Rolls-Royce

Engine Investigation Report

Model 250-C20B/J

Allison Model 250-C20B
Engine CAE 831376

Bell 206B
Registration: N59518

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Air Safety Investigator

Orbic Air LLC
Acton, CA

Accident date: February 10, 2013
Investigation date: February 11 - 13, 2013
Engine disassembly date: August 13, 2013
Report date: 13 March, 2014

Background

On February 10, 2013, approximately 0330 local time, a Bell 206B helicopter operated by Orbic Air LLC, registration N59518, was involved in an accident near Acton, CA. The accident occurred when the helicopter collided with terrain shortly after departing from a landing zone on a movie ranch. The pilot and two passengers sustained fatal injuries and the helicopter was substantially damaged. The flight departed the landing zone about 1 minute prior to the accident for the purpose of shooting an aerial video sequence. Dark night visual meteorological conditions prevailed, and no flight plan was filed.

Wreckage and Impact Information

Rolls-Royce was invited by the NTSB to participate in the on-site investigation of the accident on February 11, 2013. Also present were investigators from Bell Helicopters, the FAA, and NTSB. The accident site was located at the base of a valley wall with a portion of the left skid being the first identified point of impact. The helicopter's debris field scattered approximately 170 feet. The main wreckage, which consisted of a majority of the airframe fuselage, was located about 70 feet west of the edge of the plateau's ridgeline. All major structural components of the helicopter were located throughout the wreckage debris path. The engine was oriented exhaust down, located within the engine compartment along the debris path approximately 75 feet from the main wreckage. All engine mounts remained attached to the engine. However, they were separated from the airframe side of the engine bay. The majority of impact damage to the engine was on the left side with crushing and flattening of several components located on that side. One exhaust stack had separated from the exhaust collector with the other remaining in position, but crushed. The exhaust collector was crushed inward on both sides Fig 1. The aircraft wreckage was transported to a secured facility for further inspection.

Engine Information

Engine Model	Allison 250-C20B
Rating:	420 HP
Serial Number	CAE831376
Engine Total Hours	7435.9 Hours
Last 100-Hour Inspection	7435.9 Hours
Last 300-Hour inspection	Unknown

Engine Examination at Recovery

The wreckage was recovered to a secure location for further examination. On 12 February, 2013 representatives from Rolls-Royce ASI, NTSB, and Bell Helicopters gathered at the recovery location for a detailed examination of the engine and aircraft wreckage. The following engine observations were noted: Fig 2

The majority of external damage was isolated to the left side of the engine. The compressor assembly remained fully intact and did not exhibit signs of impact damage. There was a small amount of debris (small sticks/grass) in the compressor inlet. The first two stages of the axial compressor showed signs of minor foreign object damage Fig 3. The bleed air valve was in the open position and could be manually actuated closed. The anti-ice valve was broke away from the scroll and held in place by the sensing lines. The left side air discharge tube was crushed/flattened and disconnected from the compressor scroll. It remained connected to the outer combustion case. The right side air discharge tube was not damaged and connected at both ends.

The outer combustion case was dented at the bottom due to impact, but otherwise unremarkable. The fuel nozzle was in place and normal in appearance. The engine fuel line between the check valve and fuel nozzle remained in position and attached at both ends. The line was removed from the fuel nozzle and a normal amount residual fuel drained out. The igniter was in place within the outer combustion case, but the ignition lead was separated from the igniter.

Both the gas producer and power turbine supports were normal in appearance and displayed no impact damage. The fourth stage turbine wheel, as viewed through the exhaust collector, was normal in appearance Fig 4.

The accessory gearbox was undamaged and normal in appearance. The upper and lower chip detectors were removed and visually examined. Both chip detectors contained a small amount of metallic debris, but were otherwise normal in appearance Fig 5. The fuel control unit was undamaged and normal in appearance. The throttle arm was free and smooth from stop to stop. Fig 6. The power turbine governor had a large section broken away exposing the internal flyweights. The missing portion included the governor arm Fig 7. The fuel pump was undamaged and normal in appearance. The fuel in line was fractured just aft of the “B” nut and residual fuel leaked out when the engine was shifted. All other external lines and associated fittings were secure when checked by hand with no cracks noted. The PG pneumatic line was loose at the first accumulator. A painted torque strip was present on the line, but was not aligned. The accumulator was damaged by impact. All other engine pneumatic lines were normal in appearance with “B” nut and connectors at least finger tight. Fig 8

The N2 drive train was free and continuous from the 4^{th} stage turbine wheel to the power takeoff gear during manual rotation. The N1 drive train could be rotated by hand and was continuous to the starter generator.

