

PT6A SERIES BORESCOPE REPORT

Customer: Ruhe Ag		Work Order # 23-1215	Order/Task: Borescope	Date: 8/16/2023	Tech: Geoffrey Lance
Model: PT6A-34AG	Serial: PCE-56520	TSN: UNK	CSN: UNK	TSO: UNK	CSO: UNK

Engine Installation and Condition on Arrival:

The Engine was installed on aircraft tail number N5048S. Engine was involved in an incident
The propeller was bent from crash landing. Evidence suggests propeller was not moving at time of contact with ground.
The left and right cowling had been removed and reinstalled with only 2 cam locks per piece upon arrival.
The engine oil indicated down three quarts cold.

INSPECTION POINT		FINDINGS:
Inlet and First Stage Blades:		Inlet appeared to be in good shape. First stage blades showed slight erosion and slight rub at the radial tip. No FOD damage was observed.
Combustion Liner:		Heavily damaged and bent from power turbine blade failure. Was required to be cut open to be removed for further inspection.
Small Exit Duct:		Was in general good condition.
CT Vane Ring:		Was in general good condition.
CT Blades:		Trailing edge of blades and disc experienced heavy rub from power turbine.
CT Segments:		Evidence of light rub.
Power Turbine		Experienced blade failure resulting in the PT disc and shaft decoupling from the flex joint connection to the RGB.
Exhaust Duct:		Heavily damaged from PT Blade failure and subsequent PT decoupling.

GENERAL INSPECTION:		FINDINGS:
External Visual:		Engine installation was good.
State of Preservation:		NA

Additional Information:

Propeller spun free but had clicks in the gearbox and zero backlash.

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1. Engine Data Tag



2. Owner supplied picture of aircraft post incident. Pre Inspection.



3. Owner supplied picture of aircraft post incident. Pre Borescope Inspection.



4. Picture of aircraft upon arrival for Borescope Inspection.

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5. First Stage Compressor. Showing signs of very fine erosion.



6. First Stage Compressor Blades.



7. Signs of light rub, top of First Stage Compressor.



8. Signs of light to moderate rub on First Stage Compressor. Bottom/Gravity side.

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9. Centrifugal Compressor Disc. No signs of damage.



10. Centrifugal Compressor Disc. No signs of damage.



11. Centrifugal Compressor



12. Centrifugal Compressor Guide Vanes

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13. Compressor Turbine Blades. No signs of damage.



14. Compressor Turbine Blades. No signs of damage.



15. Compressor Turbine Blades. Bottom side of engine. Showing little to no radial tip clearance.



16. Compressor Turbine Blades. Showing signs of light rub and soot from a fire in the gas path post shutdown.

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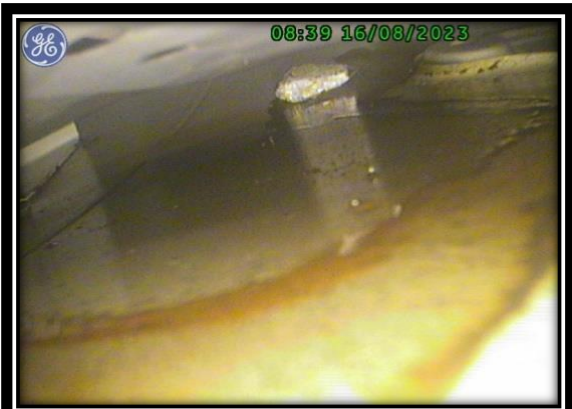
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17. Trailing edge of Compressor Turbine Blades.



18. Trailing edge of Compressor Turbine Blades.



19. Picture of debris in the gas case.



20. Picture of debris in the gas case, at diffuser tubes.

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21. Power turbine blades. Heavily damaged, with breakage.



22. Power Turbine Blades. Heavily damaged, with breakage.



23. Power Turbine Stator and Housing. Damaged from Blade failure.



24. Power Turbine Blades and Disc. Complete Blade failure at the root/fir tree.

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25. Image of PT Blade breakage.



