4 PT shaft and shaft housing

The PT shaft and shaft housing assembly and support bearings rotated freely. It was not disassembled.

8.2.5 Reduction gearbox

The S1 sun gear turned freely. Some axial displacement of the S1 planet gear assembly was noted. The planet gears rotated freely. Continuity with the PT shaft was confirmed. The carrier was not disassembled. The torquemeter was not assessed.

The S2 sun gear and flex coupling gear were coated with debris consistent with exposure to site debris after flange separation. The gear teeth displayed impact damage and damage consistent with spiral mis-meshing. See Figure 61.

Figure 61. S2 sun gear tooth damage

The S2 planet gear carrier was separated at the slotted diameter of its web. See Figures 62 and 63.

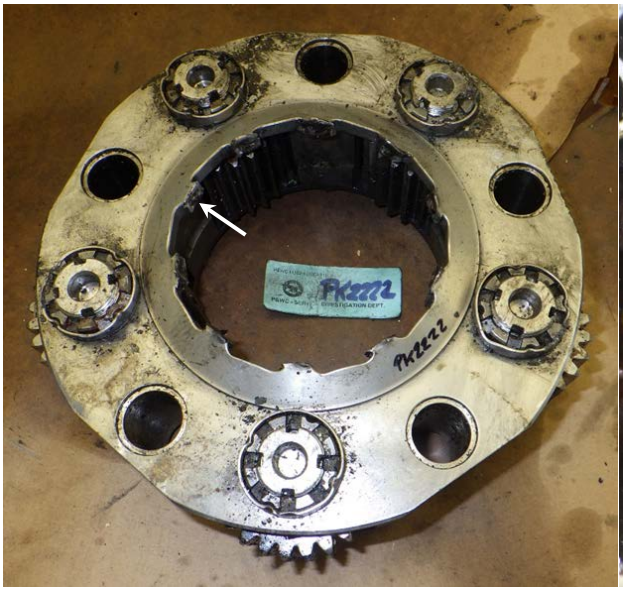

Figure 62. Aft side of S2 reduction gearbox planet gear with one web fracture surface noted

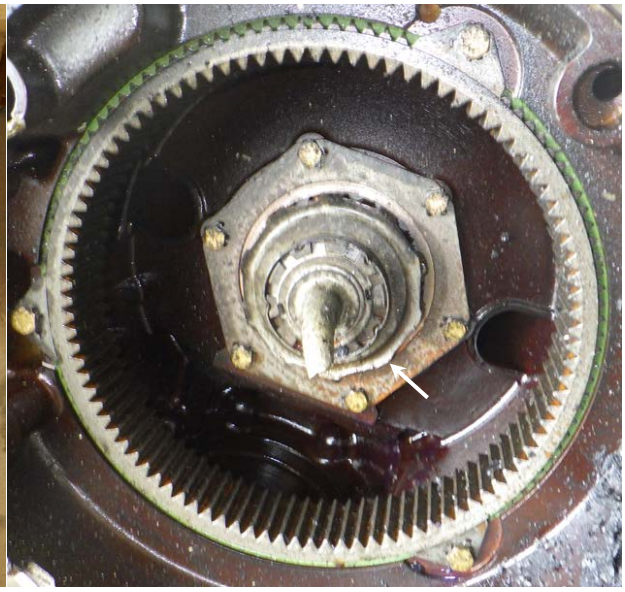

Figure 63. Forward side of S2 planet gear carrier with with one web fracture surface noted

The fractured web section remnants were plastically deformed opposite the direction of propeller rotation. The fracture surfaces were smeared consistent with post-fracture rotational damage. Examination of the fracture surfaces at a P&WC materials lab found ductile torsional overload features. The material was as specified. No evidence of fatigue was found.

The carrier edges and most of the planet gear teeth showed impact damage, consistent with the carrier having liberated during the impact sequence.

Impact/scoring damage was noted on the gear shaft retaining nuts. The S2 planet gears rotated freely. The S2 ring gear appeared undamaged. The S2 planet assembly was not disassembled.

The No. 5 bearing outer race retaining bolts were intact. The bearing was not disassembled.

The propeller flange appeared undamaged. The propeller shaft sleeve oil nozzle was bent 90°.

The Nos 6 and 7 bearings were not accessed.

The forward housing bolting flange was fractured 360°. A crack extended from the flange to the ring gear support at 4 o'clock.

