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TEARDOWN REPORT OF TWO MODEL TH0871 TURBOCHARGERS PART NUMBER 408610-9001, SERIAL NUMBER JJR0158 (LEFT) AND PART NUMBER 406990-4, SERIAL NUMBER UER0521 (RIGHT)

1. INTRODUCTION AND SUMMARY

1.1 Purpose

This report presents the findings of the teardown and inspection conducted on two AlliedSignal Model TH0871 turbochargers, Part Number 408610-9001, Serial Number JJR0158 (Left), and Part Number 406990-4, Serial Number UER0521 (Right).

The teardown and inspection of the turbochargers and the associated controls was conducted at the Teledyne Continental Motors facility in Mobile, Alabama, on June 29 and 30, 1999. The teardown and inspection was conducted at the request of, and under the cognizance of, the National Transportation Safety Board (NTSB).

1.2 Background

The turbochargers were installed on a Cessna 421B aircraft, Registration Number N34TM, Serial Number 421B-0965. The aircraft crashed near Jefferson City, Missouri, on May 27, 1999.

1.3 Summary

The teardown and inspection of the turbochargers and the associated components disclosed that:

(a) There was no clear evidence that the left turbocharger was rotating at the time of impact. Rotational score marks on the compressor and turbine components may be related to foreign object damage.

(b) The left turbocharger was damaged prior to impact by foreign objects ingested into the turbine housing inlet, as shown by damage to the left turbocharger blade tips, and debris collected from the turbine housing.

(c) There were no pre-accident conditions identified, other than foreign object damage, which would have interfered with normal operation of the left turbocharger.

(d) The right turbocharger was rotating at the time of impact, as shown by rotational score marks on the turbine and compressor components, and bending of the compressor blades opposite to the direction of rotation.

(e) There were no pre-accident conditions identified that would have interfered with normal operation of the right turbocharger.

(f) The right turbocharger wastegate valve housing was retained by the NTSB for subsequent analysis. No conclusion regarding the nature of the fracture is possible, however, the mechanical deformation of the internal wall of the wastegate valve housing is indicative of damage at impact.

2. FINDINGS OF LEFT TURBOCHARGER, MODEL TH0871, PART NUMBER 408610-9001, SERIAL NUMBER JJR0158

NOTE
All observations reported herein are based on visual examinations with the unaided eye, unless otherwise noted.

Figure 1 is an illustrated parts breakdown for the Model TH0871 turbocharger.

2.1 General

(a) The turbocharger was disassembled and examined at the Teledyne Continental Motors facility in Mobile, Alabama, on June 29, 1999.

(b) The turbocharger had been removed from the engine prior to the examination (Figures 2 and 3).

(c) The turbocharger rotor was not free to rotate.

(d) The turbocharger displayed evidence of exposure to fire (Figures 2 and 3).

(e) The wastegate valve and sections of the aircraft exhaust system were attached to the turbocharger turbine inlet flange (Figures 2 and 3).

(f) A sheet-metal heat shield was installed over the turbocharger turbine housing (Figure 2).

(g) The nameplate indicated that AlliedSignal overhauled the turbocharger in October, 1980 (Figure 4).

2.2 Compressor Section

(a) The V-band clamp was intact (Figure 5).

(b) The compressor housing was intact (Figure 6). There was dirt and soot adhering to external surfaces of the compressor housing (Figure 6). The exterior of the compressor housing was deformed (Figure 7) and gouged (Figure 8). There were rotational score marks, over approximately 60 degrees, on the compressor housing impeller shroud adjacent to the exducer portion of the compressor impeller blades (Figure 9). There were static imprints on the compressor housing impeller shroud corresponding to the profile of the compressor impeller blades (Figure 9).

(c) The compressor impeller was intact (Figure 10). There was dirt, soot, and a layer of an unidentified white material adhering to surfaces of the compressor impeller (Figures 10 and 11). There were rotational score marks on the exducer portion of the compressor impeller blades (Figure 12), with corresponding rotational score marks on the compressor housing impeller shroud.

