NATIONAL TRANSPORTATION SAFETY BOARD
Office of Aviation Safety
Aviation Engineering Division
Washington, DC 20594

May 25, 2022

COMPONENT EXAMINATION FACTUAL REPORT

A. ACCIDENT INFORMATION

Place:	Smyrna, Tennessee
Date:	May 29, 2021
Vehicle:	Cessna 501 Citation, Reg. No. N66BK
NTSB No:	ERA21FA234
IIC:	L. Read

B. COMPONENTS EXAMINED

Two Pratt & Whitney Canada (P&WC) JT15D-1B engines were examined at P&WC's facility in Bridgeport, West Virginia on September 28-30, 2021. The engine data plates were missing. The compressor impeller (6B572) and the first stage high turbine (high turbine) disk (5L010) serial numbers (S/Ns) from one of the engines were matched to the engine build records for S/N 77407. The other engine's impeller (6B533) and the high turbine disk (5L018) S/Ns were matched to the engine build records for S/N 77408. According to operator service records, engines S/N 77407 and S/N 77408 were installed in the left and right engine positions, respectively of N66BK, the accident airplane. The engines were new at the time of installation. Both had accumulated 4,781 hours and 3,838 cycles since new on the day of the accident.

C. DETAILS OF THE EXAMINATION

1.0 Left engine

1.1 General condition

The left engine, S/N 77407, was missing all structure forward of the gas generator case including the inlet cone, the fan case, a forward section of the low compressor shaft, the No. 1 bearing, the No. 2 bearing, the intermediate case/oil tank, the tower shaft, and the accessory gearbox. The impeller shroud and the high compressor shaft were also missing. The gas generator case, low turbine stator support assembly and turbine exhaust duct were compressively deformed. The

compressive damage was centered, and the most pronounced at 6 o'clock. See Figure 1.[1]

Figure 1. Representative photograph of engine S/N 77407, left side view

Inspections of fragments of the separated parts delivered with the engine found no damage inconsistent with impact.

1.2 Pertinent disassembly findings

The compressor impeller vane inducer profiles were fractured or missing material. The fracture surfaces exhibited local bending in the direction opposite to impeller rotation. The vanes were heavily scored at the exducer end. See Figure 2.

[1] O'clock refers to approximate circumferential locations in a clockwise direction as viewed from the rear of the engine looking forward.

