

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

April 29, 2013

POWERPLANTS GROUP CHAIRMAN'S FACTUAL REPORT

NTSB ID: CEN13FA049

A. ACCIDENT

Location: Wichita, Kansas

Date: November 6, 2013

Time: 0745 Central Standard Time (CST)

Aircraft: Cessna 208B, Registration No. N793FE, operated by Baron Aviation Services/Federal Express

B. POWERPLANTS GROUP

Chairman: Carol Horgan
National Transportation Safety Board
Washington, D.C.

Member: Bobby D. Warren
Federal Aviation Administration
Wichita, Kansas

Member: Ricardo Asensio
Cessna Aircraft Company
Wichita, Kansas

Member: Clive Adams
Baron Aviation
Vichy, Missouri

Technical Advisor to the Transportation Safety Board of Canada:

Jeff Davis
Pratt & Whitney Canada
Bridgeport, West Virginia

C. SUMMARY

On November 6, 2012, about 0745 CST, a Cessna model 208B airplane, N793FE, was substantially damaged when it collided with a hedgerow during a forced landing following a loss of engine power near Wichita, Kansas. The loss of engine power occurred about 4-1/2 minutes after departing Wichita Mid-Continent Airport (KICT), Wichita, Kansas. The commercial pilot, who was the sole occupant, was fatally injured. The airplane was registered to the Federal Express Corporation and operated by Baron Aviation Services Incorporated, under the provisions of 14 Code of Federal Regulations Part 135 while on an instrument flight plan. Day visual meteorological conditions prevailed for the cargo flight that had the intended destination of Garden City Regional Airport (KGCK), Garden City, Kansas. Radar data indicated that the airplane departed runway 19R at approximately 0737. The airplane climbed on a westerly heading until 0742, when the pilot transmitted that his airplane had experienced a loss of engine power and that he was attempting to return to the departure airport. The pilot then asked if there were any nearby airports because he was unable to reach KICT. The departure controller provided vectors toward an airstrip that was approximately 2.5 miles southeast of the airplane's position. At 0743 the pilot advised that he could not see the airstrip because the airplane's windshield was contaminated with oil. At 0744, the pilot transmitted that he was landing in a grass field. See Figure 1. Radar contact was lost at 0745, about 2.2 miles south of KICT.



Figure 1. Accident site

An analytical disassembly of the engine found that one compressor turbine (CT) blade had failed in fatigue. The root cause of the fatigue could not be determined because a critical area of the fracture surface was missing due to secondary damage. The remaining CT blades exhibited

overload fractures. The power turbine (PT) displayed severe asymmetrical damage and there was localized No. 3 bearing air seal scoring. The PT shaft housing was fractured adjacent to the reduction gearbox (RGB) mating flange and oil was found on the downstream side of the power turbine disk, indicating that oil entered the engine gas path in this area. As a result of the damage, the engine was not capable of producing power.

D. DETAILS OF THE INVESTIGATION

1.0 Engine information

1.1 Engine service history

The airplane was powered by one Pratt & Whitney Canada (PWC) PT6A-114A, serial number (S/N) PCE-17282, manufactured in August, 1988. Review of the aircraft service records found that the engine had 13,467 hours since new (TSN) and 12,499 cycles since new (CSN), and 5,516 hours and 4,793 cycles since overhaul. The last overhaul was performed by Pratt & Whitney in Bridgeport, West Virginia on April 12, 2001.

PWC's review of engine overhaul records found that the CT disk and blades were inspected by Pratt & Whitney Engine Services on April 12, 2006 at 4,999 TSN and 5,747 CSN. The parts were installed new in engine PCE-17282 by The Hangar Inc on July 17, 2006, at engine 10,586.9 TSN and 9,774 CSN. At the time of the accident, the CT blades had accumulated 7,880 hours and 8,473 cycles since new.

1.2 Engine description

The PWC PT6A-114A is a turbopropeller engine rated at 675 takeoff shaft horsepower. The gas generator features a three-stage axial, single-stage centrifugal compressor, a reverse annular-type combustion chamber, and a single stage compressor turbine (CT). A single-stage PT drives a reduction gear assembly and power output drive flange.

2.0 On site documentation

The engine remained attached to the airplane by one mount, cabling, and tubing. See Figure 2. No evidence of fire or uncontainment was found. The propeller shaft flange was twisted/deformed aftward¹ at 9 o'clock²; 2 bolts and 1 alignment pin were liberated. The engine serial number was confirmed from the data plate. The connecting rod for the emergency power lever was fractured at the fuel control, adjacent to the jam nut. The aircraft throttle connection rod was fractured adjacent to the jam nut. The aircraft linkage to the propeller governor was intact and in the feather position. The oil cooler was fractured.

¹ All references to position are aft looking forward unless otherwise noted.

² O'clock refers to approximate circumferential locations in a clockwise direction, viewed from the rear of the engine looking forward.



Figure 2. Engine, right hand view

The propeller had separated from the engine, and was found approximately 80 feet northeast of the airplane.³ See Figure 3.



Figure 3. Propeller

³ The propeller condition is documented separate from this report.

3.0 Engine disassembly inspection

The engine was removed from the wreckage and transported to Yingling Aviation, Wichita, Kansas, for further investigation. See Figures 4 through 7.