(d) The backplate assembly was intact (Figure 13). There was dirt, soot, and a layer of an unidentified white material adhering to external and internal surfaces of the backplate assembly (Figures 13 and 14). There was thermal deformation on internal surfaces of the backplate assembly (Figure 14).

2.3 Center Section

(a) The center housing was intact (Figures 15). There were carbon and coked oil deposits on external surfaces of the center housing (Figure 15). The turbine (Figure 15) and compressor (Figure 16) bearing lands were oxidized. The center housing oil passages were unobstructed. The locating (anti-rotation) pins on the compressor side of the center housing were undamaged, were the correct type, and were in the proper position (Figure 16).

(b) The compressor (Figure 17) and turbine (Figure 18) journal bearings were intact. There were score marks on the outer diameter (OD) of both bearings (Figures 17 and 18). There were pits on the inner diameter (ID) of both bearings. The inner diameters of both bearings were axially scored during removal of the turbine wheel and shaft. The bearings displayed normal operational discoloration (Figures 17 and 18). The ID and OD of both bearings were measured with a calibrated micrometer, and were within service limits, as shown in Table I (reference Appendix I).

(c) The thrust bearing (Figure 19), thrust spacer, and thrust collar (Figure 20) were intact and displayed normal operational discoloration. The thrust collar was oxidized (Figure 20). The ID of the thrust collar was damaged during removal of the turbine wheel shaft (Figure 20).

Table I. Journal Bearing Diameters.

	Compressor	Turbine
Bearing Journal OD (inches)	0.978	0.978
Minimum OD (inches)	0.978	0.978
Bearing Journal ID (inches)	0.627	0.626
Maximum ID (inches)	0.6272	0.6272
Part Number	4922-0	4922-0

2.4 Turbine Section

(a) The turbine wheel shroud was intact (Figure 21). There was oxidation on all surfaces of the turbine wheel shroud. There was loose carbon and coked oil debris on internal surfaces of the turbine wheel shroud (Figure 21). There were rotational score marks on the surface of the turbine shroud adjacent to the back face of the turbine wheel (Figure 22).

(b) The turbine housing was intact (Figure 23). There was metallic debris within the turbine housing (Figure 24). There was an unidentified residue on external surfaces of the turbine housing (Figure 23). There was oxidation on all internal surfaces of the turbine housing (Figure 23). The exterior of the turbine housing was cracked adjacent to one bolt location (Figure 25), and deformed in the spine of the inlet housing (Figure 26). The divider wall of the turbine housing was cracked, eroded, and deformed at the exhaust gas inlet (Figure 27). The turbine housing tongue was eroded and cracked (Figure 28).

(c) The tips of all turbine wheel blades were fractured (Figure 29). The separated sections of the turbine wheel blade tips were not available for examination. There was an unidentified residue on the turbine wheel (Figure 29). There were rotational score marks at the base of the back face of the turbine rotor (Figure 30).

(d) The turbine wheel piston ring was oxidized, but expanded and compressed freely (Figure 31).

(e) The turbine rotor shaft bearing surfaces were oxidized, but were otherwise undamaged (Figure 31). The turbine rotor shaft bearing journals displayed normal operational discoloration (Figure 31). The OD of the bearing journals was measured with a calibrated micrometer, and was below service limits (reference Table II and Appendix I). The turbine shaft nut and threads were intact.

Table II. Turbine Wheel Shaft Bearing Journal Diameters.

	Compressor	Turbine
Bearing Journal OD (inches)	0.6250	0.6250
Minimum OD (inches)	0.6251	0.6251

2.5 Controls

(a) The wastegate valve housing was attached to the turbine housing exhaust gas inlet flange (Figures 2 and 3). The wastegate actuator bracket mounting bolts were fractured (Figure 32). The wastegate actuator was not available for examination. No part number or serial number information was identified. The wastegate butterfly valve was found in a partially opened position (Figure 2), and was not free to move. The wastegate actuating linkage was not available for examination.

(b) The wastegate valve housing internal divider wall was eroded (Figure 33). There was oxidation on all internal surfaces of the wastegate valve housing (Figures 32 and 33).

(c) No other controls were available for examination.