Engine/Component Records

Component	Serial Number	Part Number	TSO	Total Time
Engine	CAE831376	6853341	7435.9	7435.9
Gearbox	CAG33681	6886442	3942.9	9056.1
Compressor	CAC32175	6890550	6752.4	827.6
Turbine	CAT33536	23038241	220.4	8865.6
Fuel Control	324947	23070606	98.1	UNK
PTG	17737	23065121	98.1	UNK
Fuel Pump	PE3881	23003114	738.7	UNK
Fuel Nozzle	AG68338	23077068	220.5	UNK
Bleed Valve	FF14052	23053176	388.1	UNK

Engine/component times are from 24 Jan 2013 when the last 50 hr inspection was annotated in the engine log book.

Engine Examination at Rolls-Royce

The engine arrived at Rolls-Royce, Indianapolis in an engine shipping container and remained unopened until the NTSB commenced the examination. On 13 August 2013 the engine was removed for disassembly/examination. The NTSB IIC presided over the investigation and the following was noted: Fig 9

Turbine Module:
The Turbine module was removed for examination. The outer combustion case and combustion liner were removed to facilitate further inspection. The combustion section displayed no signs of significant damage other than the previously noted impact damage to the outer combustion case. Inspection of the combustion liner revealed a small amount metallic spatter on the inside of the liner. The liner was otherwise normal in appearance with no unusual damage or streaking Fig 10. There was a small amount of carbon material on the face of the fuel nozzle, but it was otherwise normal in appearance. The fuel nozzle was disassembled with no damage noted. The screen was clean and unremarkable.

The gas producer and power turbine were disassembled down to the rotors. The 1st stage turbine nozzle and nozzle shield revealed metallic spatter across the nozzle shield face and nozzle surfaces. The 1st stage nozzle was otherwise undamaged. Ingestion of small metallic debris was noted throughout the gas path. All four turbine wheels were otherwise undamaged. The 2st stage turbine nozzle, which contains the blade tracks for the 1st and 2nd stage turbine wheels, had indications of slight rub on the 2st stage blade track. The 3rd stage turbine nozzle was unremarkable. The 4th stage turbine nozzle, which contains the blade tracks for the 3rd and 4th stage turbine wheels, revealed signs of heavy rub on both the 3rd and 4th stage blade tracks. The 4th stage nozzle also had a crack and was sent to the Rolls-Royce Metallurgy lab for examination and documentation. Metallurgical evaluation of a 4th stage turbine nozzle indicates fatigue caused the initiation of cracking in the airfoil casting on the surface between two airfoils along the radial axial plane. Propagation of the crack through the casting and into the diaphragm appeared to be tensile overload. Small areas of fatigue features were observed at the end of the crack. Heavy oxidation on the surface of the fracture indicated that it was not related to or caused by the accident under investigation. The damage observed is not considered contributory to the event. Fig 11, Fig 12, Fig 13, Fig 14, Fig 15, Fig 16, and Fig 17

Carbon buildup was noted on the No. 6 and 7 bearing oil pressure tube. The tube was otherwise normal in appearance. The No. 6 and 7 bearing oil pressure screen was clean and unremarkable. The No. 8 bearing oil pressure tube was unremarkable Fig 18. All Turbine main line bearings were oil wetted and intact with no damage noted Fig 19. No visible damage was noted to the four thermocouples or harness.

Compressor Module:
The compressor was removed and disassembled for examination Fig 20. The axial compressor showed signs of foreign object damage with small nicks on the first three stages of blades and vanes. The plastic compressor case liner had several cracks and missing material, which was likely caused by impact. The centrifugal compressor impeller shroud showed signs of significant rub damage from the impeller with corresponding rub indications 360 degrees around the impeller blades Fig 21. The No. 1 and 2 bearings were both oil wetted and undamaged Fig 22.

Gearbox Assembly and Accessories:

The gearbox was not opened, but was turned by hand. There was no visible damage to the interior or exterior of the gearbox. Both the N1 and N2 drive systems rotated freely with no unusual noise. There was continuity to all accessory drive pads. The No. 2 ½, 3, and 4 bearings as viewed through the gearbox appeared to be oil wetted and undamaged Fig 23. The fuel filter bowl was removed and contained a small amount of fuel. The filter was clean and unremarkable. The fuel control unit was removed and no damage was noted. The drive shaft turned freely and the throttle arm had full, smooth travel from stop to stop. The power turbine governor was removed and displayed impact damage as noted previously. The governor drive shaft was sheared at the drive coupling Fig 24. The fuel control and governor were sent to Honeywell for further examination and testing.

On 14 August, 2013 Honeywell conducted a functional test of the fuel control. In addition to the functional test a complete disassembly was conducted. Testing and disassembly did not disclose any condition that would prevent the unit from functioning normally. On the same date Honeywell disassembled the power turbine governor and concluded that discounting obvious impact damage the disassembly did not disclose any condition that would prevent the unit from functioning normally.

Engine Shafting:

Turbine-to-compressor coupling and power turbine-to-pinion gear coupling verified intact and properly engaged with no damage noted. The spur adapter gearshaft was intact with the retaining ring in place and secured. Fig 25

Summary of Findings

Based on the investigation conducted the engine revealed no evidence of a pre-impact failure, fire, damage, or any other mechanical condition which would have prevented the engine from operating as designed. The engine presented evidence supporting operation at impact. Foreign object damage in the compressor is consistent with debris entering the compressor during the accident sequence. Metal spatter and debris throughout the gas path are supportive of engine operation during impact.