Figure 4. Engine, right side view



Figure 5. Engine, viewed from front



Figure 6. Engine, left side view



Figure 7. Engine, rear view

3.1 External engine inspection

There were no case ruptures. The RGB was unremarkable. The propeller governor showed some external gouging but was otherwise intact. The overspeed governor was intact except for a fractured cannon plug. The static oil pressure tube was loose, 1 full turn plus 1 flat. The oil cooler supply and return hoses were pressurized with shop air and no leaks were noted. An ultraviolet (UV) light RGB inspection found oil residue in several locations. See Figure 8.



Figure 8. Oil residue fluorescing under UV light

The RGB main oil pressure tube O-ring was found displaced from its groove. See Figure 9.

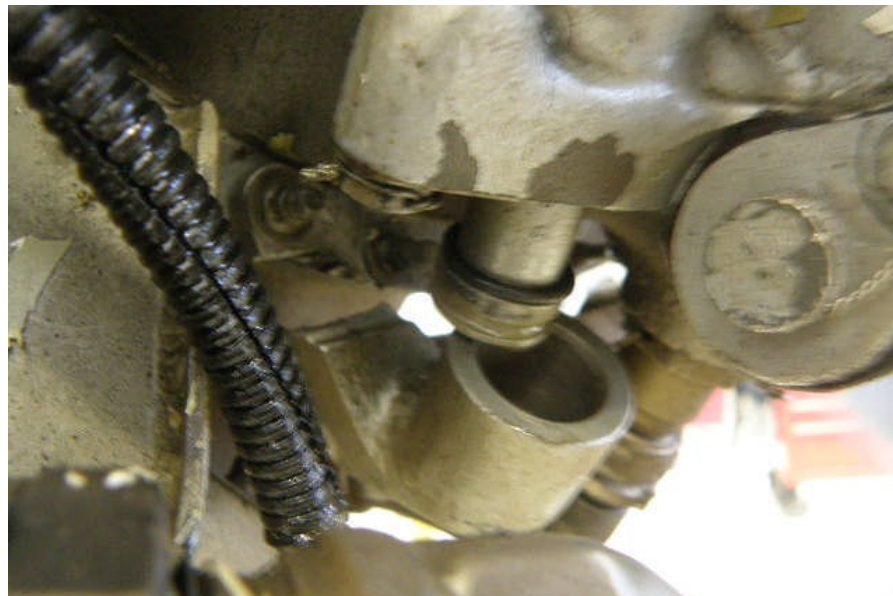


Figure 9. RGB pressure tube O-ring displaced

The inlet case was intact. The inlet screen and fairing were buckled and distorted. The compressor bleed valve was intact.

The exhaust duct exhibited some dimpling/deformation.

The gas generator case was buckled adjacent to the fuel nozzles, 360° around. See Figure 10. The fuel nozzles were intact and appeared in good condition.

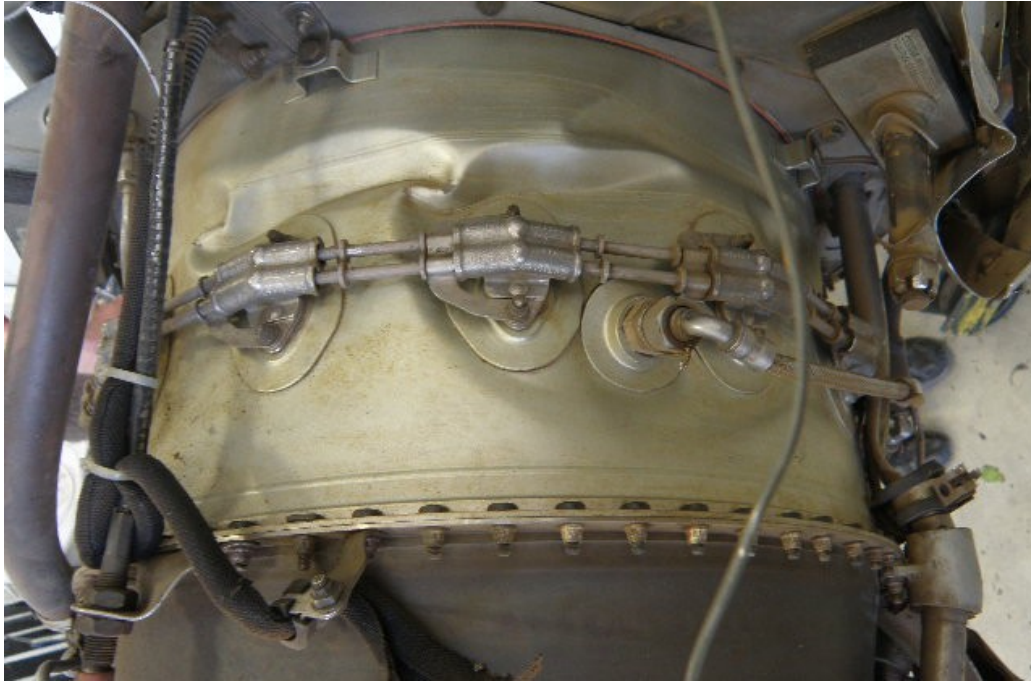


Figure 10. Gas generator case buckling damage

The accessory gearbox (AGB) was unremarkable except for a fracture at the external oil scavenge pump mounting flange. The fuel control had one bent bracket. The fuel control, fuel pump, and fuel/oil heater were in good condition.

The rod between the fuel control unit and the cam box was intact and lock wired. See Figure 11. The connection cable between the cam box and the propeller governor was bent on both ends, but was intact and lock wired. The rod between the reset arm and the beta arm was bent but intact. The beta arm was intact. See Figure 12.



