

National Transportation Safety Board

Office of Aviation Safety

Washington, DC 20594



WPR23LA338

POWERPLANTS

Group Chair's Factual Report

March 18, 2025

TABLE OF CONTENTS

A. ACCIDENT	3
B. POWERPLANTS GROUP	3
C. SUMMARY	4
D. DETAILS OF THE EXAMINATION.....	5
1.0 Engine Description	5
2.0 Engine Maintenance History	6
3.0 Engine Examinations	6
3.1 Left (No. 1) Engine (s/n CP-PS 60529).....	6
3.2 Right (No. 2) Engine (s/n CP-PS 72332)	20
3.3 Combining and Accessory Gearbox Components	33
4.0 Power Turbine Blade Metallurgical Examination.....	35
E. ATTACHMENTS	35

A. ACCIDENT

Location: Balch Camp, California, USA
Date: September 9, 2023
Time: 13:45 Pacific Daylight Time
Helicopter: Bell 212, Registration N873HL
NTSB IIC: Stephen Stein

B. POWERPLANTS GROUP

Group Chair	Stephen J. Yee National Transportation Safety Board Washington, D.C., USA
Group Member	Matt McLuckie Bell Fort Worth, Texas, USA
Group Member	Barbara Caufield Federal Aviation Administration Burlington, Massachusetts, USA
Accredited Representative (Canada)	Helen Tsai Transportation Safety Board of Canada Ottawa, Ontario, Canada
Technical Advisor (Canada)	Merryn Spielman Pratt & Whitney Canada Longueuil, Quebec, Canada

C. SUMMARY

On September 9, 2023, about 1345 Pacific Daylight Time, a Bell 212 helicopter, registration number N873HL, was destroyed when it was involved in an accident near Balch Camp, California. The pilot was seriously injured. The airplane was operated as a Title 14 *Code of Federal Regulations* Part 133 firefighting flight.

The National Transportation Safety Board (NTSB) did not travel to the accident site. Based on ground witness video provided to the NTSB by the United States Forest Service (USFS), the accident helicopter did not experience an inflight breakup prior to contacting trees. Photographs of the accident site provided by USFS showed the helicopter experienced a postcrash fire that consumed large portions of the wreckage. Red-colored fire retardant was visible on portions of the wreckage, which was applied on the wreckage due to the postcrash fire.

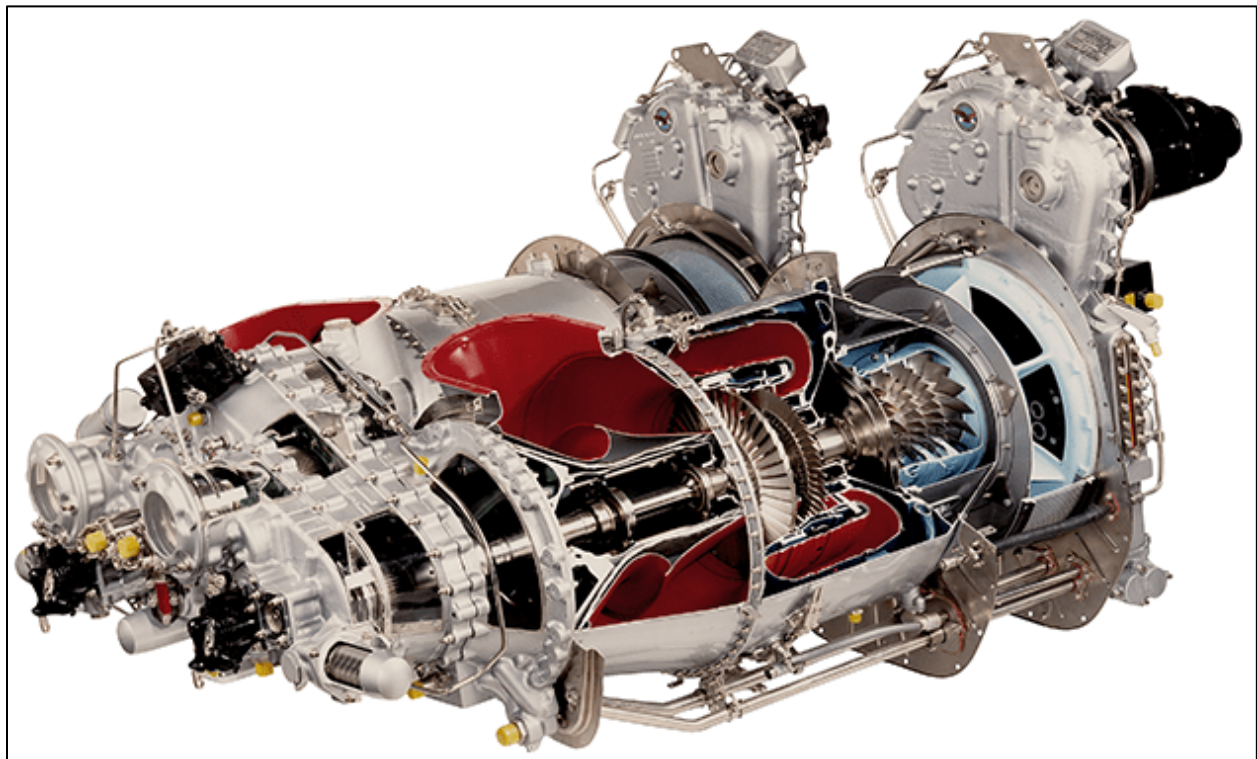
Examinations of the accident engines were completed at the Pratt & Whitney Canada (PWC) facility in Longueuil, Quebec, Canada from March 5-7, 2024. Participants from the NTSB, Federal Aviation Administration (FAA), Pratt & Whitney Canada PWC, and Bell attended the exams.

D. DETAILS OF THE EXAMINATION

All directional and numbering references (front, rear, right, left, top, bottom, clockwise, counterclockwise) are made aft-looking-forward unless otherwise specified. References to clock positions, directions, and lengths are approximate.

1.0 Engine Description

The accident helicopter was powered by one PWC PT6T-3B¹ Twin-Pac® (Figure 1). The Twin-Pac® installation has two PT6 engines coupled together by one combining gearbox that drives the aircraft main rotor transmission and various engine sensing and indicating components. Each engine has a three-stage axial and one-stage centrifugal compressor driven by a single-stage compressor turbine (CT), a reverse-flow annular combustor, a free-turning², single-stage power turbine (PT), and an accessory gearbox.



(Source: Pratt & Whitney Canada)

Figure 1. Cutaway of the PT6T engine

¹ The letter "T" in the model number (-6T) denotes a Twin-Pac® installation.

² The power turbine is free to rotate independent of the compressor turbine operation.

According to FAA Type Certificate Data Sheet E22EA, Revision 15, dated December 20, 2012, the PWC PT6T-3B engine has a maximum continuous power output of 1,600 shaft horsepower (shp) and a maximum takeoff power output of 1,800 shp, flat-rated to 71.6°F (22°C).

2.0 Engine Maintenance History

According to PWC, the left (No. 1) engine, serial number (s/n) CP-PS 60529, was manufactured in March 1974. The right (No. 2) engine, s/n CP-PS 72332, was manufactured in September 1977.

On October 19, 2017, Mint Turbines in Stroud, Oklahoma completed an overhaul of engine s/n CP-PS 60529. The engine had accumulated 20,522.6 hours time since new (TSN) and 20,343 cycles since new (CSN) at the time of overhaul. Mint Turbine's records showed the PT disk, s/n 36A881, was part of this engine since at least August 24, 1998.