3. FINDINGS OF RIGHT TURBOCHARGER, MODEL TH0871, PART NUMBER 408610-9001, SERIAL NUMBER UER0521

3.1 General

(a) The turbocharger was disassembled and examined at the Teledyne Continental Motors facility in Mobile, Alabama, on June 30, 1999.

(b) The turbocharger had been removed from the engine prior to examination (Figure 34).

(c) The turbocharger displayed evidence of exposure to fire (Figure 34).

(d) The turbocharger rotor was not free to rotate.

(e) The wastegate valve housing and sections of the aircraft exhaust system were attached to the turbocharger turbine inlet (Figure 34) and discharge flanges. The wastegate valve housing was fractured.

(f) A sheet-metal heat shield was installed over the turbocharger turbine housing (Figure 34).

(g) The nameplate indicated that Main Turbo Systems, Inc. (Figure 35) remanufactured the turbocharger.

3.2 Compressor Section

(a) The V-band clamp was intact (Figure 36).

(b) The compressor housing was intact (Figure 37). There were gouges on the exterior of the compressor housing (Figure 37). There was soot and dirt adhering to external surfaces of the compressor housing (Figure 37). There were rotational score marks, over approximately 180 degrees, on surfaces of the impeller shroud adjacent to the inlet portion of the compressor impeller blades (Figure 38). There were rotational score marks, over approximately 60 degrees, on surfaces of the impeller shroud adjacent to the exducer portion of the compressor impeller blades (Figure 38). There was a layer of what appeared to be soot and dirt deposited over the rotational score marks (Figure 38).

(c) The compressor impeller was intact (Figure 39). There was soot and dirt adhering to surfaces of the compressor impeller (Figure 40). There were rotational score marks, through 360 degrees, on the back face of the compressor impeller (Figure 41), with corresponding rotational score marks on the compressor backplate assembly. The impeller blade tips at the compressor impeller inlet were bent opposite to the direction of rotation (Figure 42).

(d) The backplate assembly was intact (Figure 43). There was dirt and soot adhering to external surfaces of the compressor backplate (Figure 43). There were rotational score marks, through 360 degrees, on the compressor backplate surface adjacent to the back face of the compressor impeller (Figure 44), with corresponding rotational score marks on the back face of the compressor impeller. There was a layer of coked oil in the bearing cavity of the compressor backplate (Figure 43).

3.3 Center Section

(a) The center housing was fractured at the six retaining bolt locations (Figure 45). There was corrosion on all surfaces of the center housing (Figures 45 and 46). There was corrosion on both bearing surfaces of the center housing (Figures 45 and 46). There were coked oil deposits on external surfaces on the turbine side of the center housing. The center housing oil passages were unobstructed. The locating (anti-rotation) pins on the compressor side of the center housing were solid (Figure 46). AlliedSignal does not authorize solid pins for installation in aircraft turbocharger center housings.

(b) The compressor (Figure 47) and turbine (Figure 48) bearings were intact. There was a layer of coked oil on both bearings (Figures 47 and 48). There were score marks on the OD of both bearings (Figures 47 and 48). There were pits on the ID of both bearings. The ID of both bearings was axially scored during removal of the turbine wheel and shaft. The ID and OD of both bearings were measured with a calibrated micrometer, and were within service limits, as shown in Table III (reference Appendix I).

(c) The thrust collar (Figure 49), thrust bearing (Figure 50), and thrust spacer (Figure 51) were intact. The thrust spacer piston rings were intact and free to expand and compress (Figure 51). There were rotational score marks on the thrust bearing surfaces adjacent to the compressor bearing (Figure 50). There was corrosion on the thrust collar, thrust spacer, and thrust bearing (Figures 49 through 51). The retaining rings and washers were intact (Figure 52). There was corrosion on the retaining rings and washers (Figure 52).

Table III. Journal Bearing Diameters.