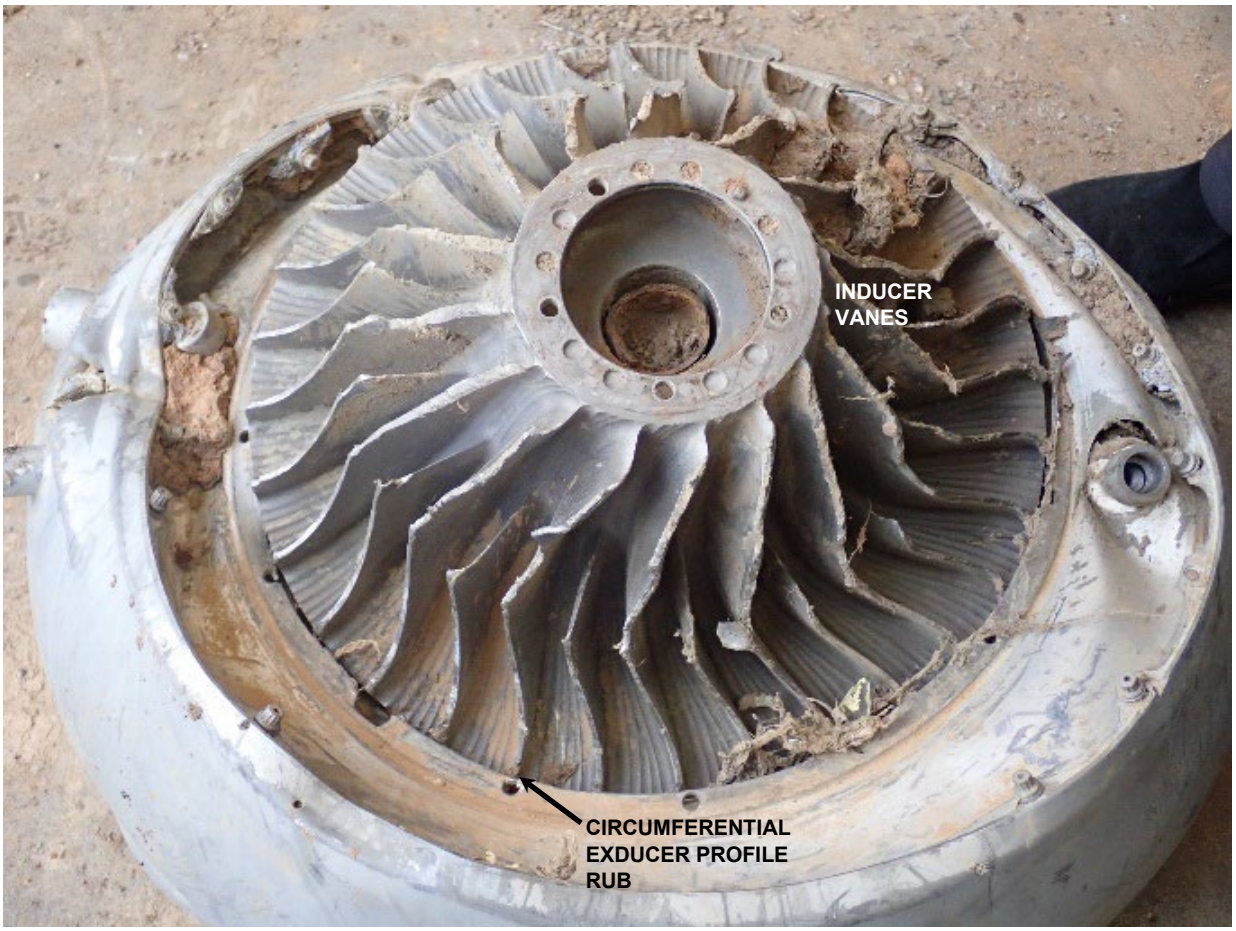

Figure 2. Front view of engine S/N 77407 showing impeller damage

The impeller shroud housing was not recovered.

The downstream[2] side of the high turbine stator assembly was circumferentially scored along the vane shroud and along the baffle edge. An arc of the baffle was machined to separation. The high turbine vane shroud segments were scored 360°. See Figure 3.