On January 26, 2021, the operator's maintenance records showed engine s/n CP-PS 60529 had accumulated 20,787.8 hours TSN and 20,617 CSN, and engine s/n CP-PS 72332 had accumulated 5,304.5 hours TSN and 6,509 CSN. No records of engine ownership were found prior to this date.

On August 31, 2023, the last recorded engine maintenance performed by the operator prior to the accident flight was a 25-hour inspection on both engines with no defects noted.

Maintenance records showed the operator completed 14 engine inspections between February 7, 2022 and August 31, 2023 with no defects noted at any inspection. Aircraft flight total time between these dates was 191.6 hours. No records of engine maintenance were found prior to February 7, 2022.

On September 4, 2023, engine s/n CP-PS 60529 had accumulated 21,071.2 hours TSN and 20,978 CSN and engine s/n CP-PS 72332 had accumulated 5,587.9 hours TSN and 6,872 CSN. These were the last recorded values prior to the accident flight.

3.0 Engine Examinations

3.1 Left (No. 1) Engine (s/n CP-PS 60529)

The left engine was secure in a wooden box (Figure 2). According to the engine data plate, the left engine was s/n CP-PS 60529 but its box was mislabeled "s/n 72332" (Figure 3). The accessory gearbox's internal components were in a separate bag inside the box.



Figure 2. Box mislabeled as "s/n 72332" containing the left engine, s/n CP-PS 60529

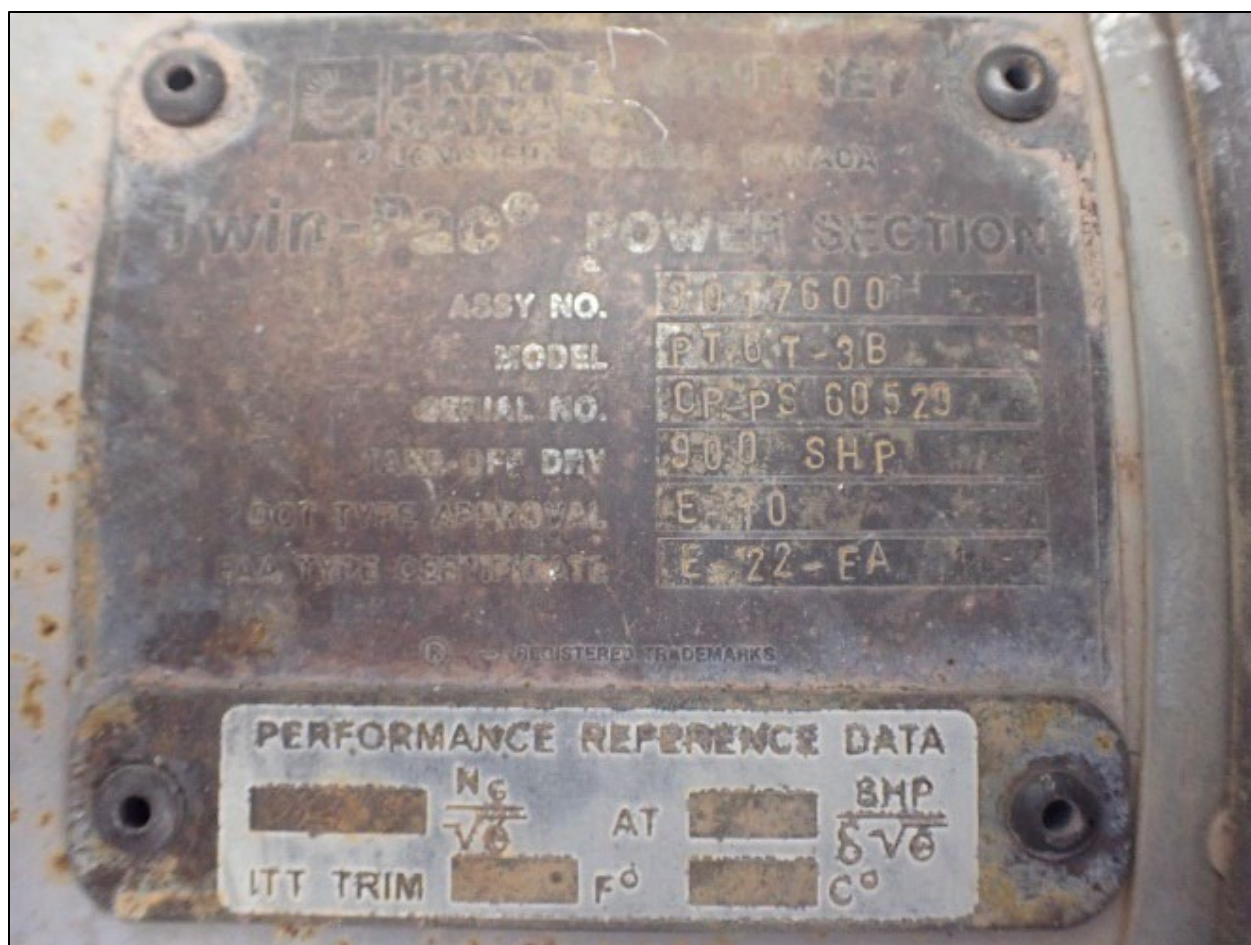


Figure 3. Left engine data plate

The engine's external surfaces from 2 to 6 o'clock were coated white along the entire length of the engine (Figure 4). The gas generator case had a dent and small tear at 5 o'clock but had no evidence of uncontainment (Figure 5). All visible external tubes and wirings had post-crash damage such as bends and breaks.