	Compressor	Turbine
Bearing Journal OD (inches)	0.978	0.978
Minimum OD (inches)	0.978	0.978
Bearing Journal ID (inches)	0.625	0.625
Maximum ID (inches)	0.6272	0.6272
Part Number	4922-0	4922-0

3.4 Turbine Section

(a) The turbine housing was intact (Figure 53). There were rotational score marks, over approximately 360 degrees, at the turbine housing outlet adjacent to the turbine blade tips (Figures 53 and 54), with corresponding rotational score marks on the turbine blade tips. There was a weld on the exterior of the turbine housing adjacent to one bolt location (Figure 55). AlliedSignal does not authorize weld repairs of the turbine housing. The divider wall of the turbine housing exhaust gas inlet was cracked, eroded, and deformed (Figure 56). There was oxidation on all internal surfaces of the turbine inlet housing (Figures 53, 54, and 56).

(b) The turbine wheel shroud was intact (Figures 57 and 58). There was oxidation on all surfaces of the turbine wheel shroud (Figure 57 and 58). There were rotational score marks on the surface of the turbine wheel shroud adjacent to the back face of the turbine wheel (Figure 57). There was a layer of coked oil on the internal surface of the turbine wheel shroud (Figure 58).

(c) The turbine wheel was intact (Figure 59). There was oxidation on the turbine wheel (Figures 59 through 62). There were rotational score marks on the back face of the turbine wheel (Figure 60), with corresponding rotational score marks on the turbine wheel shroud. There were rotational score marks on all turbine blade tips (Figure 61), with corresponding rotational score marks on the turbine inlet housing.

(d) The turbine wheel piston ring was corroded, but expanded and compressed with resistance (Figure 62).

(e) The turbine rotor shaft bearing surfaces displayed normal operational discoloration (Figures 59 and 62). The turbine rotor shaft bearing surfaces were axially scored during disassembly (Figures 59 and 62), but were otherwise undamaged. The OD of the bearing journals was measured with a calibrated micrometer and was 0.0001 inch below the minimum service limit (reference Table IV and Appendix I). There was corrosion on the turbine shaft nut and threads (Figure 59).

Table IV. Turbine Wheel Shaft Bearing Journal Diameters.

	Compressor	Turbine
Bearing Journal OD (inches)	0.6250	0.6250
Minimum OD (inches)	0.6251	0.6251

3.5 Controls

(a) The wastegate valve housing was attached to the turbine housing exhaust gas inlet flange (Figure 34). The wastegate valve housing was fractured at two of the wastegate actuator bracket mounting bosses (Figure 63), and between two of the mounting locations (Figure 64). The separated piece of the wastegate valve housing was not available for examination. The divider wall of the wastegate valve housing was fractured and mechanically deformed (Figure 65) inwards. The wastegate butterfly valve was found in the fully closed position (Figure 66), and was not free to move.

(b) No other controls were available for examination.

4. ANALYSIS AND CONCLUSIONS

The teardown and examination of the turbochargers and associated components disclosed that:

(a) There was no clear evidence that the left turbocharger was rotating at the time of impact. Rotational score marks on the compressor and turbine components may be related to foreign object damage.