Figure 11. Fuel control unit-to-cambox linkage



Figure 12. Reset arm-to-beta arm rod

The compressor discharge pressure (P3) tubes and filter housing were intact but were bent at several locations. The power turbine control (Py) tubes were intact and secured.

Approximately 85 oz. of oil was recovered from the oil tank; an additional 4 oz. was recovered when the AGB chip detector was removed. Approximately 6 oz. of oil was recovered from the RGB when the chip detector was removed.

The RGB chip detector was bridged and showed a buildup of ferrous material. The AGB chip detector showed a small amount of ferrous material but was not bridged. See Figure 13. A small amount of metal particles was found in the oil filter. The main fuel filter element was clean. The fuel pump inlet filter screen/strainer showed some minor contamination.

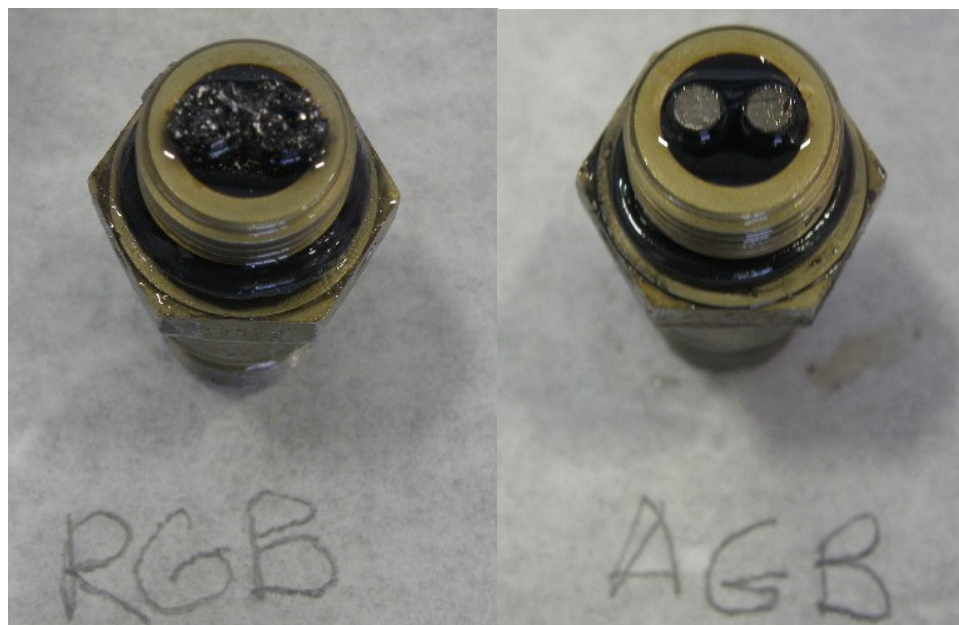


Figure 13. RGB and AGB chip detectors

4.0 Engine disassembly observations

4.1 Compressor

As viewed through the inlet, the 1st stage compressor blades exhibited some minor erosion and the 1st stage compressor shroud showed some circumferential scoring. No foreign object damage was noted. See Figure 14. When turned at the N1 tachometer drive pad, the compressor and the accessory drive train rotated freely, with no unusual sounds noted. The compressor section was not disassembled.



Figure 14. 1st stage of compressor viewed through the engine inlet

4.2 Combustion section

The combustor chamber liner showed minor buckling damage but was otherwise in good condition. See Figure 15. The large exit duct was unremarkable except for one localized heat deformed area at 10 o'clock. The small exit duct had some erosion at the cooling holes but was otherwise unremarkable.

4.3 Turbine section

4.3.1 Compressor turbine

4.3.1.1 CT guide vane ring

The CT guide vane ring exhibited minor erosion at the airfoil leading edges (LEs); the airfoil trailing edges (TEs) were severely battered with numerous deep impact marks and missing material. See Figure 16. The compressor turbine vane inner drum displayed a light rub between 4 and 7 o'clock.