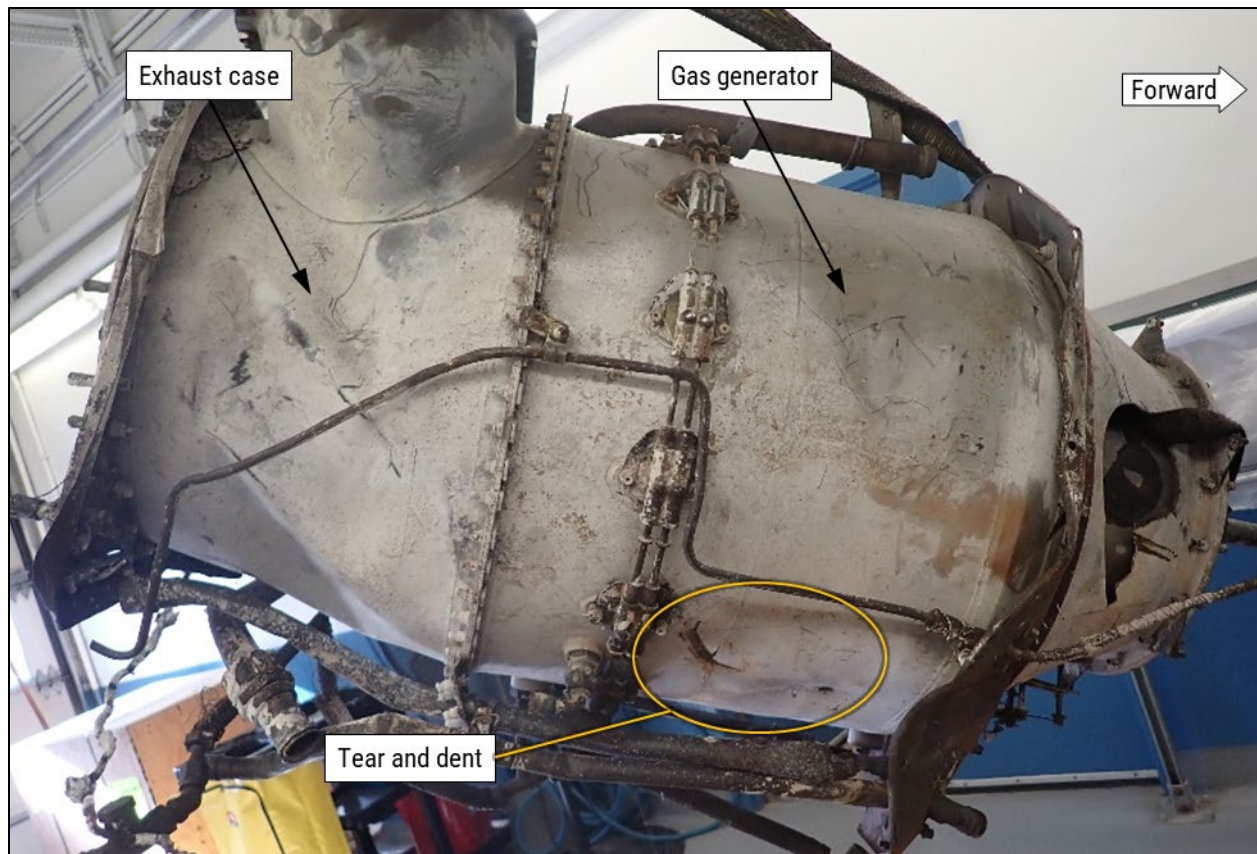


Figure 4. Right side of left engine



Figure 5. Tear and dent in left engine's gas generator case

The inlet screen, inlet case, front oil tank, bleed valve, and accessory gearbox housing were missing. Remnants of the magnesium inlet case were still attached to the front inlet case mating surface. The front of the stage 1 compressor blades appeared full length, bluish in color, and the airfoil surfaces were coated white when viewed through the inlet. The compressor section could not be rotated by hand. The front fire shield was thermally damaged, bent forward at 7 o'clock, and bent aft at 4 o'clock (Figure 6). The front cone of the gas generator case at 9 o'clock was torn (Figure 7).



Figure 6. Front of left engine



Figure 7. Tear in gas generator case

The combining gearbox was missing, but 22 connecting bolts (of 23 total) that secured the gearbox to the exhaust case flange were still present and molten metal was adhered to the flange. The rear fire shield was thermally damaged all around, bent forward at 7 o'clock and bent aft at 4 o'clock. The bottom half of the exhaust case was angularly buckled, most pronounced from 3 to 6 o'clock. The exhaust case had a burned through hole at 7 o'clock near the gearbox mating flange (Figure 8).

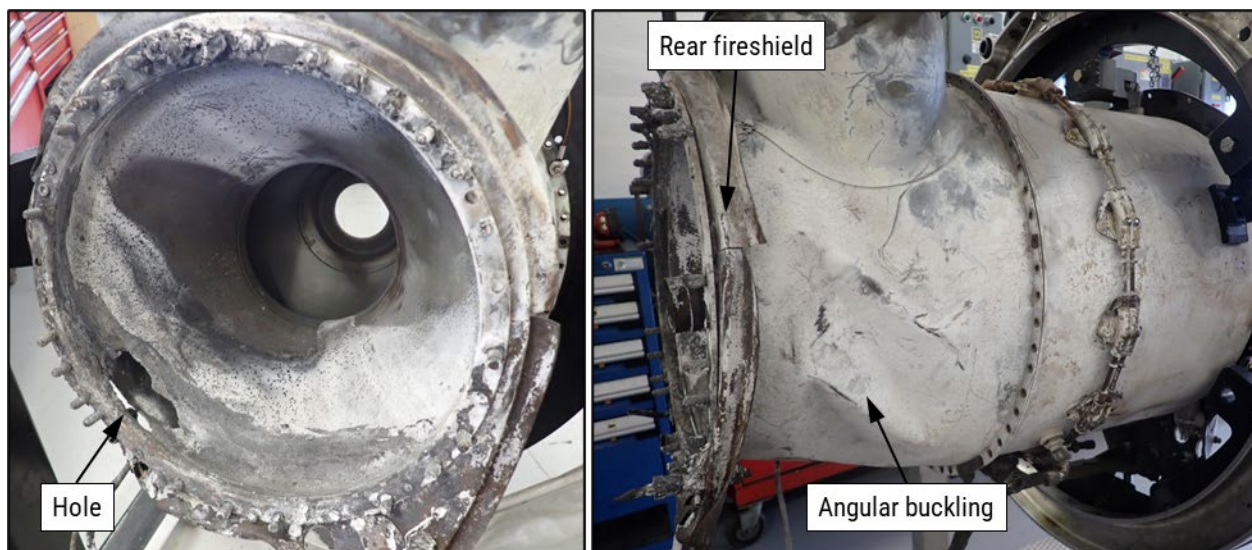


Figure 8. Left engine exhaust case damage

Looking through the exhaust port, the PT blades that were visible all had fractured transversely across the airfoils. The PT spool was loose, unsupported, and could not be rotated.

The PT stator housing was intact and its exterior surfaces had rust spots. The PT outer blade airseal shroud was deformed radially outward and stuck within the stator housing. A portion of the airseal shroud at 9 o'clock was rubbed away and missing and what remained of the airseal grooves were rubbed away 360° around. The stuck airseal shroud prevented removal of the PT vane ring from the housing. The aft edge of the PT vane's outer diameter platform was damaged at 9 o'clock while the suction side and trailing edges airfoils had nicks and dents. The aft side of the PT interstage baffle had three locations with circumferential rubs. The front of the PT vanes and baffle appeared undamaged (Figure 9).