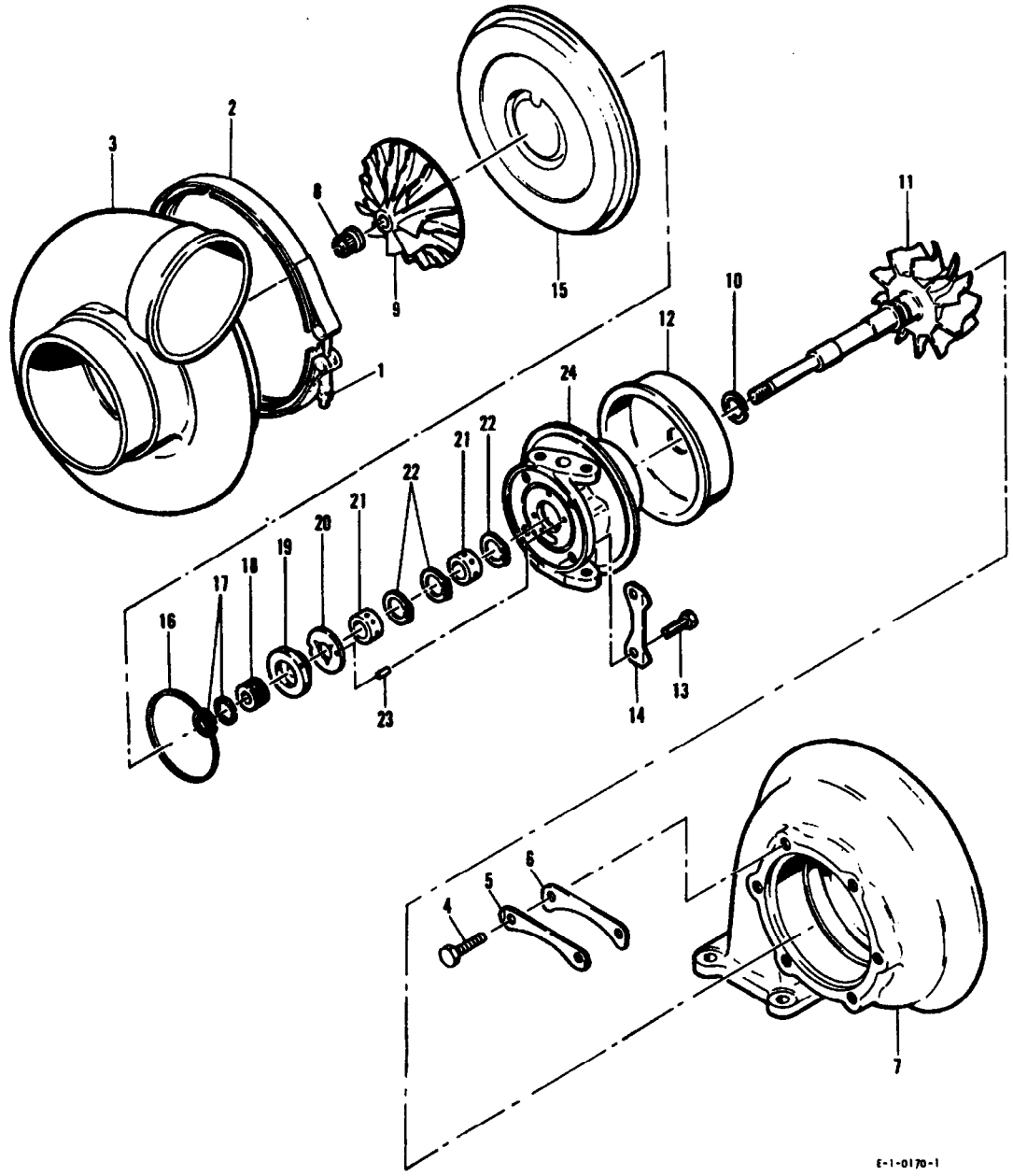
(b) The left turbocharger was damaged prior to impact by foreign objects ingested into the turbine housing inlet, as shown by damage to the left turbocharger blade tips, and debris collected from the turbine housing.

(c) There were no pre-accident conditions identified other than foreign object damage that would have interfered with normal operation of the left turbocharger.

(d) The right turbocharger was rotating at the time of impact, as shown by rotational score marks on the turbine and compressor components, and bending of the compressor blades opposite to the direction of rotation.

(e) There were no pre-accident conditions identified that would have interfered with normal operation of the right turbocharger.

(f) The right turbocharger wastegate valve housing was retained by the NTSB for subsequent analysis. No conclusion regarding the nature of the fracture is possible, however, the mechanical deformation of the internal wall of the wastegate valve housing is indicative of damage at impact.



1. LOCKNUT
2. V-BAND COUPLING
3. COMPRESSOR HOUSING
4. BOLT
5. LOCKPLATE
6. CLAMP
7. TURBINE HOUSING
8. LOCKNUT
9. COMPRESSOR WHEEL
10. PISTON RING
11. TURBINE WHEEL ASSEMBLY
12. WHEEL SHROUD
13. BOLT
14. LOCKPLATE
15. BACKPLATE ASSEMBLY
16. SEAL RING
17. PISTON RING
18. THRUST SPACER
19. THRUST COLLAR
20. INBOARD THRUST BEARING
21. BEARING
22. RETAINING RING
23. PIN
24. CENTER HOUSING

Figure 1. Illustrated Parts Breakdown for TH08 Series Turbochargers.