26. PT Blade breakage at root/fir tree.



27. Damage to Exhaust Duct, PT Guide Vanes and Stator Housing.



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29. Close up view of Power Turbine Disc with Blades broken at root.



30. Close up view of Power Turbine Disc with Blades broken at root.



31. Broken Power Turbine Blades.



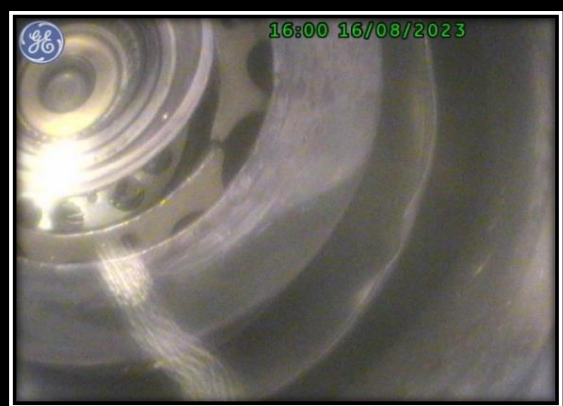
32. Second Stage Reduction Ring Gear.
Note: At this stage in the inspection the gear box siezed and would no longer turn for the remainder of the inspection.

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33. Picture of the 3/4 Bearing Housing. Note: in particular, a missing #3 bearing.



34. Damaged #3 Bearing support webbing.



35. #3 Bearing Cage.



36. #4 Bearing with webbing, bolts, and bearing intact.

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37. Lower right of picture shows possible retaining ring, likely from flex coupling.



38. #3 Bearing Cage. Note: Plating intact and undamaged.



39. #3 Bearing Race.



40. #3 Bearing Race. Note: Broken in half.

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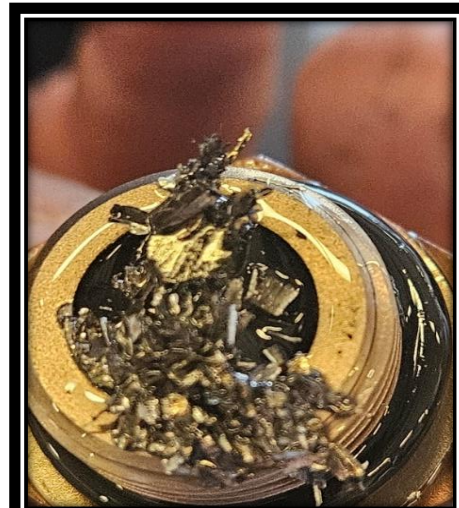
41. #3 Bearing Race Retaining Bolt, sheared.



42. #3 Bearing Bolt, sheared, and broken Race.



43. #3 Bearing Race. Sheared bolts. Roller Bearing and possible Retaining Ring from Flex Coupling.
Note: Images of #3 Bearing Roller and Race does not show indication of oil starvation type bearing failure.



44. Reduction Gear Box chip detector.

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45. Hot Section Component.
Power Turbine Guide Vanes.



46. Steve Vilimonovic inspecting
the Combustion Liner. Liner had
to be cut off with saw due to
heavy damage and warping
encountered as a result of blade



47. Power Turbine Disc and
Blades, as removed.
Note: Retaining Bolt was properly
crimped at time of removal and all
Blade retaining rivets were
installed and tight.



48. Picture of aircraft post
inspection.

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49. Parts as quarantined by Steve and aircraft owner.

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List of Events & Conclusions:

8/16/2023

8:00 AM - Arrived at Ruhe Airport. Steve Vilamononvic (FAA, Cleaveland FSDO) arrived shortly after, followed by (Aircraft Owner & Pilot during incident) Eric Ruhe. Began with immediate discussions about the type of incident, followed by the Borescope Inspection.

Inspection began with a general visual inspection of engine installation. It was found to be acceptable, however dirty.