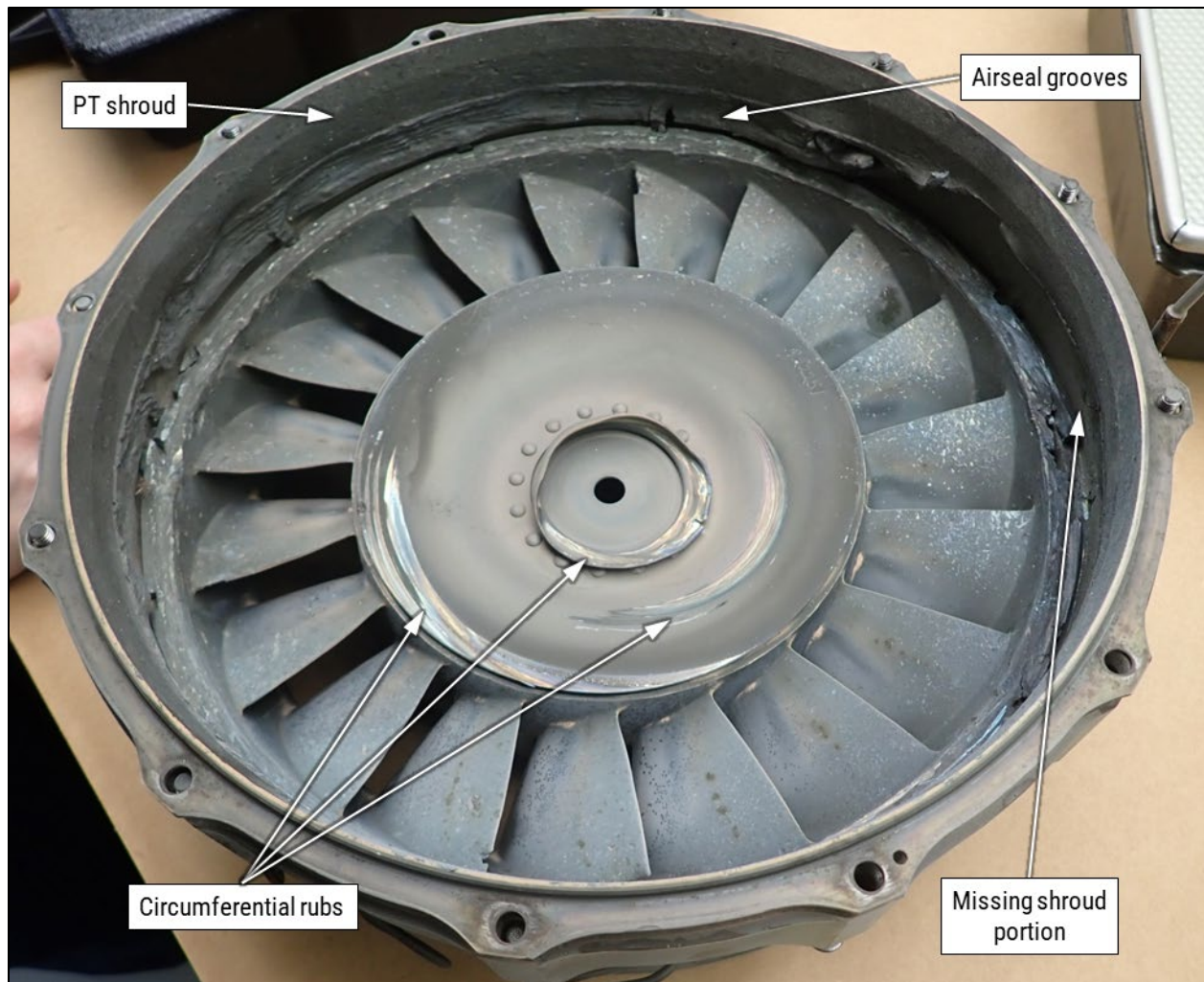


Figure 9. PT stator housing with PT vane pack and PT outer blade airseal shroud

Three circumferential rubs were found on the forward face of the PT disk assembly: the front edge of the PT blade platforms, the assembly tabs on the balancing flange, and on the inner hub surface. All the PT airfoils were fractured transversely across the airfoil at various lengths and their trailing edges were wavy, dented, or both. Some airfoils were bent opposite the direction of rotation. All PT blade fracture surfaces appeared jagged and rough. The PT disk had bluish discoloration outboard of the balancing flange and the aft spline teeth appeared in good condition (Figure 10). The PT disk and blades were held for further examination.

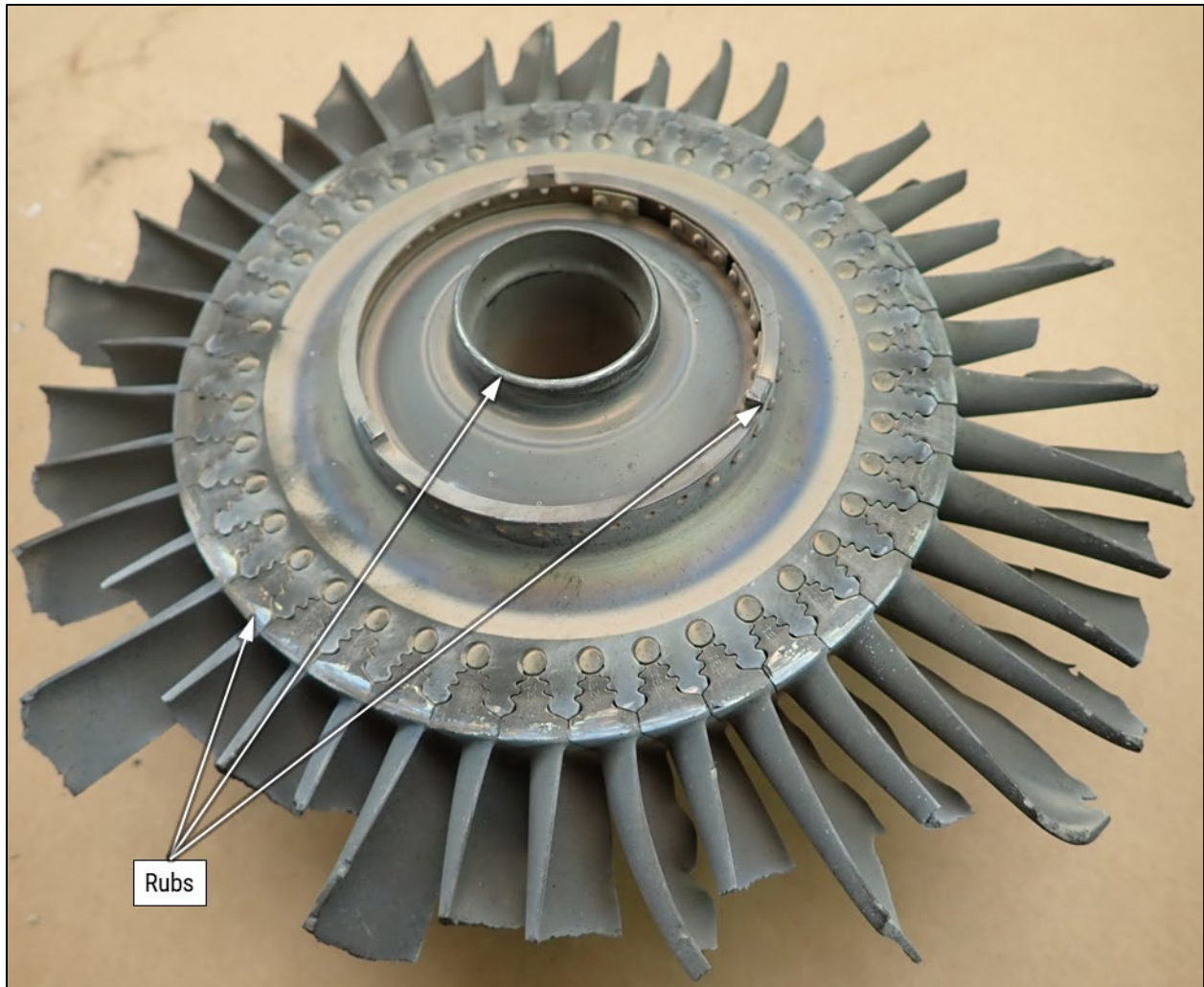


Figure 10. PT disk assembly circumferential rubs

The PT shaft housing and coupling shaft were intact and coated white. All No. 3 roller elements were present and visible portions of the roller elements appeared dry and dark in color. The PT shaft, No. 3, and No. 4 bearings within the PT shaft housing were not further disassembled.

The fuel manifold adapters were numbered clockwise (aft looking forward) from one to 14 with adapter one located at 12 o'clock. Nozzles five through 10 were more difficult to remove compared to the other nozzles. All transfer tubes that connect the adapters were present and intact, but all sealing o-rings were consumed by the post-crash fire (Figure 11).