Figure 15. Combustion liner

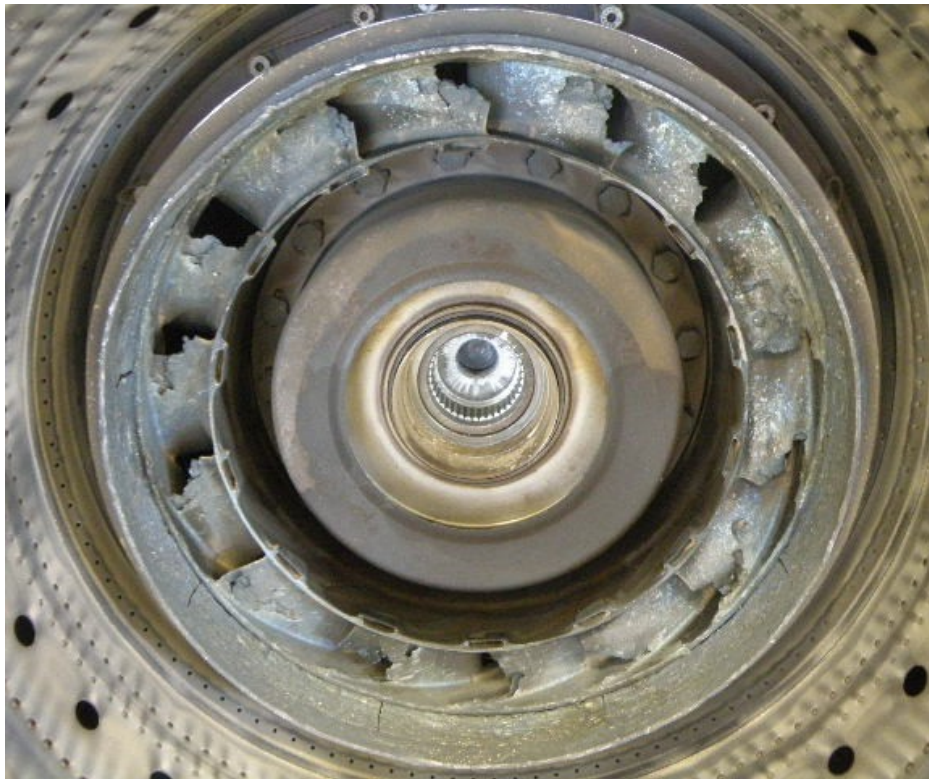


Figure 16. Compressor turbine vane ring showing extensive airfoil TE damage

4.3.1.2 CT shroud

The CT shroud segments were severely battered with numerous deep impact marks. See Figure 17.

4.3.1.3 CT disk assembly

All of the CT blades were fractured at various heights, from just above the platform to approximately 75% of blade height. See Figure 17.

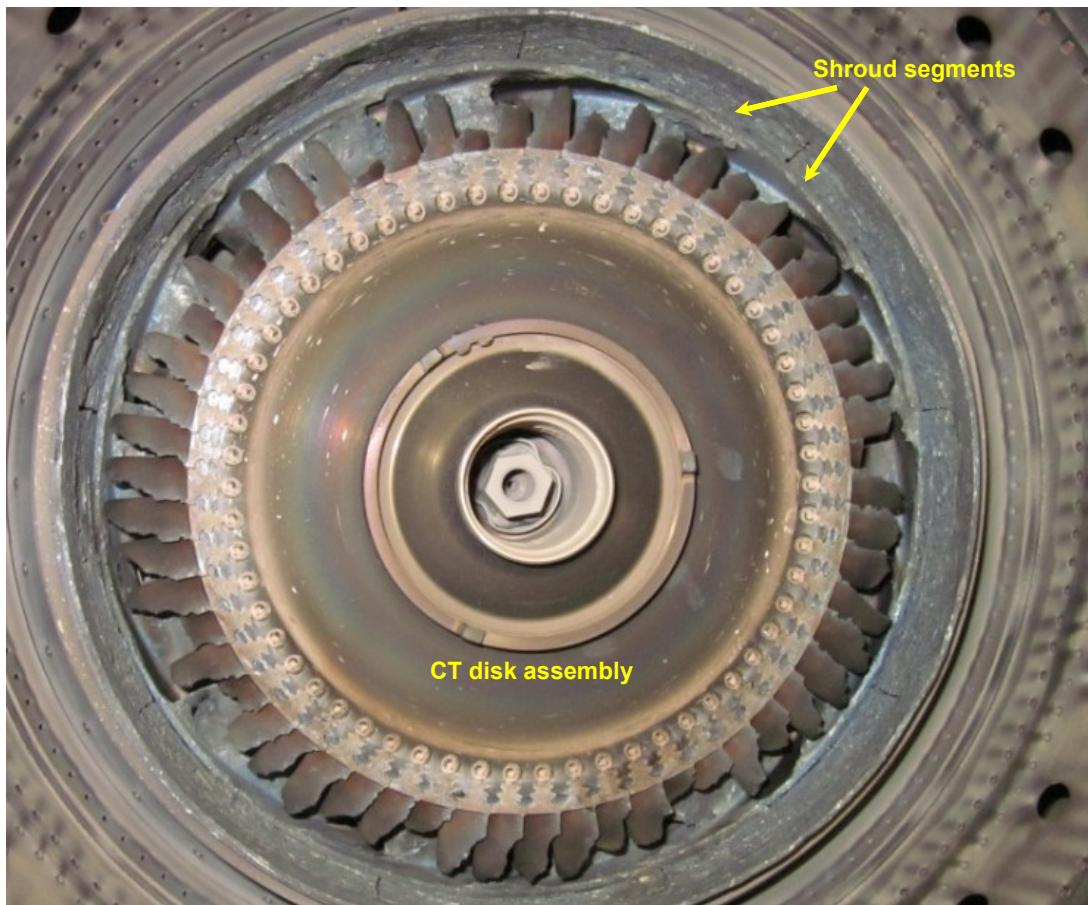


Figure 17. View of severe CT blade material loss and battered shroud segments

The fracture surface of one CT blade (“blade 1”) was flat and featureless from the TE to approximately mid-span, and was rough and dimpled from midspan to the LE. See Figure 18.

