Log # 2579

National Transportation Safety Board

Washington, D.C. 20594

Safety Recommendation

Date: NOV 14 1996

In reply refer to: A-96-124 through -127

Honorable David R. Hinson
Administrator
Federal Aviation Administration
Washington, D.C. 20591

On January 5, 1995, at 1835 mountain standard time, a Beech A60 Duke, N3LP, lost power on one engine during climb to cruise flight, and subsequently crashed near the Silver City/Grant County Airport, Hurley, New Mexico. The pilot and two passengers were killed, and the airplane was destroyed. The intended business flight from Hurley, New Mexico, to Mesa, Arizona, was being conducted under Title 14 Code of Federal Regulations (CFR) Part 91. At the time of the accident, visual meteorological conditions prevailed. The Safety Board determined that the probable cause of this accident was the pilot's failure to maintain airspeed during a single-engine approach, resulting in an inadvertent stall. Also a factor in this accident was the fatigue separation of the turbine shaft in the left engine turbocharger because of improper repair by maintenance personnel, which resulted in the loss of power to the left engine.[1]

The Safety Board's investigation of the accident found that the turbine shaft on the left engine turbocharger, an AlliedSignal Aerospace Company Model T1879, was fractured where the shaft is joined to the turbine wheel.[2] Examination of the turbine shaft in the Safety Board's materials laboratory revealed ratchet marks indicative of fatigue cracking initiating from a large number of origins within the radius. Scanning electron microscope (SEM) examination disclosed fatigue striations on the relatively undamaged regions of the fracture. The turbine shaft normally has a fillet radius at the point where the shaft is joined to the turbine wheel; however, the failed shaft had a sharp corner. SEM examination showed that the radius had been filled with chrome plating that had increased the dimension of the turbine shaft bearing journal lands to the dimension of the adjacent section of the turbine shaft. A longitudinal section taken through the centerline of the turbine shaft revealed that the shaft met the manufacturer's dimensional requirements before chrome plating. The AlliedSignal overhaul manual for the Model T1879 turbocharger states that chrome plating of shaft journals and wheel hub surfaces is not permitted.

[1]For more detailed information, read Brief of Accident FTW95FA082 (attached).

[2]See Figure 1 for a diagram of the AlliedSignal Model T1879 Turbocharger.

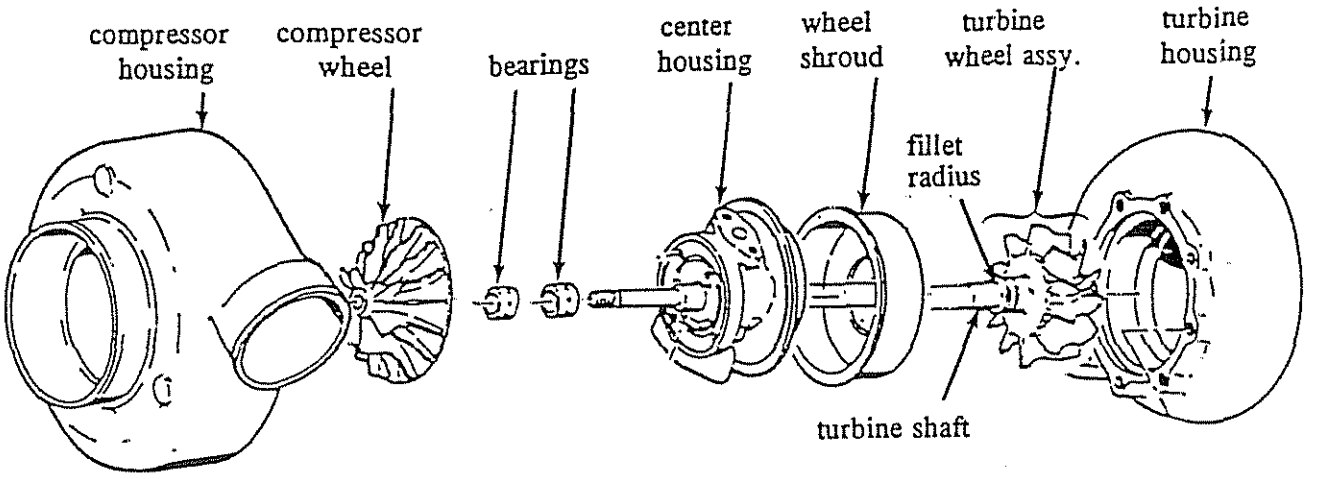

Figure 1. AlliedSignal Model T1879 Turbocharger

Further examination of the accident turbocharger showed that the locating pins for the center housing thrust collar were the type used in diesel turbocharger applications, instead of the split pins required for aircraft applications. There were no identifying marks or part numbers on the center housing, the compressor, or the turbine bearing. The turbine bearing was worn with extruded material on the ends of the bearing. Examination of the turbocharger's center housing revealed a microstructure of gray iron containing graphite flakes, typical of diesel applications; the AlliedSignal-specified material for aircraft turbocharger center housings is a ductile iron containing graphite in the form of nodules. AlliedSignal requires replacement of the turbocharger center housing and locating pins for the center housing thrust collar when the pins become worn.