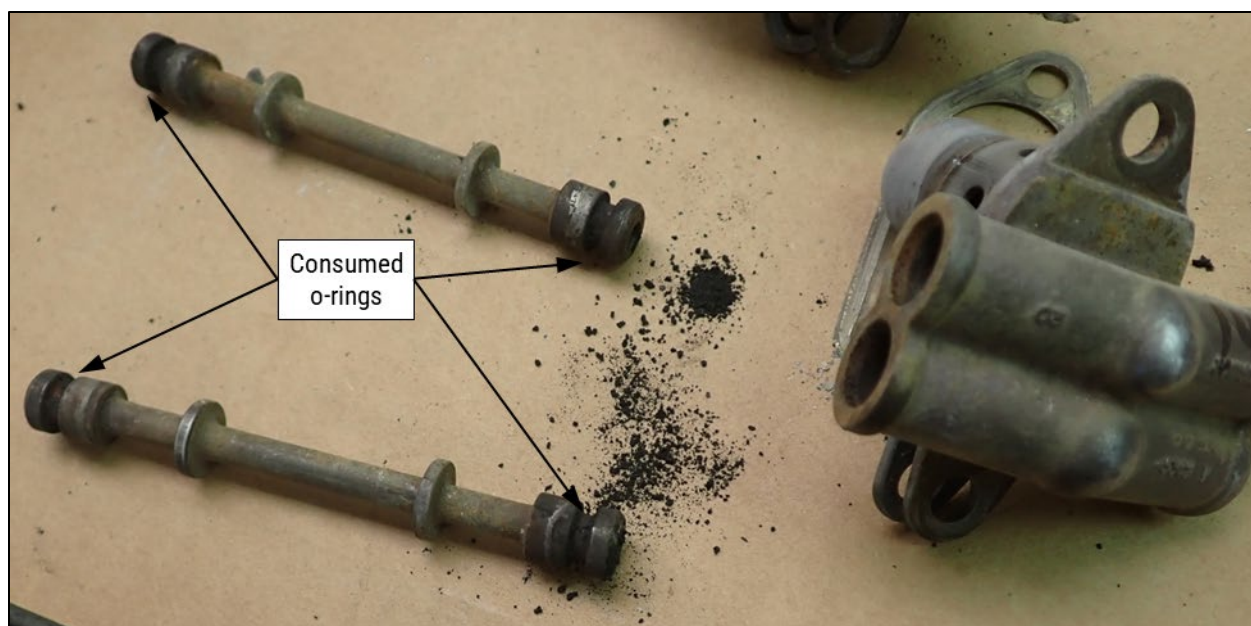


Figure 11. Fuel nozzle manifold and transfer tubes

The CT disk, combustion chamber liner, large and small exit ducts, and CT vane ring appeared in good condition consistent with normal engine operation. The CT disk forward splines were undamaged. The front of the CT blade platforms had circumferential rubs. Corresponding rub marks were found on the aft side of the inner diameter (ID) vane ring platform. The CT blade airfoil tips had light circumferential rubs (Figure 12).

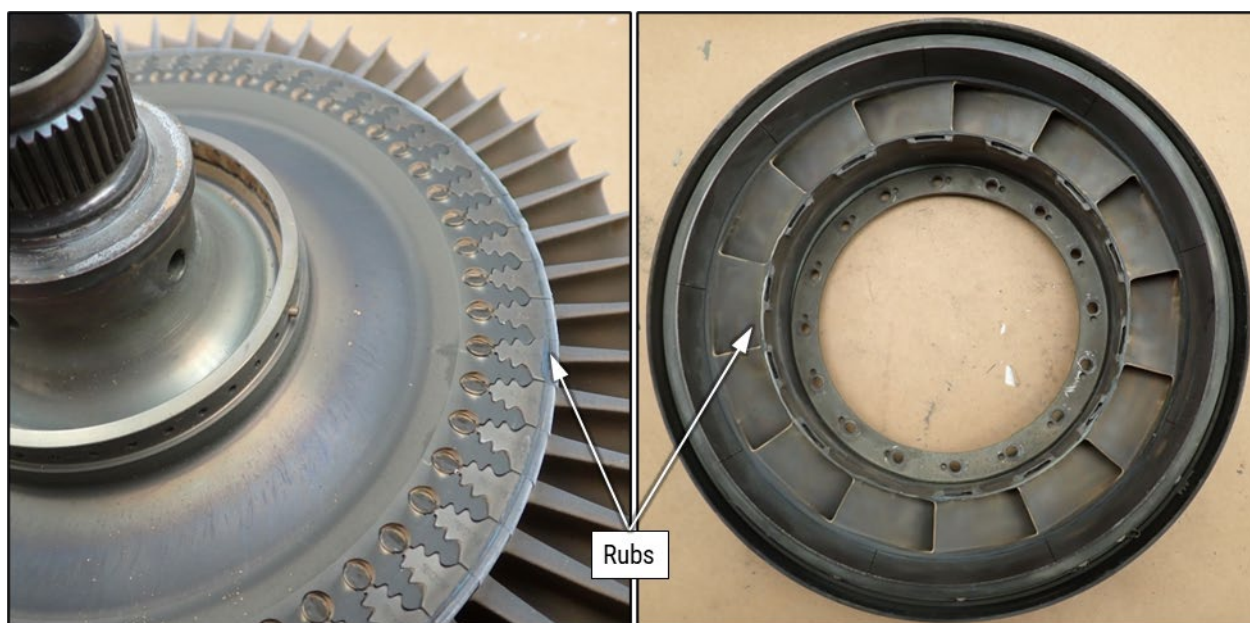


Figure 12. CT disk (left) and CT vane pack with small exit duct (right)

Penetrating oil was used to remove the No. 1 ball bearing assembly. All parts were thermally distressed. The No.1 ball bearing housing, inner and outer races, ball elements, lock nut, and lock washer had darkened appearances and coked oil on their surfaces. The No.1 ball bearing flexible housing was mostly melted and consumed. The lock washer anti-rotation tabs were still present and engaged with the bearing nut locating slots. Multiple parts had indications of surface corrosion/oxidation. The ball bearing cage had a yellowish tint. No evidence of pre-impact damage was found on any parts (Figure 13).



Figure 13. No. 1 ball bearing components

All three stages of the axial compressor blade airfoils had white coating. All compressor blade and vane airfoils appeared to be full length. All stage 1 blades had a bluish color (Figure 14). Some stage 2 and 3 blades had small trailing edge dents. All compressor section parts had indications of surface corrosion/oxidation. The centrifugal impeller appeared intact. Circumferential rub marks were found on the shroud edge lines closer toward the exducer (Figure 15) and corresponding 360° rubbing was found on the impeller shroud (Figure 16). Deposits on the impeller and external housing surfaces were flaking off. The No. 2 roller bearing was dry and seized to the compressor stub shaft. All No. 2 roller elements were present and no dents, nicks, or spalling were seen. The six tie rods that secure the compressor rotors together were present and appeared intact.



Figure 14. Stage 1 compressor disk assembly covered in white coating

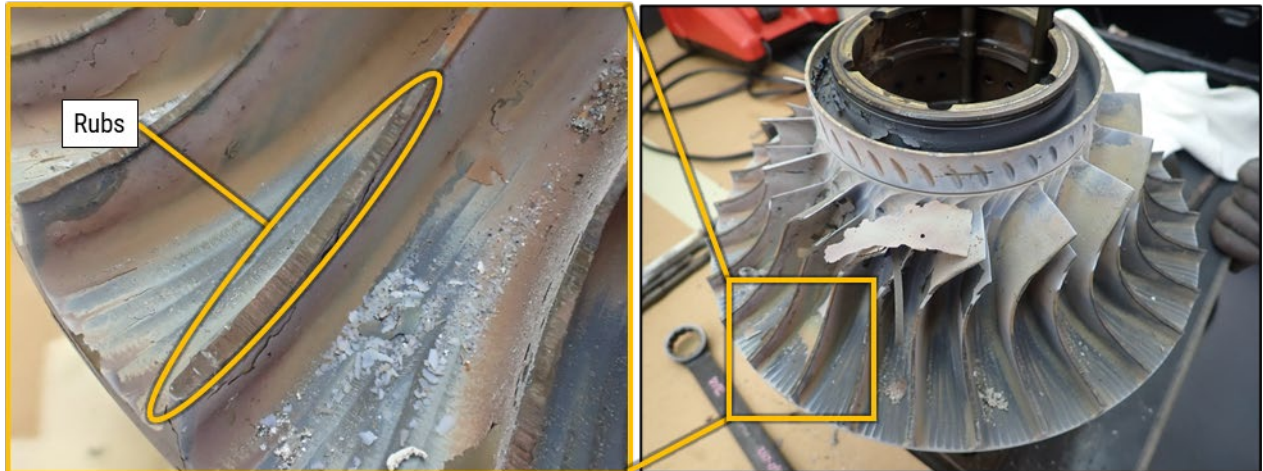


Figure 15. Centrifugal impeller with circumferential rub on the shroud line edges