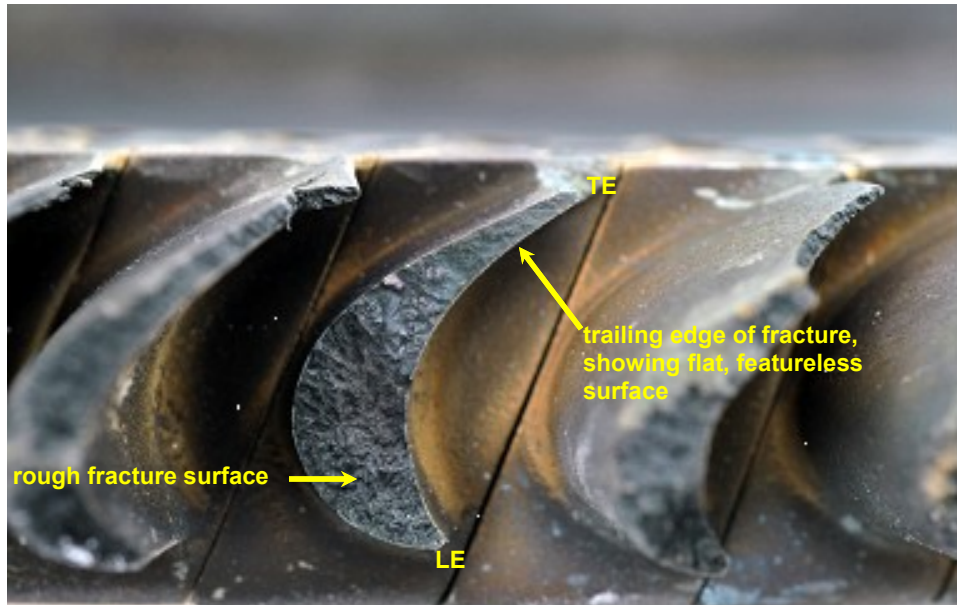


Figure 18. CT "blade 1" fracture surface

There were very light contact marks on the downstream platform and face of the disk, 360° around, consistent with rubbing contact with the PT vane baffle or with blade debris during operation.

One random blade was removed and the part number (P/N) was 3102401-01.

4.3.2 ITT system

The ITT probes were sheared; the harness and the busbar were unremarkable.

4.3.3 Power turbine

The power section was partially disassembled.

4.3.1.1 PT guide vane ring and interstage baffle

The PT vane ring airfoil LEs exhibited impact damage and erosion. The TE's were heavily battered with missing material, and coated with metal splatter. The upstream baffle lugs had rotated out of position and were scored consistent with rubbing contact with the downstream side of the CT disk and blade platforms. See Figure 19. The downstream baffle face was heavily scored with missing material consistent with rotational contact. See Figure 20.



Figure 19. Upstream side of the PT vane assembly showing baffle lug scoring



Figure 20. Power turbine vane assembly downstream side showing heavy scoring along the baffle face

4.3.1.2 PT shroud

The PT shroud was heavily battered and the exhaust duct locating flange was distorted. See Figure 21.



Figure 21. PT shroud and exhaust duct

4.3.1.3 PT disk assembly

The PT disk assembly showed severe asymmetrical damage, with 28 adjacent blades fractured at varying heights and the remaining 13 consecutive blades at full height. See Figure 22. All of the blade fracture surfaces had a rough, dimpled appearance. The shrouds of the 13 full-height blades showed severe rotational scoring, consistent with contact during operation.



Figure 22. PT disk assembly showing severely localized blade loss

All of the PT blades were slightly loose in their rivet slots. The blade LEs, platforms and the center bore of the disk showed rotational scoring consistent with contact with the PT guide vane ring and interstage baffle. See Figure 23. The downstream side of the disk was oil-wetted. The No. 3 bearing air seal exhibited localized scoring opposite the arc of severe blade material loss. See Figure 24.