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

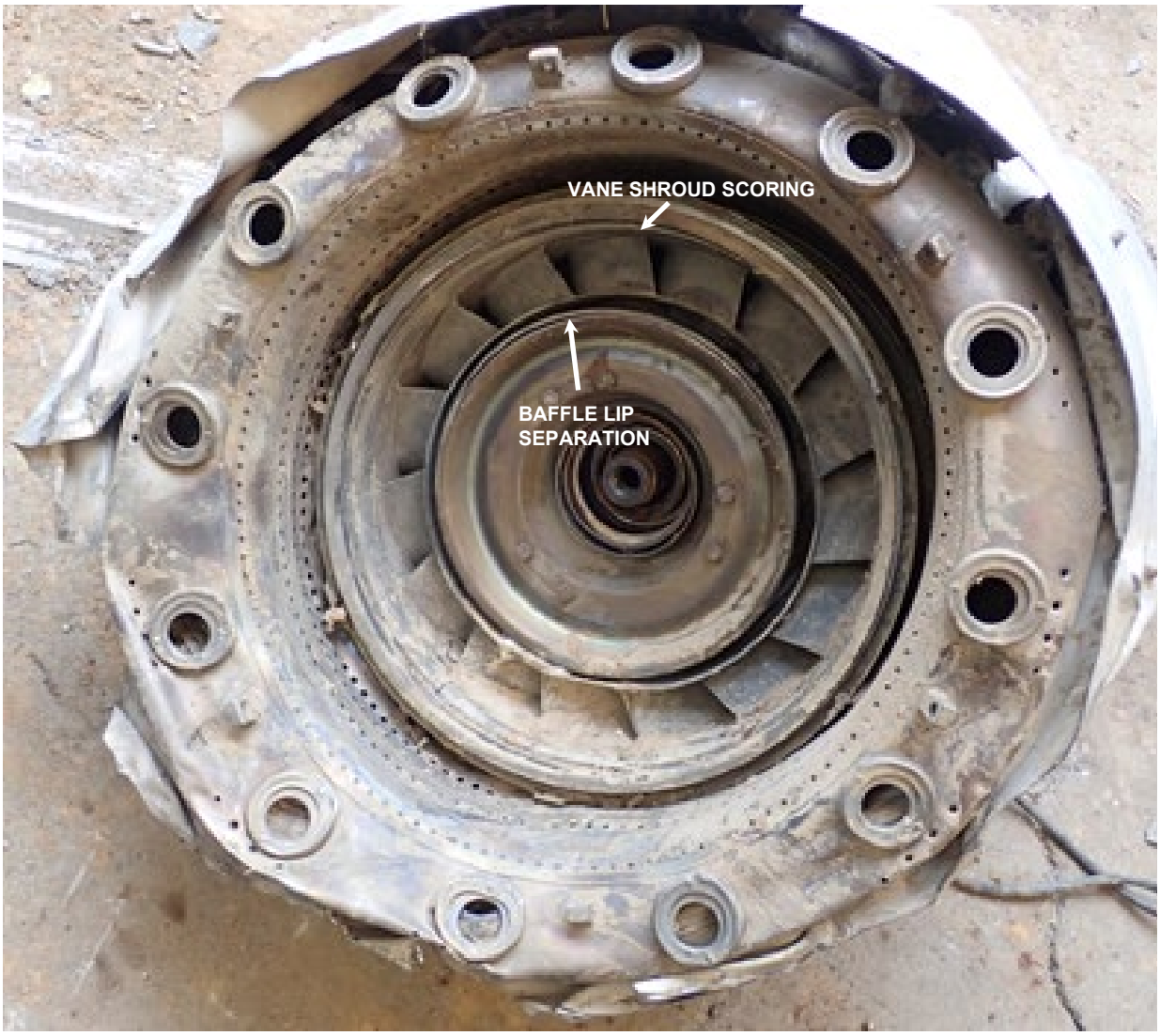

Figure 3. Downstream view of the high turbine stator, showing 360° rub at the shroud and the baffle lip

The high turbine upstream face was circumferentially scored along the balance flange and along the fir tree roots and blade platform edges. This damage was axially coincident with the scoring observed on the high turbine stator downstream face.[3] The blade tips exhibited rub damage consistent with the damage to the shroud segments. See Figure 4.

[3] Rotational/rub damage signatures can result when an operating engine experiences impact forces sufficient to cause clearance loss between static and rotating components.