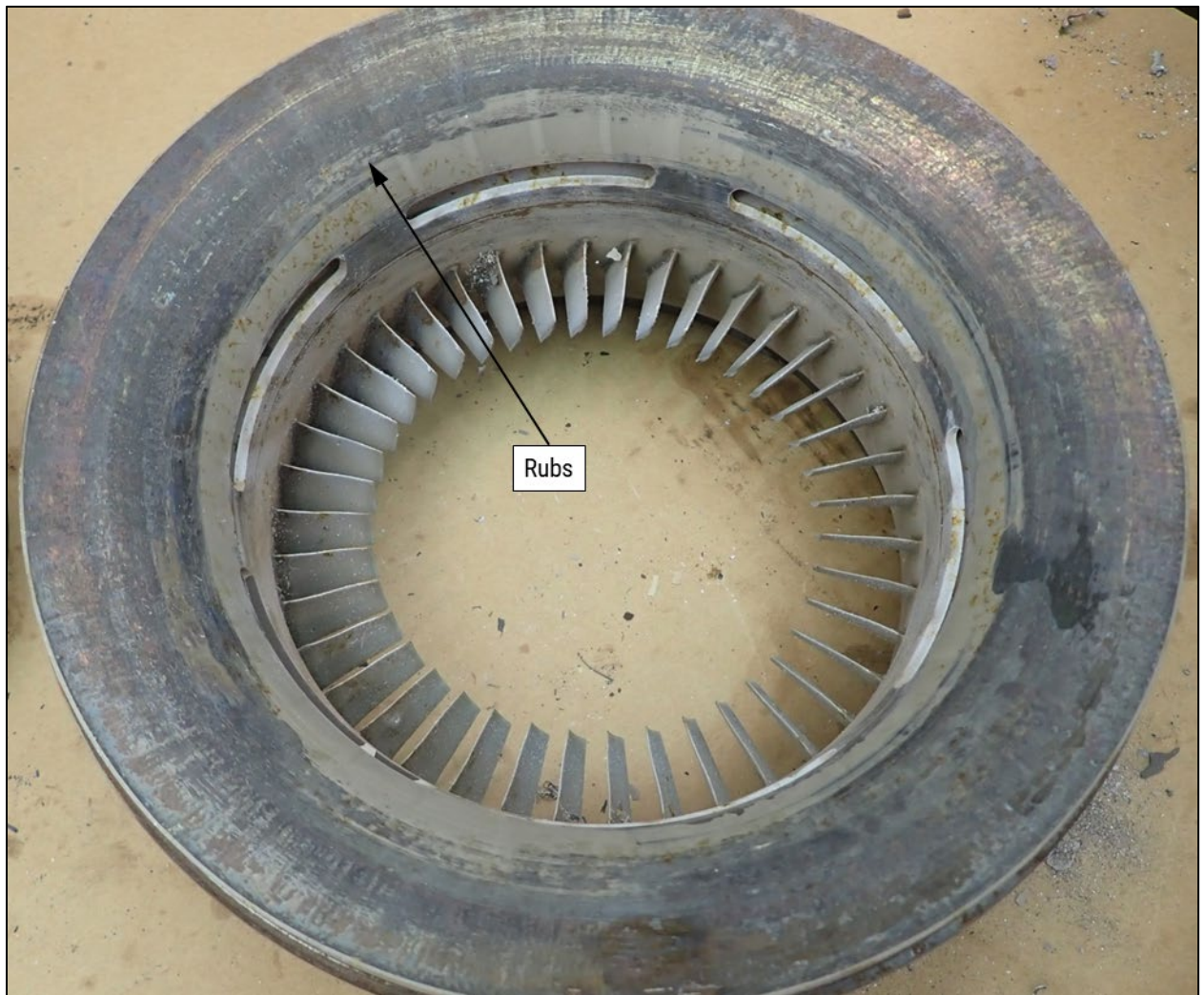


Figure 16. Impeller shroud with circumferential rub

3.2 Right (No. 2) Engine (s/n CP-PS 72332)

The right engine was secure in a wooden box (Figure 17). According to the engine data plate, the right engine was s/n CP-PS 72332 but was in the box mislabeled "s/n 60529" (Figure 18). Internal components from the accessory gearbox and the combining gearbox were included in separate bags inside the box.



Figure 17. Box mislabeled "s/n 60529" containing the right engine, s/n CP-PS 72332



Figure 18. Right engine data plate

The gas generator's external surfaces had spots of flaking paint and was coated white. The gas generator case was dented at 3 o'clock but had no evidence of uncontainment. The Pg line located on the right side of the exhaust case provides a pneumatic signal from the power turbine governor to the automatic fuel control unit. The Pg line's outer silicon rubber sheathing was thermally consumed, exposing the underlying fiberglass insulation and heating element. The front fire shield was thermally damaged and bent forward at 7 o'clock (Figure 19).



Figure 19. Right side view of right engine

The exhaust case had a white coating over all external surfaces. The exhaust case flange where the combining gearbox attaches had all 23 connecting bolts still installed. Looking through the exhaust port, PT blades that were visible appeared full length. The right side of the exhaust case from 3 to 6 o'clock was angularly buckled. The rear fire shield was thermally damaged all around and crumpled at 7 o'clock, bent aft at 3 o'clock, and bent forward at 5 o'clock (Figure 20).



Figure 20. Right engine exhaust case covered with a white coating

The PT stator housing was intact and undamaged with rust spots on its external surfaces. The PT shaft housing and coupling shaft were intact and coated white. The PT shaft, No. 3, and No. 4 bearings were removed together from the PT shaft housing. Both bearings could not rotate and could not be removed from the shaft. All No. 3 roller and No. 4 ball elements were present and visible portions appeared dry and dark in color with black-colored coking. The shaft and bearings were not further disassembled. Most of the No.1 bearing's flexible housing was thermally consumed. All parts had no evidence of pre-impact damage (Figure 21).



Figure 21. PT shaft with No.3 roller and No. 4 ball bearings

The PT vane ring was intact. The aft side of the interstage baffle had two rub locations and areas with bluish color. The PT vane airfoils appeared full length and undamaged (Figure 22).



Figure 22. Aft side of PT vane ring with interstage baffle

The PT disk was intact and all PT blades appeared full length. The disk aft splines appeared in good condition. The suction sides of all the PT airfoils were blue in color and all their shroud tips were circumferentially rubbed (Figure 23). Two circumferential rub marks were found on the forward side of the PT disk, one near the top of the blade firtree and one near the ID bore lip (Figure 24).