Fig: 1

Wreckage Debris Field

Engine On-Site

Fig: 2

Engine At Recovery

Fig: 3

Compressor

Fig: 4

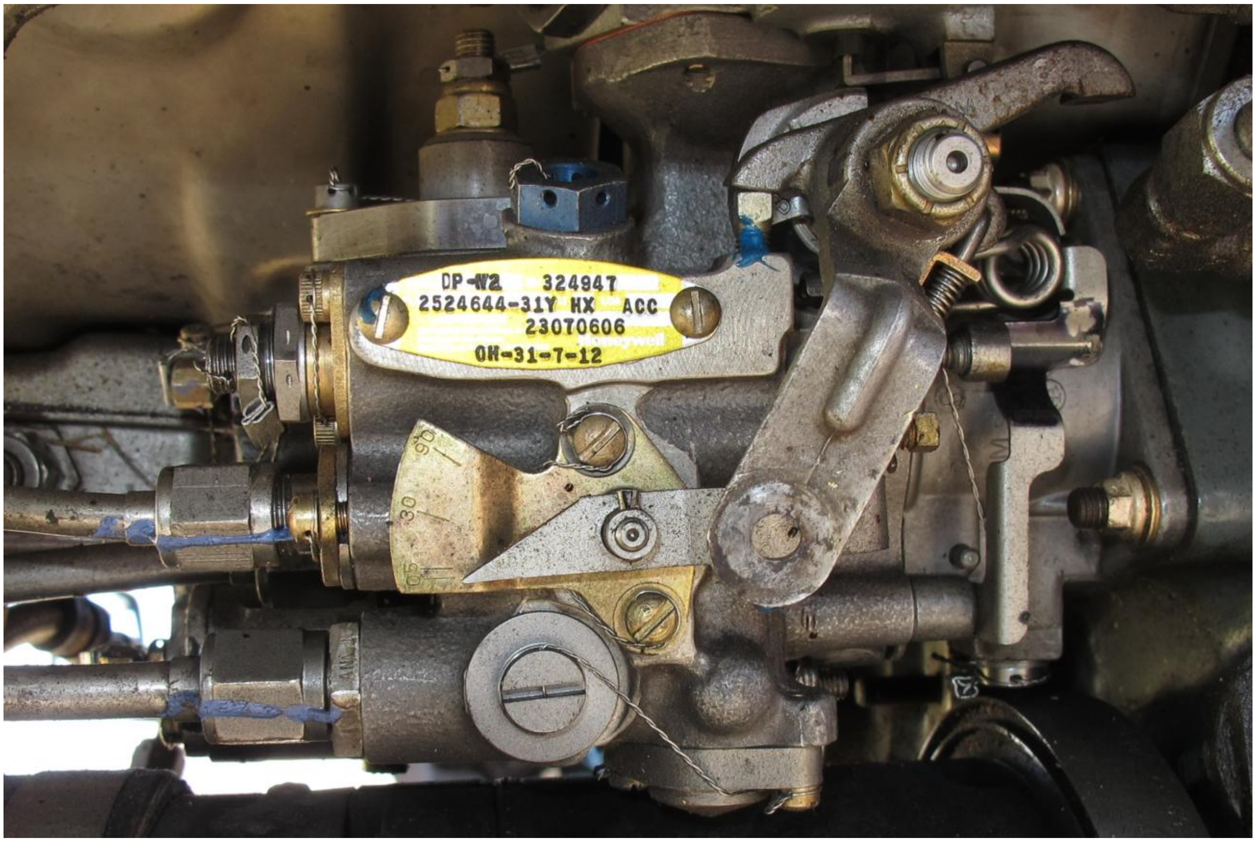
4th Stage Turbine Wheel