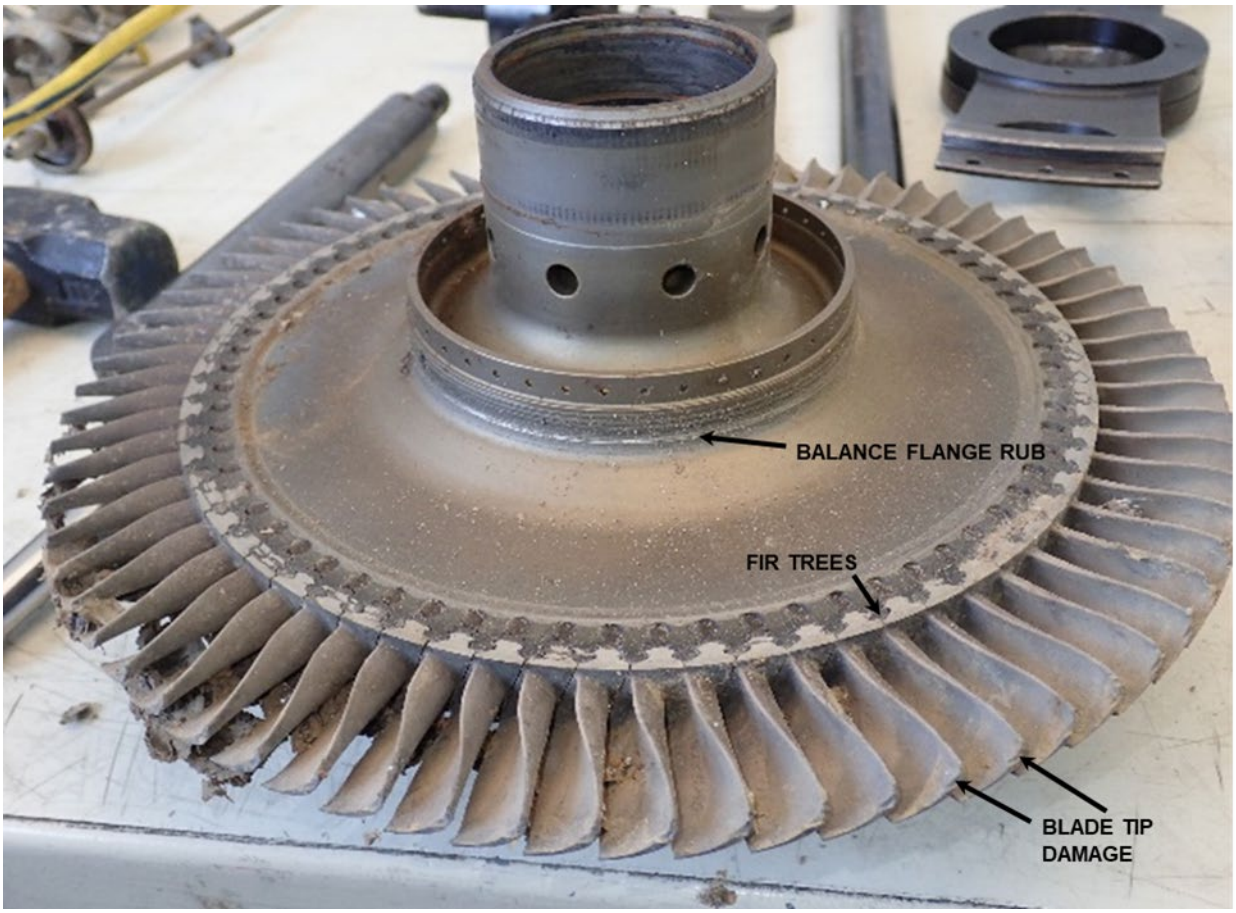

Figure 4. High turbine upstream face showing blade tip rub damage and circumferential scoring along balance flange and fir tree root/blade area

The high turbine downstream face was rubbed along all blade retention rivets, fir tree root and adjacent disk, blade platforms and blade trailing edges. 360° rub was also observed at the balance flange. See Figures 5 and 6.

Figure 5. High turbine downstream face showing circumferential scoring along the blade retention rivets, fir tree root area, and blade platform and trailing edges

Figure 6. 360° scoring at high turbine balance flange

The upstream side of the 2nd stage low turbine stator (T2 stator) was circumferentially scored along the vane inner rim and the inner baffle rim. See Figure 7. The scoring was axially coincident with the damage observed to the high turbine downstream face.

Figure 7. T2 stator upstream side showing 360° scoring damage along vane inner shroud and inner baffle ring

The high turbine shaft was separated aft of the high turbine disk splines. Circumferentially-oriented scoring was observed on the shaft fracture surface. See Figure 8.

Figure 8. Rotational scoring damage marring the high turbine shaft fracture surface

The downstream side of the T2 stator was scored 360° along the vane inner rim. See Figure 9.

Figure 9. T2 stator downstream side showing 360° scoring along the vane inner and outer rims

The T2 upstream face was scored 360° at two diameters, along the blade platform edge and along the blade shroud tip edge. The scoring was axially coincident with the scoring damage observed to the high turbine downstream face. See Figure 10.

The low turbine rotor was not disassembled.