8.2.6 Accessory gearbox

The accessory gearbox gears and bearings rotated freely as assembled. The gearbox was split, and the main oil pump was disassembled for visual inspection. No anomalies were found.

9.0 Controls and accessories investigation

The engine accessories were evaluated at P&WC July 22-23, 2019 and at Woodward, Rockford, Illinois January 14-16, 2020.

9.1 Accessories evaluations at P&WC

Receiving inspections were performed. The fuel nozzles passed visual inspections and following the engine teardowns it was decided to forego fuel nozzle flow tests based on the condition of the engine combustors. The bleed valves, flow dividers, fuel pumps, and the right engine FCU were cleared for any pre-impact failure condition at Longueuil. See Table 7.

position	unit	P/N	S/N	Longueuil		Woodward
LEFT	**bleed valve**	3117032-01	AHX2901336	**PASSED ATP**		
	flow divider	3036640	T1684	**PASSED ATP**		
	fuel pump	3040760	014849	**PASSED ATP**		
	fuel control unit	3120644-01	20565991	PARTIAL ATP (bent base plate)		**PASSED ATP - minor exceedances were impact damage-related**
	propeller governor	3057250-01	20472549	Damage precluded ATP		**disassembled; NO EVIDENCE OF PRE-IMPACT FAILURE**
	overspeed governor	210631-01	20691859	Damage precluded ATP		**disassembled; NO EVIDENCE OF PRE-IMPACT FAILURE**
RIGHT	**bleed valve**	3117032-01	AHX2901339	**PASSED ATP**		
	flow divider	3036640	T1679	Damage precluded ATP	**disassembled; NO EVIDENCE OF PRE-IMPACT FAILURE**	
	fuel pump	3040760	0148857	**PASSED ATP**		
	fuel control unit	3120644-01	20572127	Damage precluded ATP	**disassembled; NO EVIDENCE OF PRE-IMPACT FAILURE**	
	propeller governor	3057250-01	20540237	Damage precluded ATP		**disassembled; NO EVIDENCE OF PRE-IMPACT FAILURE**
	overspeed governor	210631-01	20691854			**PASSED ATP**

Table 7. Engine accessory assessments at Longueuil

9.2 Further controls evaluations at Woodward

The propeller governors, OSGs, and the left engine FCU were examined at the manufacturer. No evidence of pre-impact failure was found.

9.2.1 FCU S/N 20565991

Receiving inspection. There were lockwires identified as non-Woodward-installed on field-adjustable settings: condition lever cam follower, low idle speed adjustor screw, flight idle max stop [16] screw, and max reverse stop screw. There was also an altered lockwire on the dead band screw adjustment; however, although not strictly field adjustable, Woodward is aware that it is

[16] These control adjustments names are the correct manufacturer nomenclature.

adjusted in the field. All remaining lockwire was Woodward-installed. The min speed and min flow-to-delta P adjustor lockwires were broken. The base plate was bent consistent with impact damage. See Figure 64.

Figure 64. Deformed baseplate, FCU S/N 20565991

Test. The FCU was installed on a test bench. The external leakage observed during test at Longueuil was present; it was shielded using plastic barrier material. The fuel flow was set at 735 pound per hour (pph) and the P3 was held at 130 psia for 20 minutes. The fuel remained at 735 pph, indicating no leakage into the P3 bellows.

All test points were within limits except for several that either couldn't be tested or were slightly over limits due to impact damage. See Table 8. For test results see Attachment A.

Schedule	Test point	Outside of limit	Comment
Deceleration	MIN FLOW	2 pph over limit	Power lever damage
Start-accel	Low idle	Not performed	Unit damage precluded test
P3 (CDP)	40 psia	3.0 pph over limit	Bellows (calibration) shift due to impact loading
Start-accel	High idle 9.1	2.5 pph over limit	
Start-accel	High idle 9.2	5.0 pph over limit	
Start-accel	High idle 9.3	5.0 pph over limit	
Start-accel	High idle 9.4	7.0 pph over limit	
Start-accel	High idle 9.5	2.0 pph over limit	
Start-accel	Max forward 9.4	1.0 pph over limit	

Table 8. Review of left engine fuel control unit S/N 20565991 ATP test points exceeded or unable to test

Disassembly. The powerplants group agreed that disassembly inspection was not required.