Figure 23. Shroud tips of exemplar PT blades (top) and event blades (bottom)

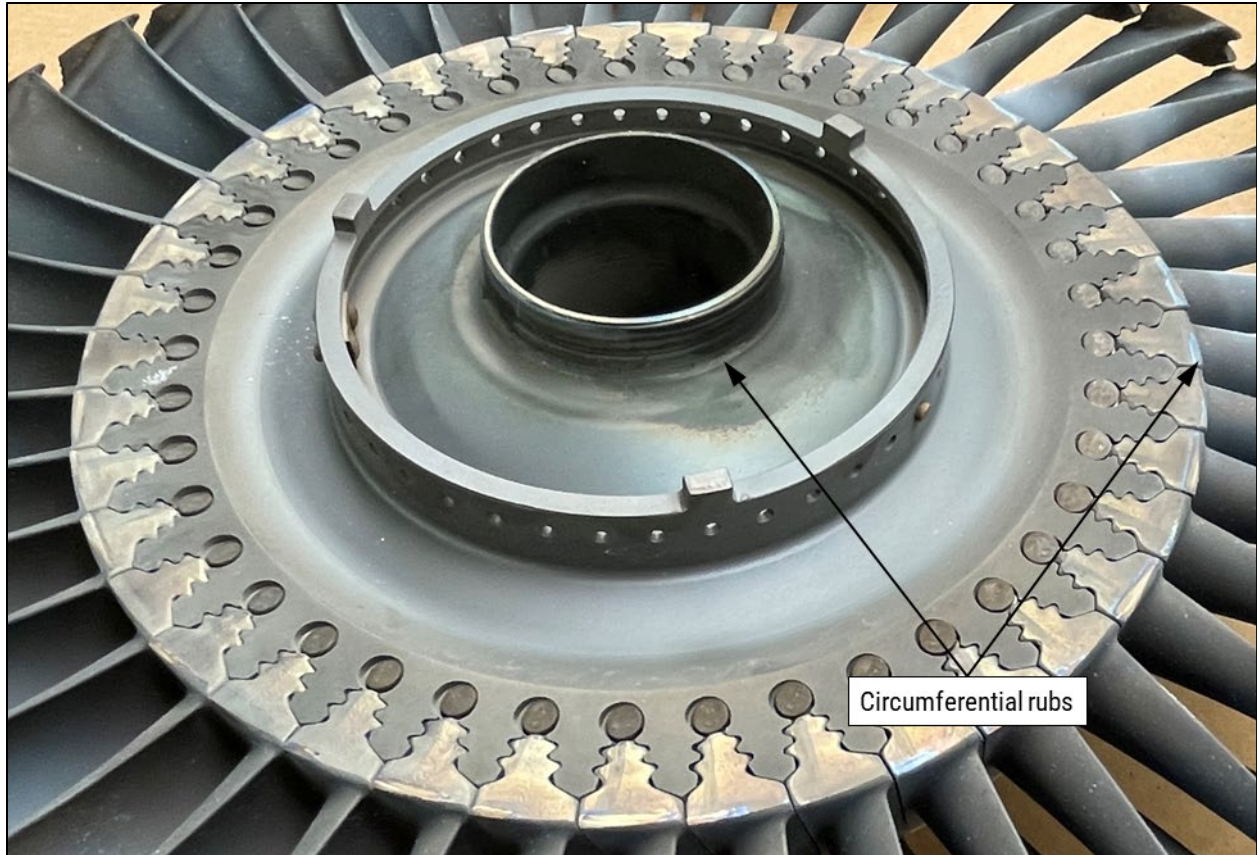


Figure 24. Forward side of PT disk assembly

The PT outer blade airseal shroud had 360° rubs to the inner surface most significant from 9 to 12 o'clock. A small section of the shroud was machined away and displaced outward at 9 o'clock (Figure 25).



Figure 25. PT outer blade airseal shroud outer (top) and inner (bottom) surfaces

The fuel manifold adapters were numbered like the No. 1 engine's adapters. Most of the transfer tubes that connect the adapters were either missing or thermally damaged. All the transfer tube o-rings were consumed by the post-crash fire (Figure 26).

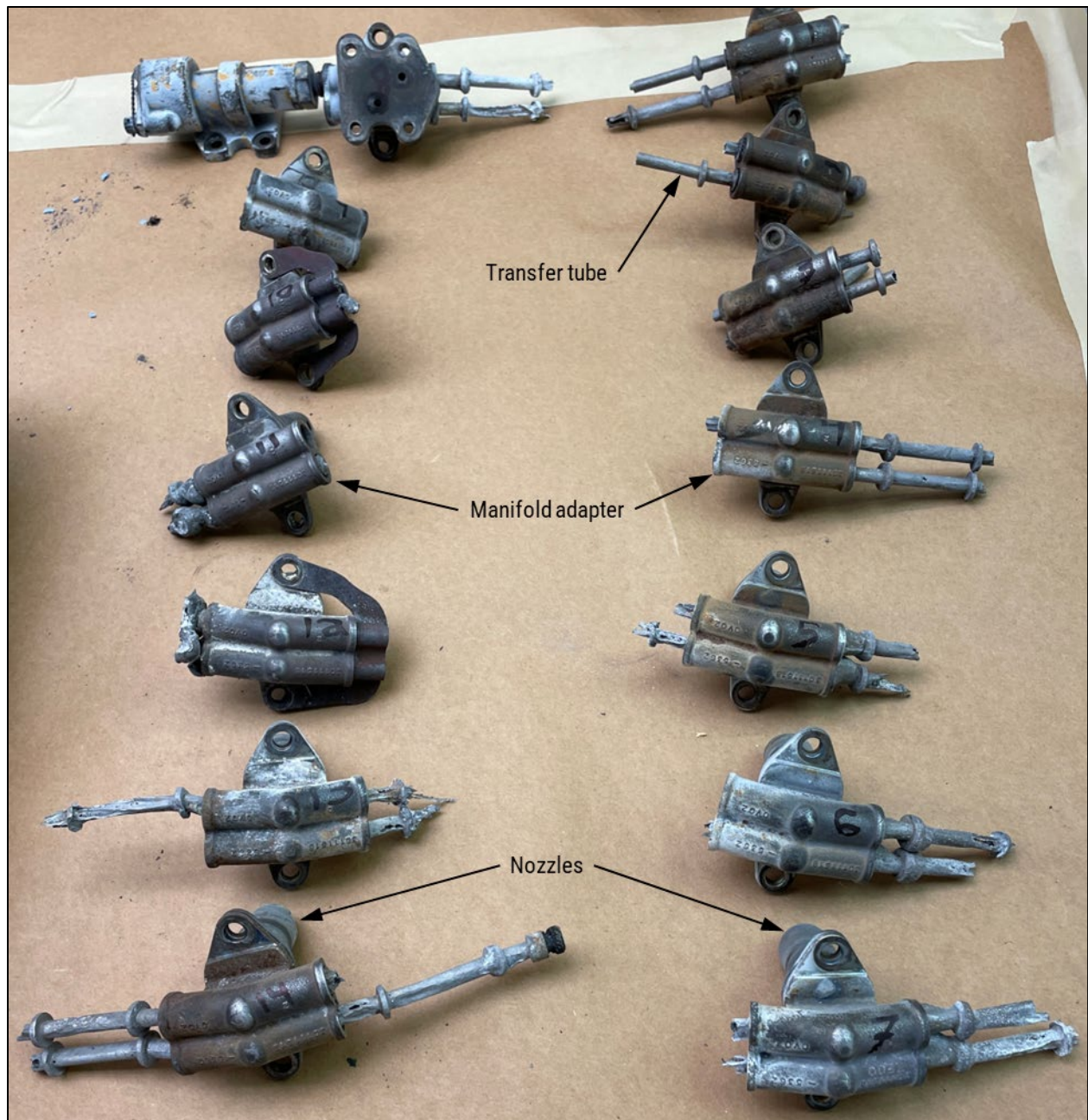


Figure 26. Fuel manifold adapters, nozzles, and transfer tubes

The CT disk appeared intact and mostly undamaged. The disk forward splines appeared in good condition. The forward face of the CT blade firtrees had circumferential rubs. All CT blade airfoils were lightly coated with white powder (Figure 27).