Fig: 5

Upper Chip Detector

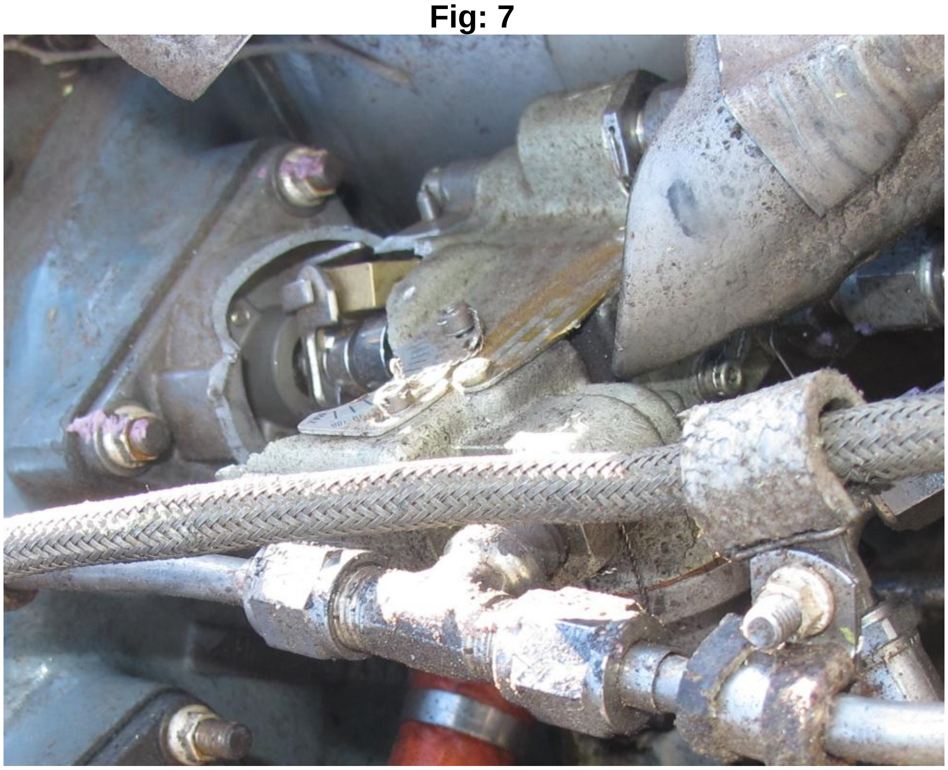
Lower Chip Detector

Fig: 6



Fuel Control Unit

Fig: 7



Power Turbine Governor

Fig: 8