The propeller spun free, with clicks in the Reduction Gearbox and zero backlash.

Power Turbine was found to be disconnected from Reduction Gear Box.

Compressor Section was found to be siezed, and attempts to rotate were unsuccessful.

The engine oil registered three quarts down cold.

8:20 AM - Borescope inspection began with #7 and #8 fuel nozzle assemblies.

First Stage Compressor did not show signs of FOD, note Picture #5, #6, #7, and #8.

First Stage Compressor showed signs of light to medium rub, note pictures #7 and #8.

Second Stage Guide Vanes showed no signs of damage, note picture #5.

Centrifugal Compressor showed no signs of damage, no did its Guide Vanes. Note pictures #9, #10, #11, and #12.

Compressor Turbine showed signs of soot from a fire in the gas path after shut down. Note picture #16.

No further damage noted to Compressor Turbibe Blades. Note pictures #13, #14, #15, #16, and #17.

Debris from the incident migrated to the gas case during transport from crash site to airfield. Note pictures #19 and #20.

Power Turbine Blades experienced failure and caused significant downstream damage. This also caused the compressor section to sieze when the Power Turbine decoupled from the RGB. Compressor siezed due to the Power Turbine causing the Guide Vanes and Shroud to shift aft, and contact the Trailing Edge of the Compressor Turbine Disc and Blades. Upon removal of the Power Section the Compressor spun freely, with no further signs of damage, at that time.

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Examples of Power Turbine Blade breakage and subsequent damage can be viewed on images #21-#31.

11:30 AM - While borescoping the Reduction Gear Box, the Power Turbine managed to re couple with the Reduction Gear Box, and wedge against the Guide Vanes. This caused the Reduction Gear Box to also sieze. The Gear Box no longer turned, until the Power Section was split at the C-Flange.

When the engine was split at the C-Flange, the Combustion Liner remained attached and the use of a saw was required for removal due to the damage of the shroud containment ring. The Shroud Containment Ring and the Combustion Liner were cut off with permission of the owner and approval of Steve Vilimonovic.

The Power Turbine Disc was then inspected for evidence of blade shift and/or rivet failure. None was observed. The Retaining Bolt was found to be torqued and crimped properly. Note picture #47.

Upon the removal of the Power Turbine Disc assembly, it was noted that the #3 bearing was missing. Note picture #33.

Damage was found to the #3 Bearing Support Webbing. Note picture #34.

#4 Bearing was found to be intact, and installed. Note the foreground of pictures #36, #37, #39, and #40.

The #3 Bearing Outer Race was found to be broken into two pieces with the retaining bolts sheared and the Bearing Rollers dislodged from their cage. Note pictures #41, #42, and #38.

It is important to note that there had been much discusion during the borescope inspection about what may have caused the engine to have been siezed upon arrival. Much of that discussion was centered around possible oil starvation. Note pictures #39, #40 and #43 showing a smooth and shiny finish of the Outer Bearing Race and particularly picture #43 showing a smooth Roller Bearing, smooth and shiny Outer Bearing Race, two sheared bolts as well as what appears to be a retaining ring shown center picture running vertically. These pictures indicate that the #3 bearing was properly lubed until the moment of its failure.

Picture #34 shows damage to the #3 bearing support webbing. Image #41, #42 and #43 show four (4) sheared bolts. These images coupled with the images of smooth and shiny bearing surfaces, and a bearing cage that still has plating (picture #38) indicate that the bearing failed due to factors outside of the bearing itself, or the lubrication system associated with it.

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Conclusion:

With the data currently available, it is likely that one or more of the Power Turbine Blades experienced an in-flight failure, which caused a subsequent failure of the remaining Power Turbine Blades. This resulted in an extreme, unbalanced condition of the Power Turbine Assembly, which caused the #3 Bearing retaining bolts to shear, the outer race to break apart, and the PT shaft to decouple from the Reduction Gear Box. This all preceeded the crash.

END OF REPORT.