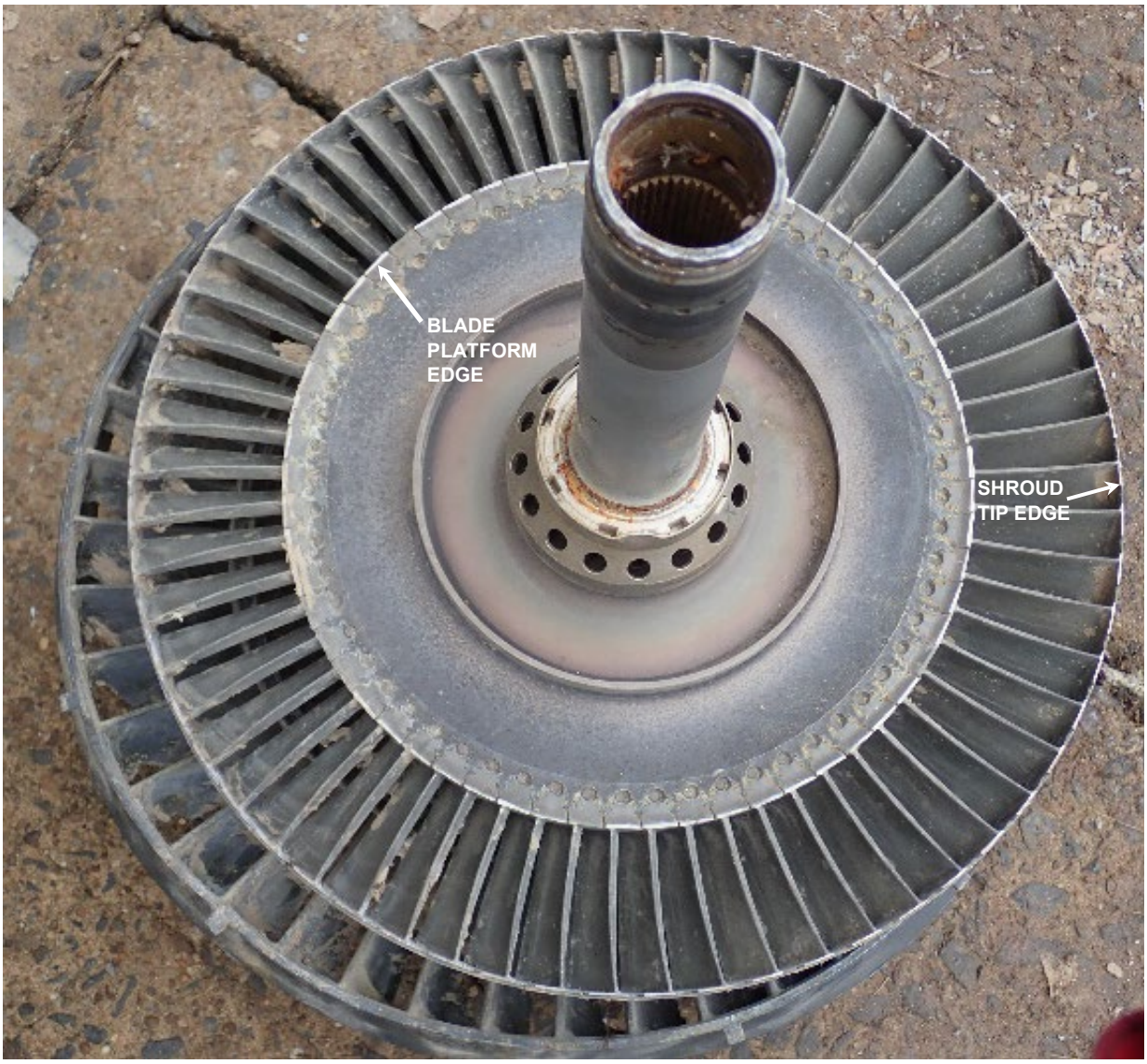

Figure 10. T2 showing circumferential rub along the blade platform and shroud tip edge

The 3rd stage low turbine stator (T3 stator) was inwardly deformed at 6 o'clock. The T3 blade shroud/blade path at this location was cracked and missing material. The stator vane trailing edges were impact damaged and missing material.

The T3 blades were separated near the platform except for seven that were fractured mid-span. See Figure 11.