PG Line and Accumulator

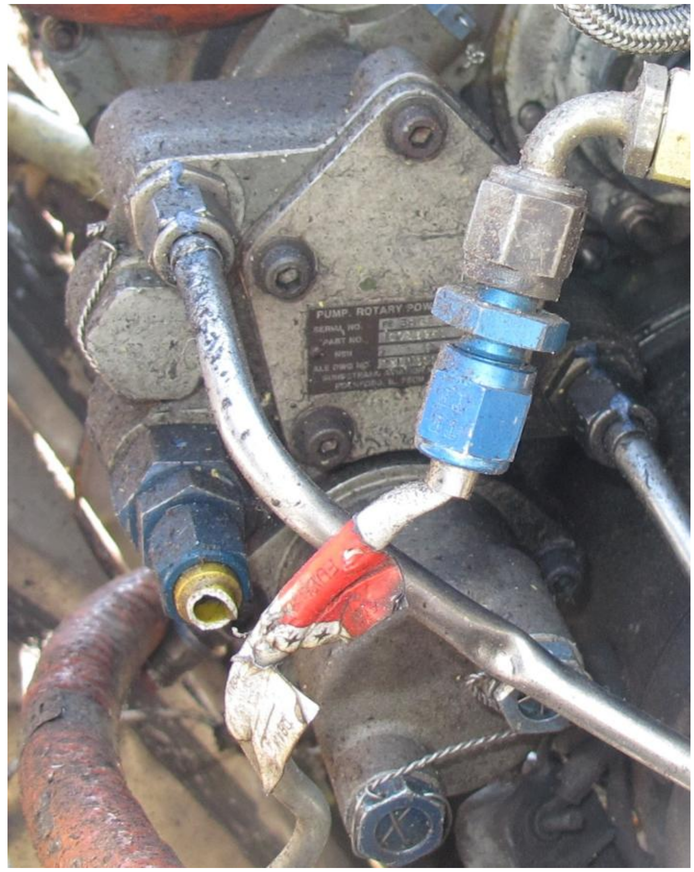

Fractured Fuel In Line

Fig: 9

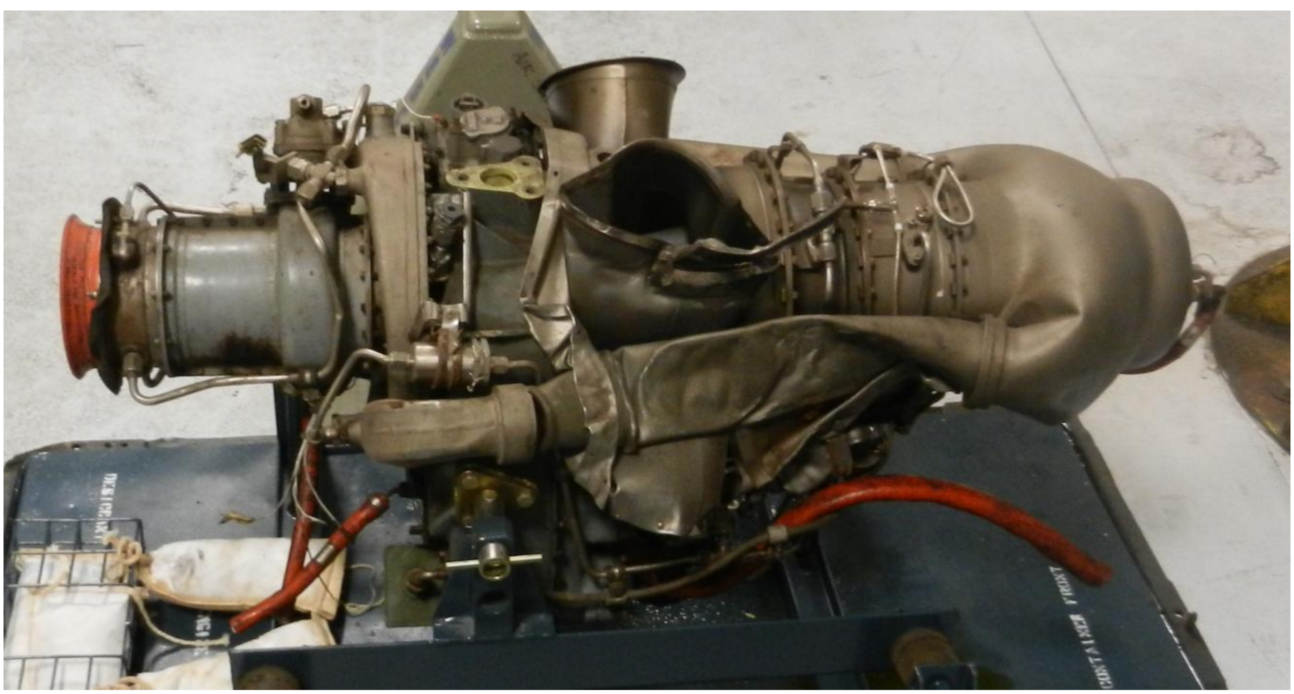
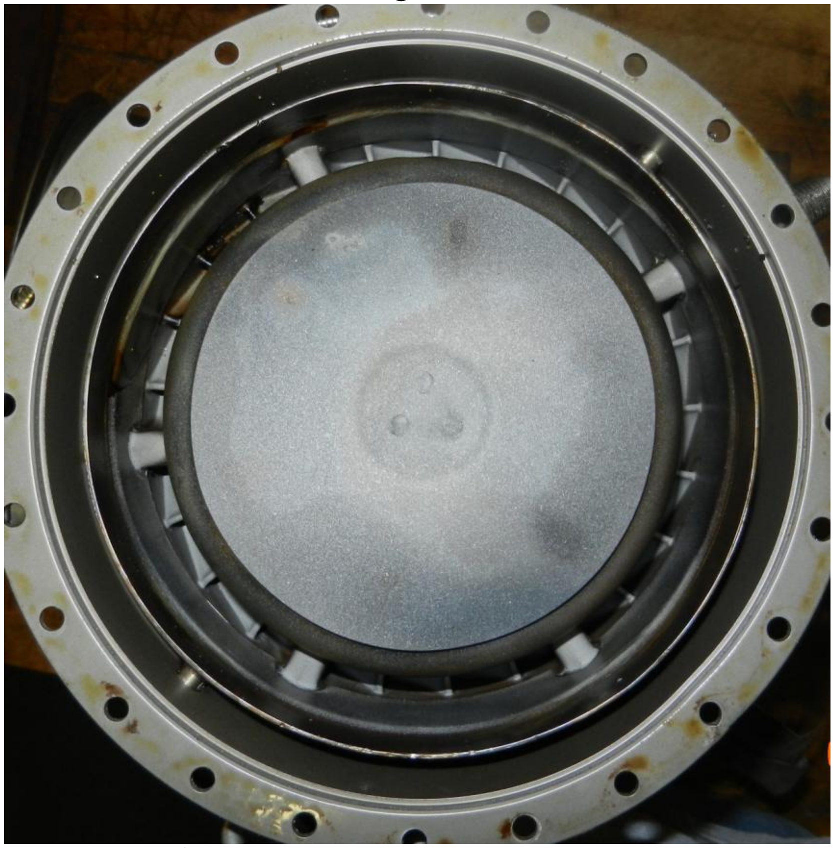