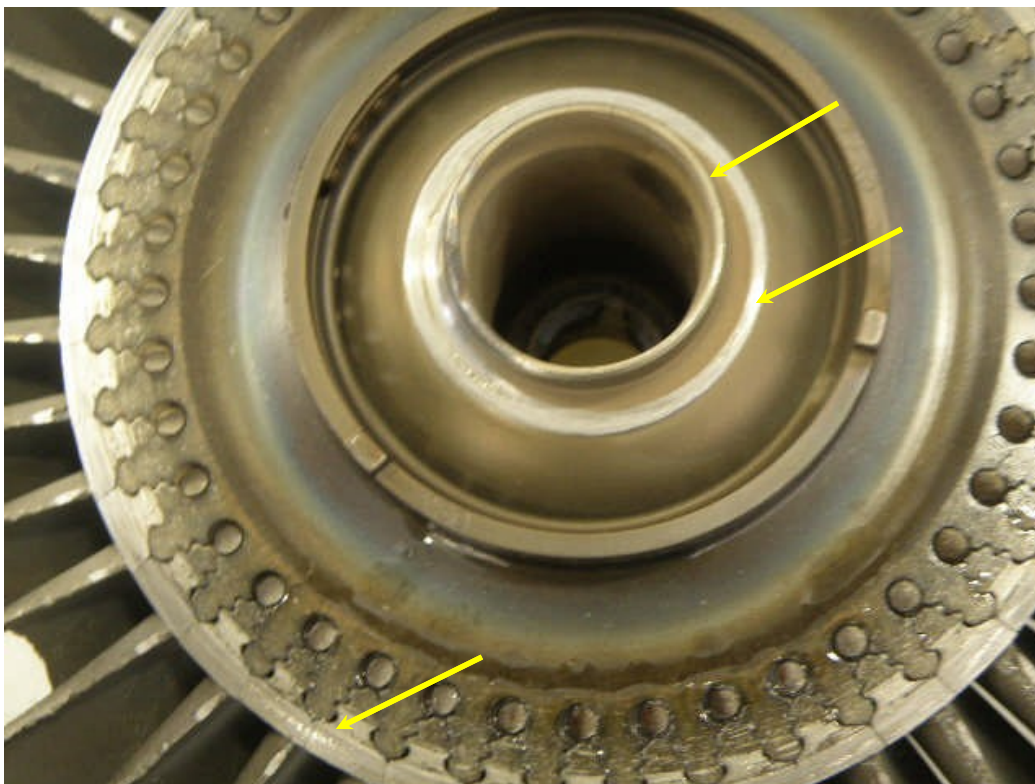


Figure 23. PT disk assembly showing rotational scoring on blades and disk

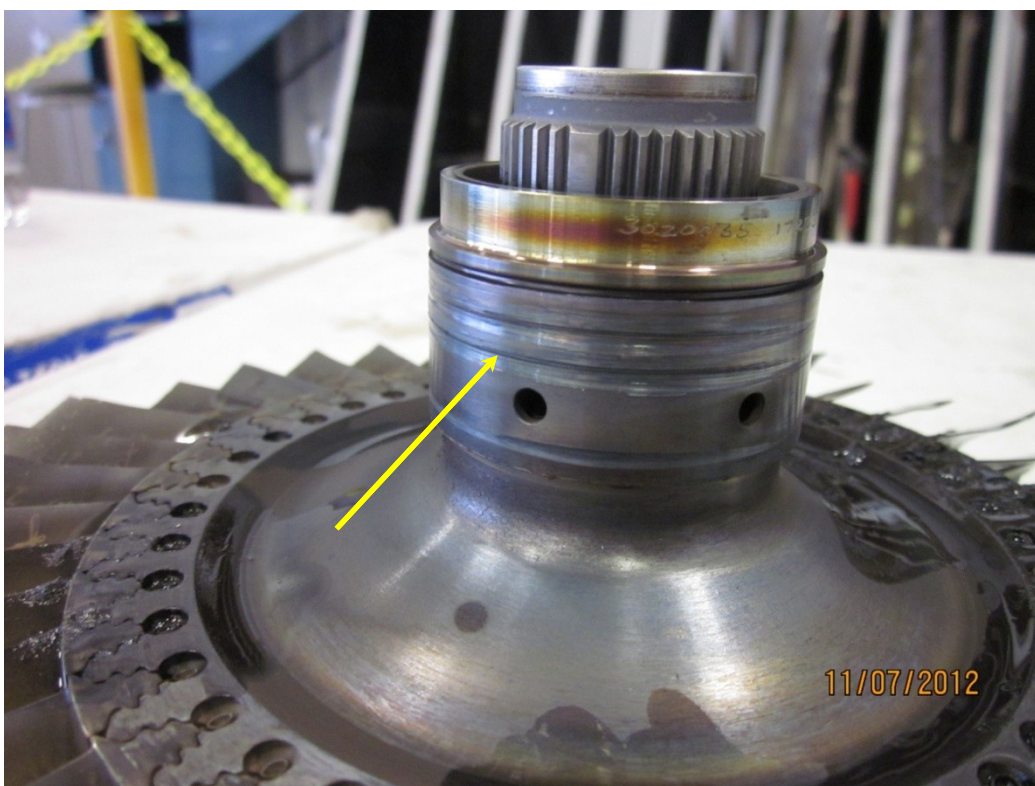


Figure 24. PT disk showing localized scoring at air seal

4.3.2 PT shaft and shaft housing

The PT shaft housing was fractured and separated adjacent to the RGB mating flange. See Figure 25.



Figure 25. PT shaft housing and rear RGB showing fracture

The No. 3/No. 4 bearing scavenge tube was fractured and the pressure tube was found out of position, consistent with housing rotation. Air was applied to the supply end of the pressure tube and no nozzle obstruction was noted. The PT shaft was heat discolored in the area of the No. 3 bearing. The No. 4 bearing was oil wetted and rotated freely. The No. 3 bearing was oil wetted and rotated freely but showed some cage plating delamination and local heat discoloration typical of some loss of lubrication. See Figure 26.