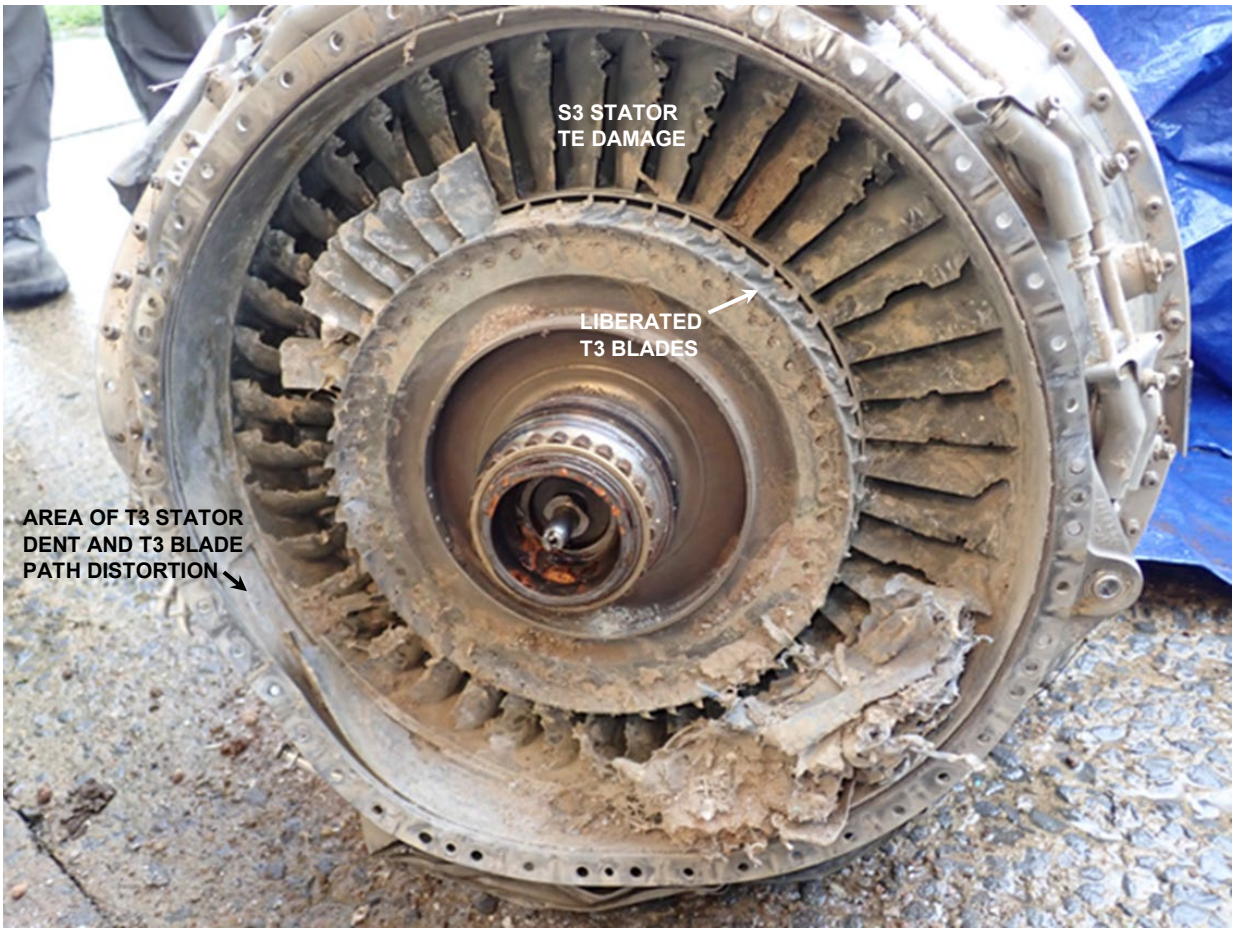

Figure 11. View of the aft end of the low turbine rotor showing deformed T3 blade path, liberated T3 blades and T3 stator trailing edge damage

The T3 blade fracture surfaces showed fracture features consistent with overload where not obscured by secondary damage.

2.0 Right engine

2.1 General condition

The right engine, S/N 77408, was missing all structure forward of the gas generator case forward flange except a section of the accessory gearbox, the fuel pump/fuel control assembly, and the hydraulic pump. The gas generator case and low turbine stator support assembly were compressively deformed. This damage was the most pronounced at 6 o'clock. The turbine exhaust duct exhibited a 360° wavy compressive signature just aft of the strut weldment. See Figure 12.

Figure 12. Representative photograph of engine S/N 77408

Fragments of parts separated from the engine were delivered with the engine. Inspection of the fragments found no damage that was inconsistent with impact.

2.2 Pertinent disassembly findings

Seven compressor impeller vane inducer profiles showed pronounced curling in the direction opposite rotation; the inducer profiles of all remaining vanes were fractured off. The exducer ends of the vanes were heavily scored 360°. All the vane edges were gouged and torn and there was local post-fracture curling of fracture edges in the direction opposite of rotation. See Figure 13.

Figure 13. Right engine front view showing impeller damage

The impeller shroud was severely distorted at the forward (inducer) end. The inside surface displayed heavy circumferential rub consistent with the damage observed to the compressor impeller. See Figure 14.

Figure 14. Impeller housing/shroud showing rotational scoring

The high turbine shaft was separated aft of the high turbine disk splines. Circumferentially-oriented scoring was observed on the shaft fracture surface. See Figure 15.

Figure 15. Post-separation rotational scoring to the high turbine shaft fracture surface

The high turbine stator inner baffle exhibited scoring along the inner diameter (ID). See Figure 16.

Figure 16. Downstream view of the high turbine stator assembly showing circumferential scoring at inner baffle ID

The high turbine upstream face exhibited deep 360° scoring at the center hub radius and along the balance rim. The balance weight retention rivets were machined /missing material. This damage was axially coincident with the inner baffle scoring observed to the high turbine stator downstream face. See Figure 17.