Engine As Received at Rolls-Royce

Fig: 10

Combustion Liner

Fig: 11



1st Stage Turbine Nozzle and Nozzle Shield

1st Stage Turbine Wheel

Fig: 12

2nd Stage Turbine Wheel and Nozzle

Fig: 13

2nd Stage Turbine Wheel Blade Tracks

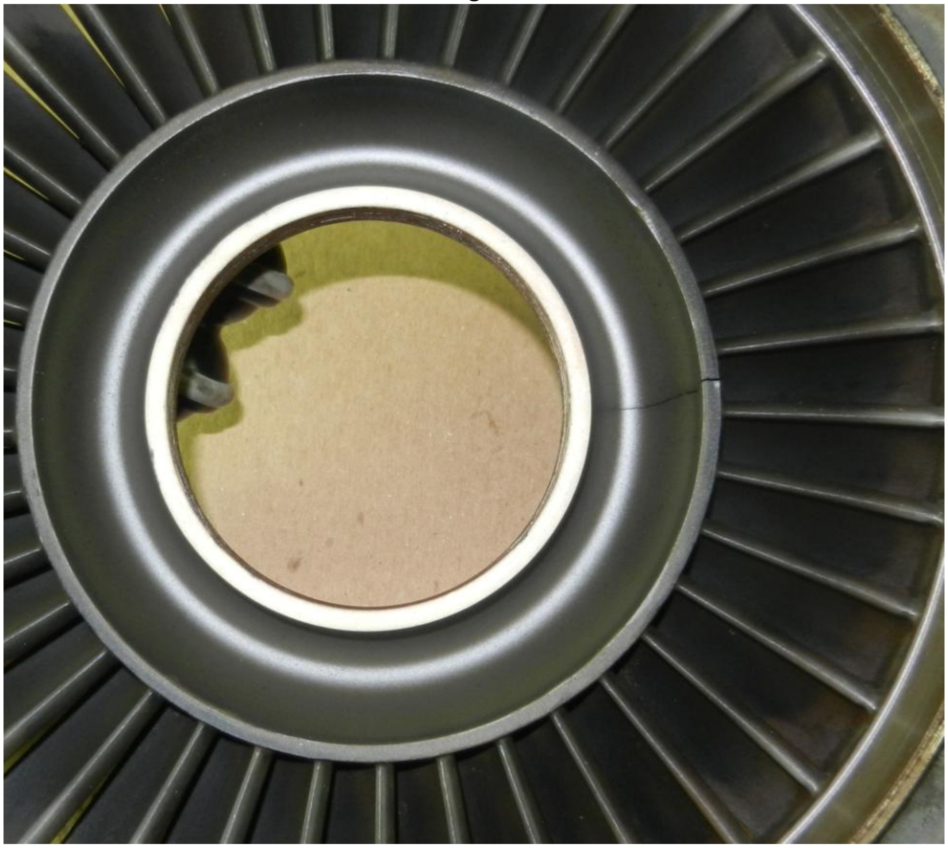
Fig: 14
3rd Stage Turbine Wheel and Nozzle