9.2.2 Prop governor S/N 20472549

Receiving inspection. The unit S/N was confirmed. The external surfaces were dirty (typical). The beta valve linkage was attached; it was fully retracted and both tangs were bent. The feather valve oil tube was attached to the cover and the main housing. The housing and cover were scratched, and gouges were noted on the body at the top of the data plate. The cover attachment screws were sheared, and the cover was separated and was fractured. There was an approximately 0.08-inch diameter circular hole in the cover where a boss housing, the speed adjust lever, lever stop, and worm gear was separated. These parts were recovered. The pilot valve, speeder spring, thrust bearing, air bleed lever assembly, cover gasket, solenoid blanking plate, and electrical connector were missing. Input shaft rotation was limited. The base plate gasket screen was clear.

The relief valve lockwire was missing its lead seal. The remaining relief valve lockwire couldn't be placed relative to screws used in the lock pattern; it was possibly stretched during the impact sequence. The lockwire on the speed adjust lever and the max speed stop screw was altered (field adjustment). All other lockwire was determined Woodward-installed. The torque seal on the eccentric adjuster was intact. The torque seal was missing from the feather valve shaft, but some sealant remained on the hex nut. The reset lever moved freely. The reset lever spring was missing, and the upper section of the post was fractured off/not recovered. The flyweights were free. One ballhead flyweight bearing was missing balls.

Test. Damage to the unit did not permit functional test.

Disassembly. The air bleed orifice was found clear. The feather poppet valve seat showed no wear or markings. There was an indentation on the back side of poppet valve stop. The stop head was cracked and showed an indentation on the brass shim in the cap. This damage was caused by feather valve impact, as evidenced by a bent screw. Both the drive and driven pump gears show witness marks from impact, with resulting shearing of housing material with some loose aluminum chips present. The gear posts and the roller bearing looked normal. The housing damage was consistent with the direction of pump rotation. The beta valve would rotate with resistance and was stuck in the retracted position due to impact to the cap, which interfered with the piston. The technician noted that the cap seemed to have low torque during removal. The gear surfaces showed no markings. The valve packing was present and normal. The spring was normal. The HPRV valve showed no abnormal markings to the hardware and the valve seat. All unit fittings were removed and found clear. The flyweight assembly was taken to Woodward Materials Lab for evaluation of the flyweight bearing with missing balls and retainer. Numerous ball indentations were noted on the races, indicating significant impact loading. Approximately 1/3 of one ball, and part of the retainer was embedded into the outer race.

No evidence of pre-impact failure was found.

9.2.3 OSG S/N 20691859

Receiving inspection. The unit S/N was confirmed. The external surfaces were somewhat dirty (typical) with localized black deposits. Some lockwire was damaged consistent with impact. All remaining lockwire was consistent with Woodward's shop installation pattern. One side of the cover (boss enclosing the speed adjustment mechanism) was deeply gouged, with material displaced; due to damage to the adjuster screw location, it was not possible to determine the torque sealant condition. There was a deep gouge in the main body just above the speed pickup port. The housing and speed adjustment screw were damaged consistent with impact. The reset solenoid coil was separated from the valve body and the connector was missing. There was a large gouge on the side of the reset solenoid. One coil screw head was "smashed" at this location. The feather solenoid was retained by lockwire through a single, partially backed-off screw. Two of the other three retention bolts were fractured and one was missing. The threads in the housing were intact at the missing bolt location and a surface scratch consistent with bolt escape was noted. The input shaft could not be rotated by hand. The drive splines were damaged. The seal was intact. All ports were clean.

Test. Damage to the unit did not permit functional test. The feather solenoid (S/N T2181) was installed on a house OSG unit and functionally tested. It was fully functional.

Disassembly. The connector pins were straight and undamaged. The feather solenoid ports were clear. The packings were present and undamaged. It was decided it was not necessary to remove the reset solenoid when a damaged screw prevented easy removal. The speed sense plug packing was undamaged. The cover flange was bent, and the screws were difficult to remove. One of the screws holes was elongated, and the cover gasket was slightly shredded in this area. Some material consistent with gasket material was found on the governor spring and in the flyweight bore. The pilot valve came away with the cover when the cover was removed. The flyweight assembly was tilted and one of the flyweight pins was extended beyond the carrier by about 0.150 inch. This condition was considered to have been a result of disassembly given there were no markings on the pin to indicate that it had operated in this position. The flyweights were free, and no abnormal wear was noted. The thrust bearing rotated freely. The pilot valve rotated freely after the cover was removed. No abnormal wear marks were noted on the pilot valve or sleeve. The governor spring appeared normal. The sleeve thrust plate appeared in good condition, with no abnormal markings.

No evidence of pre-impact failure was found.