Figure 17. Upstream face of high turbine showing 360° scoring damage at the balance rim

The high turbine downstream face was circumferentially scored along the fir tree roots and rivets, and balance ring diameter. See Figures 18 and 19.

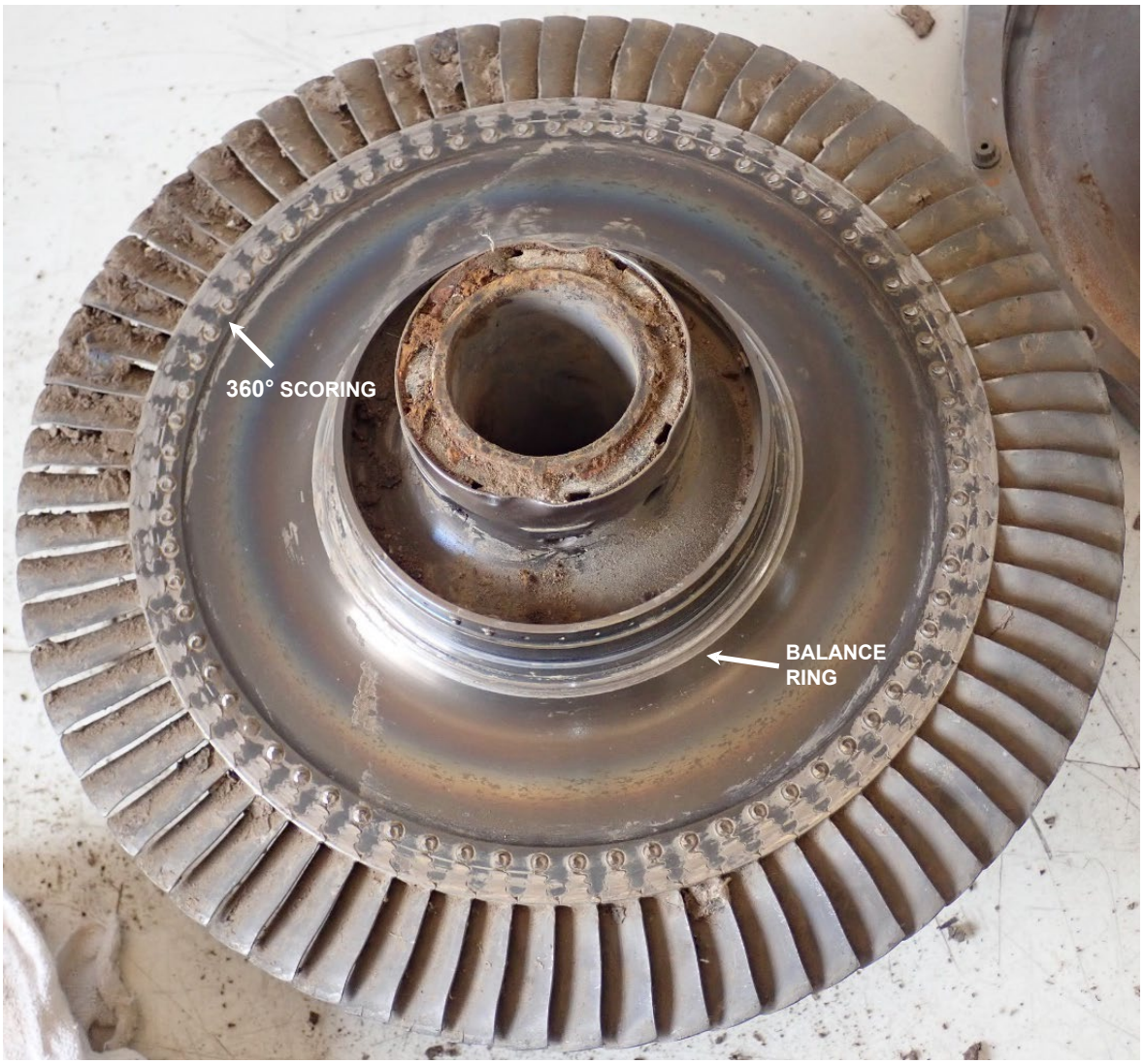

Figure 18. Rotational scoring to high turbine downstream face

Figure 19. Detail of circumferential scoring along fir tree/blade area on high turbine downstream face

The T2 stator upstream face was heavily scored 360° along the vane inner shroud and the inner baffle rim. The damage was severe enough to deform structure and an arc of the inner baffle lip was machined to separation. The locations of the scoring were axially coincident with damage observed to the high turbine downstream face. See Figure 20.