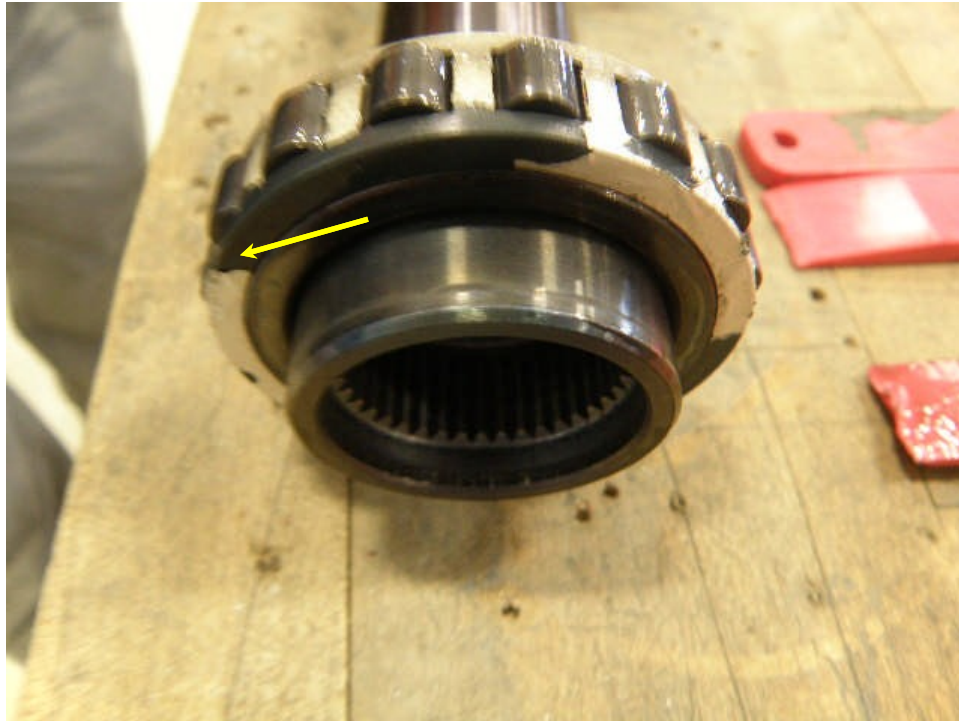


Figure 26. No. 3 bearing on PT shaft, showing delamination of cage plating

4.4 Reduction gearbox

The RGB was not disassembled. The RGB housing rear face showed heavy 360° rotational scoring. The first stage sun gear was circumferentially scored and there were metal shavings on its surface. The first stage sun gear splines showed some abnormal wear. Both the 1st and 2nd stage planet gears rotated freely, with no evidence of heat tinting or oil starvation. A large amount of metal slivers and particles were found inside the rear housing. See Figure 27.

4.5 Propeller shaft

The propeller shaft was not removed. The propeller attachment flange was deformed and was fractured at two bolt holes and one alignment pin. The propeller shaft seal showed no abnormal wear.

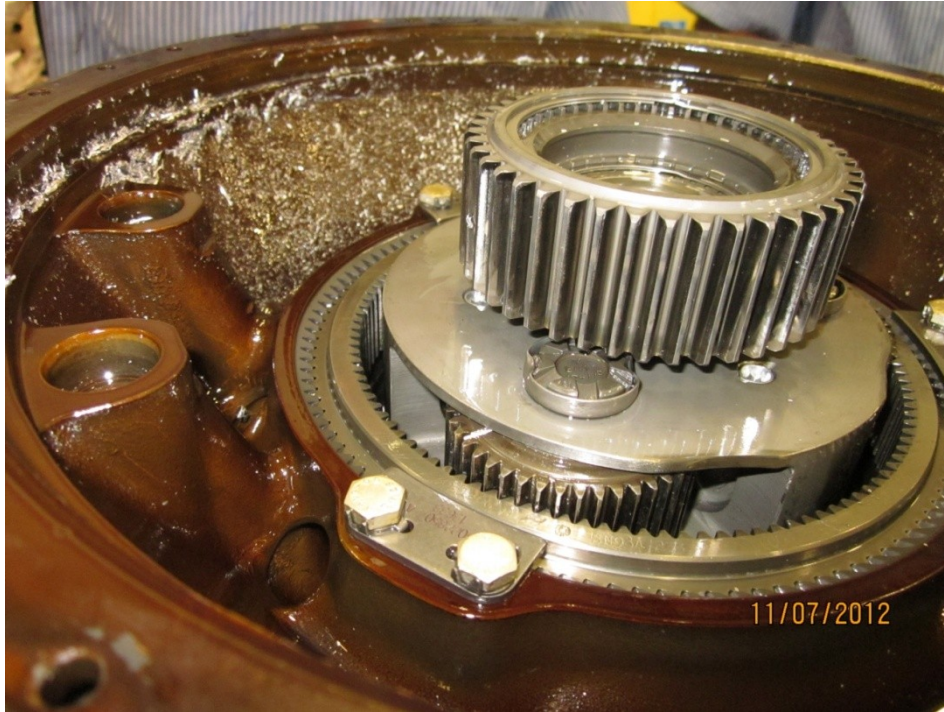


Figure 27. Metal contamination in the rear RGB housing

E. ENGINE MONITORING UNIT

The airplane was equipped with a Pratt & Whitney Engine Services Aircraft Data Acquisition System Plus (ADAS+) engine monitoring unit model EMU-A-010-3, S/N 1766. The ADAS+ records eight hours of flight data. The unit was downloaded at Pratt & Whitney Engine Services in Boston, Massachusetts. Analysis of the data by PWC found no abnormal parameter trends. All engine parameters increased slightly in the 4 seconds prior to the engine failure.

F. MATERIALS INVESTIGATION

The CT disk assembly and the PT shaft and shaft housing were submitted to PWC for materials analysis. The parts were examined at a PWC laboratory in Longueil, Quebec on November 21, 2012, with oversight by the Transportation Safety Board of Canada.

1.0 CT disk and blades

Metallurgical examination of CT “blade 1” revealed a fatigue fractures emanating from the TE area and progressing along the blade chord line to approximately mid-chord, where a mixture of fatigue and tensile overload fatigue cracking was observed. The remainder of the fracture was consistent with tensile overload. Scanning electron microscope (SEM) examination revealed oxidation on the fracture surface from exposure to hot gases and river lines indicating the direction of the fatigue crack propagation. The blade TE was damaged and an approximate 0.060-inch section including the fatigue initiating point was missing. However, the TE initiation suggested that the crack was most likely due to high cycle fatigue. Microscopic examination of

this area determined that the TE damage was caused by impact damage. Several other blades showed similar impact damage at the TE. See Figure 28.