9.2.4 Prop governor S/N 20540237

Receiving inspection. The unit S/N was confirmed. The external surfaces were oily, with localized soot-like deposits. The mounting plate gasket was clean and undamaged. The input drive shaft rotated freely and displayed no spline damage. The speed adjust lever and stop were detached from the cover. Customer linkage was attached at the reset lever. The body displayed no obvious damage. The cover had numerous gouges and was missing an approximately 0.8-inch diameter circle of material where the mounting boss for the speed adjusting lever, speed adjusting shaft and stop assembly was separated. These components were missing. The speed adjusting lever return spring was missing. The governor spring was missing. The reduction gearbox pressure relief tube appeared in good condition. The male threaded portion of the Py fitting was fractured at the

mounting flange and was missing. The electrical connector shell was broken away at its base. The reset lever translated normally and reset to the correct position. The torque seal was intact on the reset lever stop and the eccentric stop. The beta lever translated normally and reset to the correct position. The relief valve cap lead seal was intact. The feather valve drain tube appeared in good condition. The feather valve translated freely. No marks or cracks were noted. The factory torque seal was missing from the feather valve; however, residue was visible indicating that the adjustment remained in the factory position. All ports were clear. The lockwire on the max speed stop screw was altered (field adjustment). All other lockwire was unaltered (Woodward-installed).

Test. Damage to the unit did not permit functional test.

Disassembly. The feather valve fitting was clear and undamaged. Three of the four shorter cover screws were bent. The coil wiring appeared undamaged. The Py air bleed, valve, and orifice appeared normal. The pilot valve OD was clean and unmarked. The pilot valve thrust bearing rotated freely with no roughness noted. The cover gasket was intact and clean. The ballhead cavity was clean. The ballhead rotated freely and the flyweights pivoted normally. All four flyweight bearings were in place. The carbide toes were undamaged. The sleeve ID was unmarked. The Py bleed levers appeared in good condition. Both synchronizer coil wires displayed exposed conductors consistent with being pinched or chafed during assembly or the impact sequence. Resistance at the electrical connector was measured at 149 ohms, which is within CMM limits. It was noted that no arcing was present that would indicate damage during operation. The damaged

wire section with coil was retained for further investigation.[17] The reset lever rotated freely. The reset post and air bleed lever assembly appeared in good condition. All rollers and springs were intact. The clock spring was indexed seven gear teeth, providing the correct tension. No anomalies were noted to the relief valve or the seat. The inner and outer beta valve surfaces were unmarked. Some corrosion was noted on the spacer, possibly resulting from fire suppression chemicals. The high pressure oil pump components were unmarked.

No evidence of pre-impact failure was found.

9.2.5 OSG S/N 20691854

As-received inspection. The serial number was confirmed. The external surfaces were oily, with localized soot-like deposits. The drive shaft could be rotated by hand. All ports were clean. The cover exhibited minor nicks and scratches on the cover. The torque seal was broken at the rpm adjustment and the adjustment screw was repositioned clockwise approximately 1/8 turn clockwise. All other lockwire was characteristic of Woodward and was intact.

Test. The unit was installed on a test bench and a functional test was performed. The max speed was out of range (high). All other test points were within limits. The reset speed was higher than

[17] Woodward modified a house unit to evaluate the possible displacement of the coil plate in the absence of normal spring loading. They confirmed that loss of spring pressure should the input lever and spring be liberated during the impact will allow the coil plate to translate beyond its normal range, and that this can result in the wires being pinched. The spring load prevents this from occurring during normal operation.

that reflected in the manufacturing acceptance test (2016). See Attachment B.[18] The max speed adjustment screw was turned, shifting both the max speed and the reset speed test point until the as-shipped values per the 2016 ATP results were achieved. The adjustment screw position was then observed to be aligned with the factory-applied torque sealant. See Attachment C.

Disassembly. The powerplants group agreed that disassembly inspection was not required.

E. ATTACHMENTS

Attachment A	FCU S/N 20565991 Investigation Acceptance Test Sheets January 15, 2020
Attachment B	OSG S/N 20691854 Production Acceptance Test Sheets November 22, 2016
Attachment C	OSG S/N 20691854 Investigation Acceptance Test Sheets January 14, 2020

Carol Horgan
Powerplants Group Chair

[18] The test points to compare are 3.5 (max speed setting) and 3.9 (reset speed setting). Note that, although the Woodward production ATP and field return ATP formats differ, the testing is the same.