Fig: 15
4th Stage Turbine Wheel and Nozzle

Fig: 16

4th Stage Blade Track Rub

Fig: 17
Crack in 4th Stage Turbine Nozzle



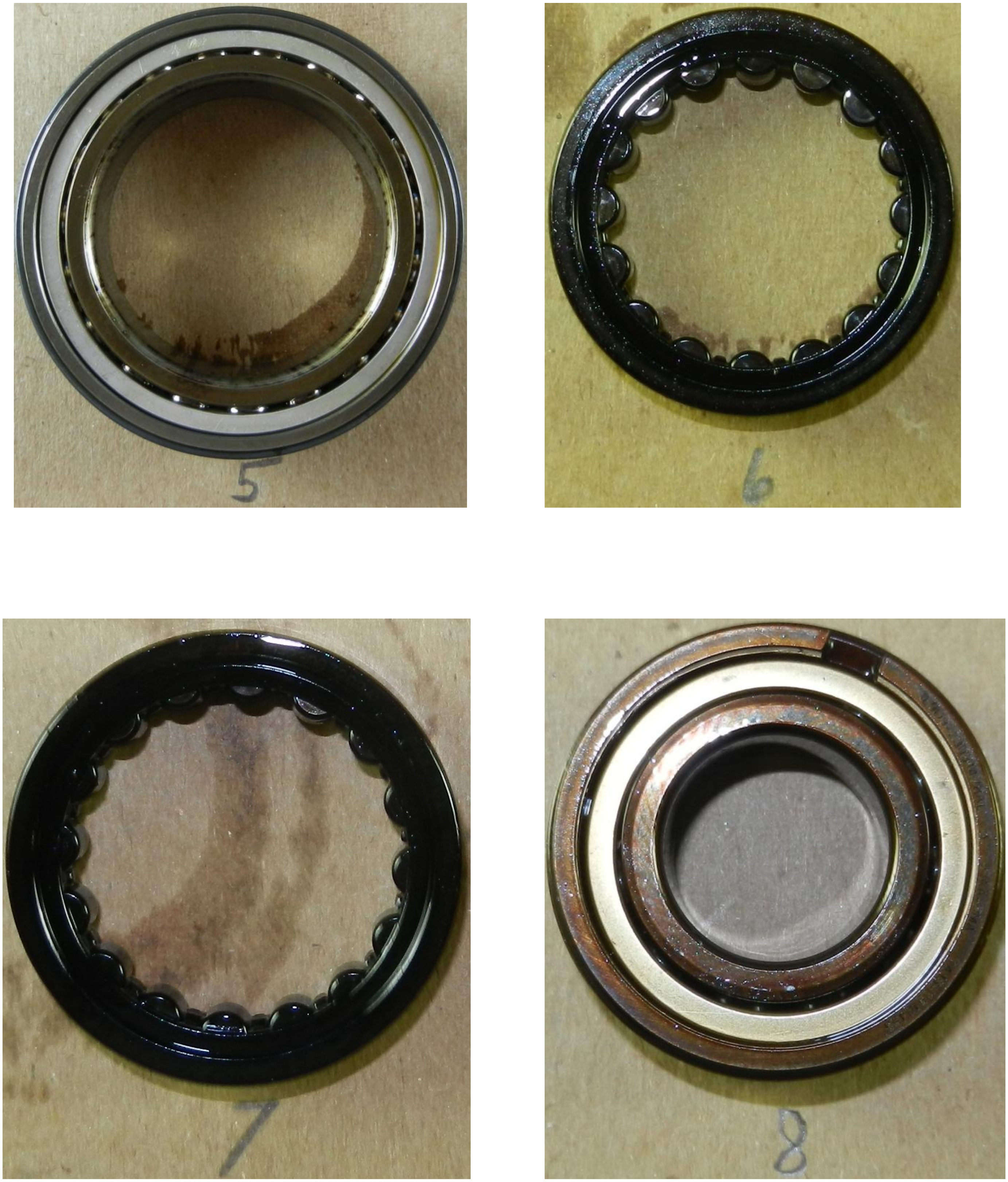
Leading Edge Side

Trailing Edge Side

Fig: 18

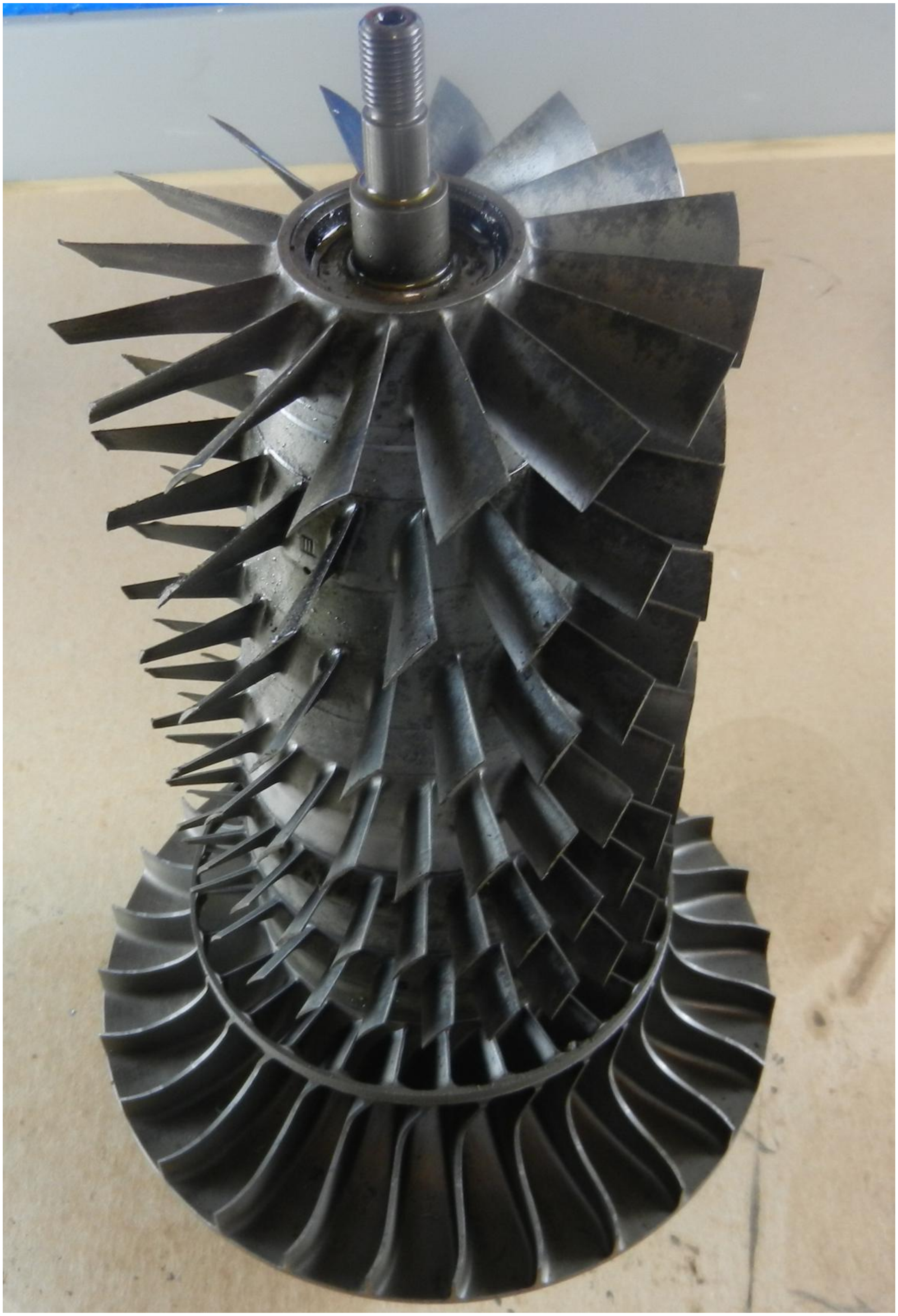
No. 6 and 7 Bearing Oil Pressure Tube, Oil Pressure Screen, and No. 8 Oil Pressure Tube