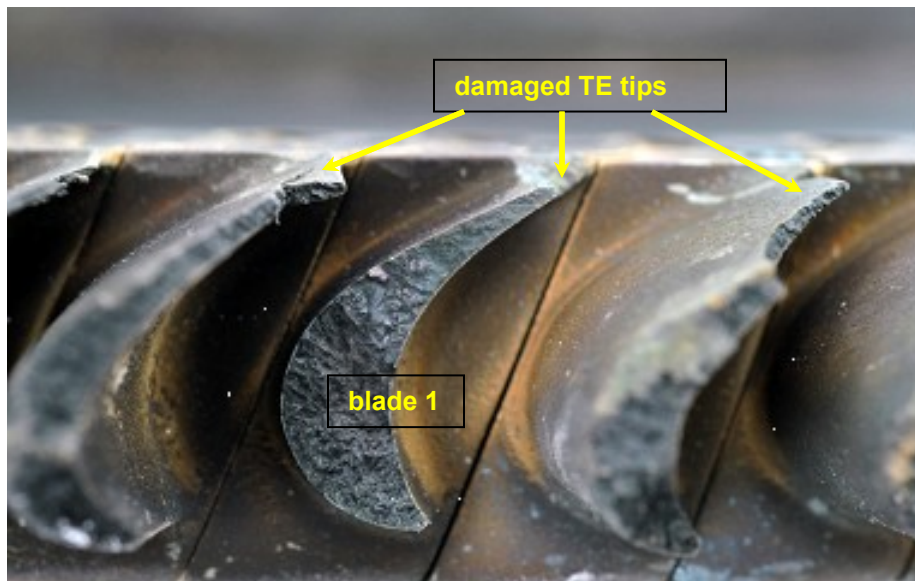


Figure 28. CT blade TE damage. Photograph courtesy of Pratt & Whitney Canada

No material defect or evidence of creep was found. Although the TE thickness of CT “blade 1” could not be measured at 0.050” from the TE due to the secondary impact damage, the airfoil thickness was measured at the beginning of the fracture and was found to be consistent with the drawing requirements. Energy dispersive spectrometry (EDS) analysis found that its chemical composition met the drawing requirements. No evidence of hot corrosion was noted on the blades or in the disk serrations.

None of the other blades exhibited similar cracking. All of the cracks observed on the remaining blades were the result of impact secondary to the initial blade fracture.

Examination of the CT disk found no evidence of damage that could have contributed to the fatigue fracture.

2.0 PT shaft housing

Most of the PT shaft housing fracture could not be analyzed, due to damage caused by relative movement between the fracture surfaces; however, a small portion of the flange section was in good condition. Metallurgical examination of this area revealed multiple fatigue cracks initiating at the outside diameter of the flange and propagating toward the inside diameter. A SEM examination of the fatigue showed striations that were not well defined, indicating the housing was subjected to low cycle fatigue. Hardness testing and EDS found that the material met the drawing requirements for chemical composition and hardness.

3.0 Engine oil cooler

The oil cooler removed from the accident airplane was examined by the NTSB materials laboratory in Washington, DC on January 11, 2013 for evidence of fatigue at the fractures. See Figure 29. Microscopic and SEM examination of the plenum fractures found no crack arrest marks or ratchet marks that would indicate progressive cracking.⁴

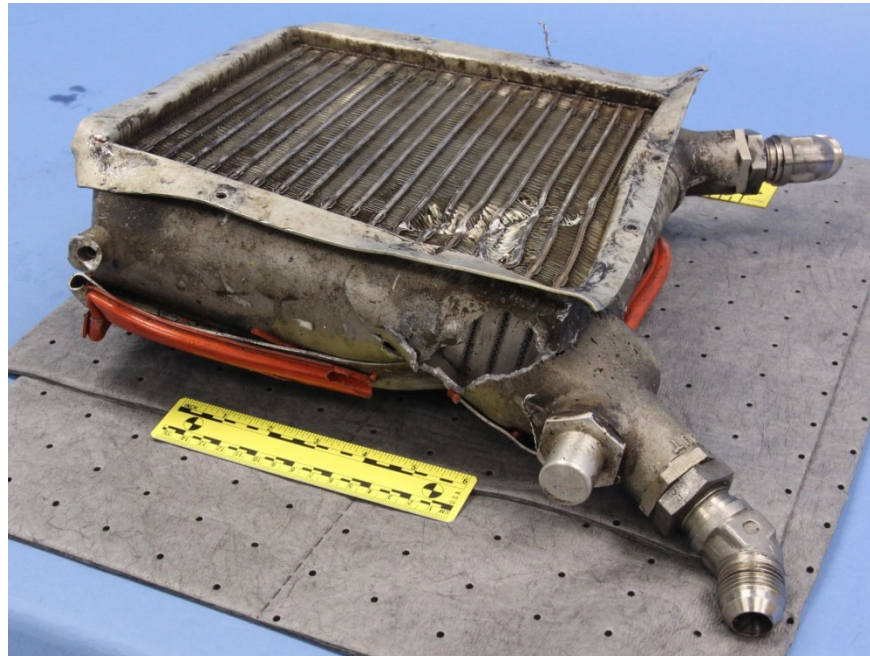


Figure 29. Oil cooler

Carol Horgan
Powerplants Group Chairman

⁴ For additional information, see NTSB Case No.CEN13FA049 Materials Laboratory Factual Report of Group Chairman.