Figure 27. Circumferential rubs on the forward side of CT blade firtrees

The combustion chamber liner and large exit duct appeared undamaged and consistent with normal engine operation.

The small exit duct and CT vane ring were intact and lightly coated with white powder. The suction side of the CT vane airfoils were bluish in color. The CT vane aft ID platform had light circumferential rubs. The CT vane shroud segments had shiny axial chatter marks from the disassembly process, but otherwise appeared consistent with normal engine operation (Figure 28).



Figure 28. CT vane ring and shroud segments

Penetrating oil was used to remove the No. 1 bearing assembly. All parts were thermally distressed. The No. 1 ball bearing housing, inner and outer races, ball elements, lock nut, and lock washer had darkened appearances and coked on the surfaces. The aft half of the No. 1 ball bearing inner race and the inner airseal land were stuck to the compressor shaft. The lock washer's anti-rotation tabs were mostly missing, but remnants of the tabs were still aligned with the No. 1 ball bearing lock nut locating slots when it was disassembled. Multiple parts had indications of surface corrosion/oxidation. The ball bearing cage had a yellowish tint. All parts showed no evidence of pre-impact damage (Figure 29).



Figure 29. No. 1 ball bearing components

All three stages of the axial compressor had a white coating primarily on the gas path and airfoil surfaces. All parts had surface corrosion and oxidation in various locations. The six tie rods that secure the compressor rotors together were present and intact. All blade and vane airfoils appeared full length. Five stage 1 blade airfoils had blue-colored spots and two other blades had resolidified metal on the airfoil tips. Some stage 2 and 3 blades had rust spots. The forward-facing side of one stage 2 airfoil was distinctly cleaner than the rest (Figure 30).



Figure 30. Resolidified metal on stage 1 compressor blade tips (left) and single clean stage 2 compressor airfoil (right)

The impeller appeared intact. Circumferential rub marks were found along the entire length of the shroud edge lines and corresponding 360° rubs were found on the impeller shroud (Figure 31). The No. 2 roller bearing was dry and seized to the compressor stub shaft.

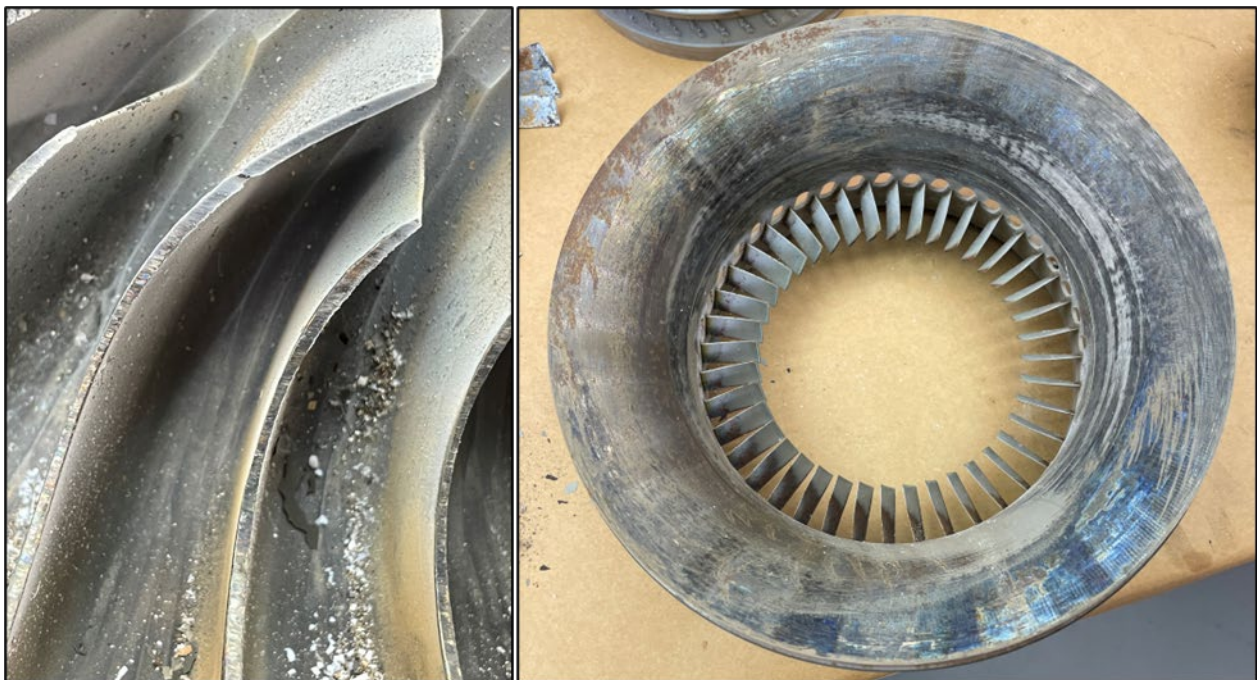


Figure 31. Rubs on impeller shroud edges (left) and on impeller shroud (right)

3.3 Combining and Accessory Gearbox Components

All combining gearbox gears were recovered. No gear teeth were missing and none of the gears appeared to have any pre-impact damage. All gears were coated white, had extensive thermal damage, and some had resolidified metal adhered to them. None of the components could be rotated by hand (Figure 32).



Figure 32. Reduction gearbox components

All accessory gearbox gears from both engines were recovered except for one “fuel pump/automatic fuel control unit” gear. No gear teeth were missing and no gears were found with pre-impact damage. All gears were coated with a white powder, had extensive thermal damage, and some had resolidified metal adhered to their surfaces (Figure 33).



Figure 33. Accessory gearbox gears

4.0 Power Turbine Blade Metallurgical Examination

The left (No. 1) engine PT disk and blades were sent to the PWC Materials Investigation Laboratory in Longueuil, Quebec, Canada for examination. The NTSB authorized PWC to perform the exam and the NTSB concurred with their findings which are included in Attachment 1.

Thirty-five of the 41 blades showed evidence of material microstructural overheating throughout the entire blade length (from blade root to airfoil tip), specifically reprecipitation/solutioning. According to PWC, the microstructural overheating was likely produced during initial manufacture or during a subsequent heat treatment and not during engine operation.

The remaining six blades had different heat codes and no evidence of material overheating compared to the above mentioned 35 blades. These six blades were installed in the PT disk as two sets of three blades 180° apart from each other. The different heat codes, material conditions, and install locations suggest these six blades were installed during an engine overhaul to replace blades from the original blade set. The date these six blades were installed could not be determined.

Visual examination of the 41 PT blades found all fracture surfaces had fractographic features consistent with overload failure. Scanning electron microscope examination of a subset of turbine blades found no metallurgical anomalies on any of the fracture surfaces. Measured blade material hardnesses were within the range specified by the drawing requirements. Energy dispersive spectroscopy of select blades found the blade material compositions conformed to the specified drawing requirements. No evidence of creep (blade elongation due to operating at elevated temperatures) damage was found on any blades.

E. ATTACHMENTS

Attachment 1: PWC Materials Investigation Laboratory Report

Submitted by:

Stephen J. Yee
Powerplants Investigator
Office of Aviation Safety