Fig: 19



No. 5, 6, 7, and 8 Bearings

Fig: 20



Compressor Assembly

Fig: 21

Impeller Shroud

Impeller

Fig: 22

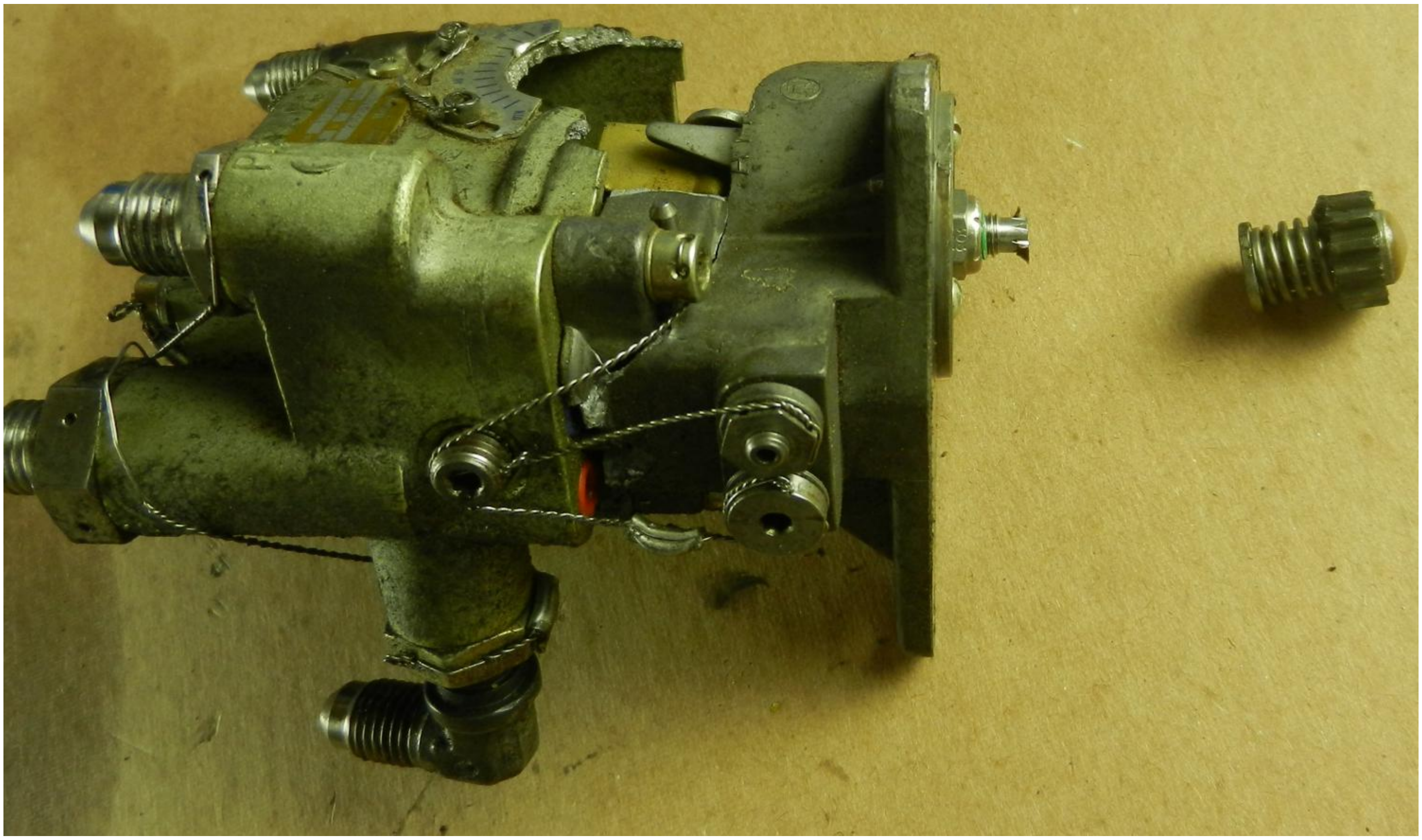
No. 1 Bearing

No. 2 Bearing

Fig: 23

No. 2 ½, 3, and 4 Bearing As Viewed Through the Gearbox

Fig: 24



Power Turbine Governor With Sheared Drive Shaft

Fig: 25

Turbine-To-Compressor Coupling and Power Turbine-To-Pinion Gear Coupling

Spur Adaptor Gearshaft