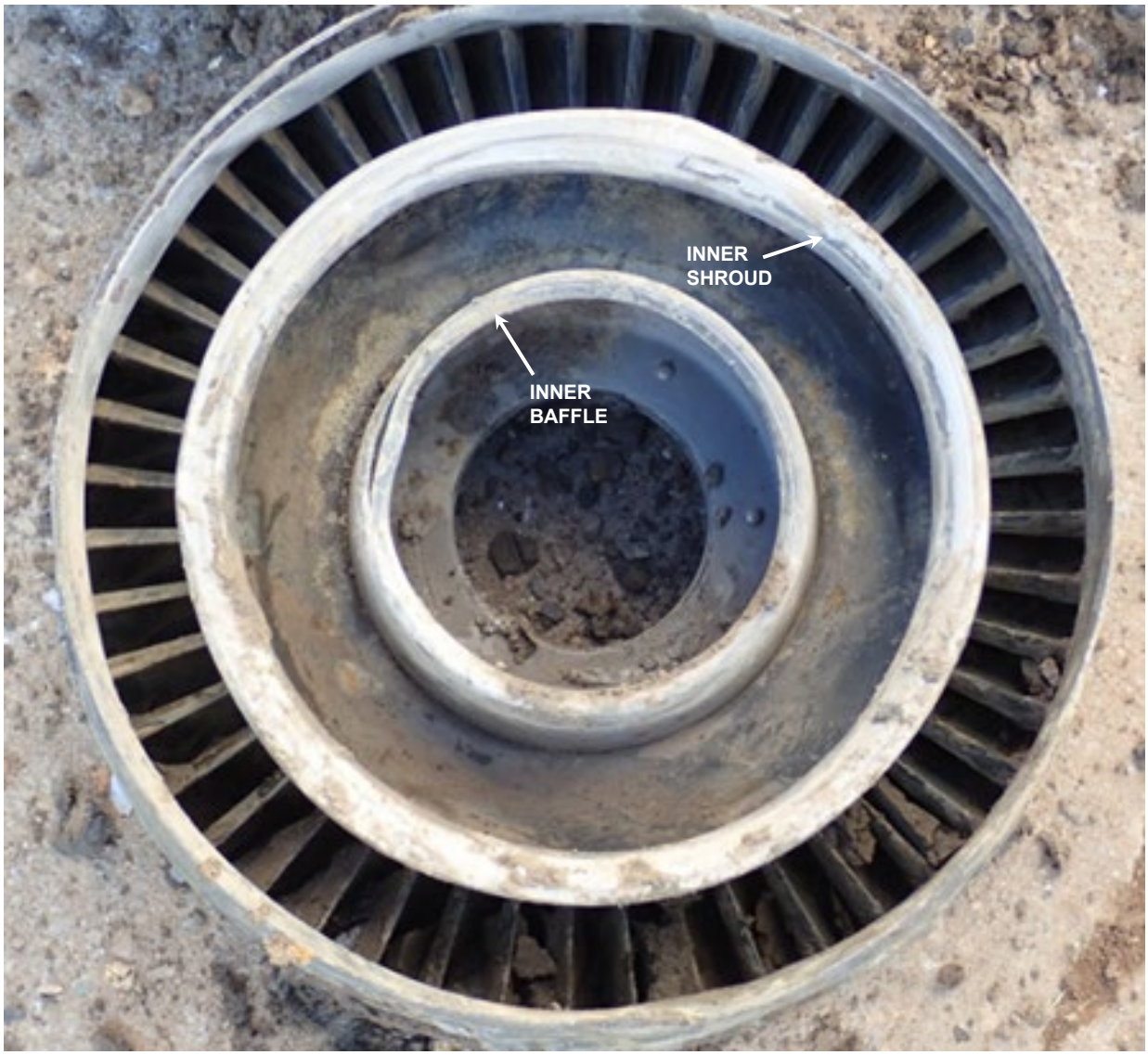

Figure 20. T2 stator upstream face

The low turbine rotor was not disassembled.

All the T3 blades exhibited under platform scoring. See Figure 21. The turbine exhaust duct inner shroud exhibited local scoring consistent with contact with the T3 low turbine blade platforms. See Figure 22.

Figure 21. T3 blade under platform rub

Figure 22. Local circumferential scoring to turbine exhaust duct inner shroud

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