AlliedSignal, through its Automotive Division, manufactures four models of aircraft turbochargers (T18, TE06, TH08, and TA04) with center housings that appear identical to the center housing in its turbochargers manufactured for use in diesel (automotive) engines. Ninety-five percent of the turbochargers manufactured by AlliedSignal are designed for diesel application, and only 5 percent are designed for aviation use.[3] AlliedSignal stated that the turbocharger center housings are sold to automotive and aircraft retailers for about the same cost; however, markup differences result in some aircraft center housings costing considerably more than similar automotive housings.

[3]AlliedSignal model numbers (T18, TE06, TH08, and TA04) consist of base numbers followed by a two-digit suffix indicating minor differences within each model turbocharger.

Aircraft turbocharger center housing thrust collar split pins have a greater shear strength than the diesel locating pins. The diesel-application pins are more prone to fracturing and rapid wearing than the split pins used in aircraft turbochargers. The turbocharger center housing material used for diesel applications is more prone to impact damage and is more porous than the stronger, more fatigue-resistant, aircraft center housing material. In addition, the diesel-application housings are not pressure-tested to demonstrate compliance with the performance requirements of 14 CFR Part 23.909, "Turbocharger Systems, Powerplant, Airworthiness Standards: Normal, Utility, Acrobatic, and Commuter Category Airplanes." The center housings for both diesel and aircraft turbochargers are ink-stamped with a part number and serial number at manufacture, but those ink stamp numbers, according to AlliedSignal, wear off after about 100 hours of operation.

AlliedSignal obtained Parts Manufacturer Approval (PMA - PQ1279NM, Supplement 3) for the Model T18 aviation turbocharger on July 20, 1995. Obtaining PMA enables AlliedSignal to sell a specific product directly to the aviation industry, as opposed to the turbocharger certificate holder. Title 14 CFR 45.15 states that, except as provided below, anyone who produces a part under a PMA shall permanently and legibly mark the part with the following designations: (1) the letters "FAA-PMA"; (2) the name, trademark, or symbol of the holder of the PMA; (3) the part number; and (4) the name and model designation of each type-certificated product on which the part is eligible for installation. The FAA provides that parts that are too small, or when impractical, may be tagged with the information that could not be marked on the part. The tag may refer to a specific readily available manual or catalog for part eligibility information. The Safety Board believes that because AlliedSignal is capable of identifying turbocharger center housings with an ink stamp, it should also be able to identify the housings permanently. Had the aircraft turbocharger components been permanently identified, on N3LP, unapproved diesel application parts may have not been installed.

The Safety Board's review of N3LP engine logbooks revealed that the turbocharger had been overhauled by Warrior Enterprises, Inc., an FAA-approved repair station, in Mesa, Arizona, on October 24, 1989, and installed on the left engine of N3LP on October 26, 1989. On October 31, 1990, FAA inspectors from the Scottsdale, Arizona, Flight Standards District Office (FSDO) conducted an in-depth repair station facility inspection at Warrior Enterprises. The FAA's inspection cited alleged violations of Federal regulations and the unapproved repair of an AlliedSignal turbocharger, installed on the right engine of a Cessna 401 on August 30, 1990. The Cessna's maintenance records indicated that the overhauled turbocharger had failed within 10 hours of overhaul. After the turbocharger failed, Warrior again repaired the turbocharger and issued a serviceable part tag on December 3, 1990. The FAA stated that Warrior failed to follow the methods, techniques, and practices acceptable to the Administrator, failed to do the work in the manner prescribed by the manufacturer, and did not return the turbocharger to a condition that was at least equal to its original or properly altered condition. On December 31, 1990, the FAA revoked the Warrior Enterprises repair station certificate.

Because of the issues raised during the investigation of the January 5, 1995, accident--improper chrome plating, unauthorized use of automotive parts, and inadequate marking of AlliedSignal aircraft turbocharger parts--the Safety Board conducted a review of its data base to determine if other, similar accidents had occurred. The first accident known to the Safety Board involving chrome plating of an AlliedSignal turbocharger turbine shaft occurred on January 13, 1992, when a Cessna T210L, N22592, lost power during a 14 CFR Part 135 sightseeing flight over the Grand Canyon near Temple Bar, Arizona. The airplane was destroyed during the subsequent emergency landing 300 feet short of runway 18 at Temple Bar Airport. The pilot and two passengers received serious injuries, and two other passengers were killed. The Safety Board determined that the probable cause of this accident was the fatigue failure of the turbocharger's turbine shaft because of inadequate maintenance.[4]

The examination of the airplane's turbocharger, an AlliedSignal Aerospace Company Model TE0659, by a metallurgist contracted by the Safety Board, revealed that the turbine shaft had failed because of multiple fatigue cracks initiating from the shaft surface under a layer of chrome plating.[5] The Safety Board found that the turbine bearing journal on the turbine shaft had been improperly chrome plated and machined. The metallurgist concluded that chrome plating of the turbine shaft did not restore the original strength of the turbine shaft.

According to N22592 logbooks, the turbocharger had been operated 125.4 hours since its overhaul on September 10, 1989. The turbocharger had been overhauled by Main Turbo Systems (an FAA-approved repair station) in Visalia, California, and Southwest United Industries, Inc., (an FAA-approved repair station) in Tulsa, Oklahoma, had performed the chrome plating of the turbine shaft and had supplied Main Turbo Systems with the reworked turbine shaft that was installed in N22592's turbocharger. According to the FAA, Southwest United Industries, Inc., and its parent company, Southwest Aeroservice (an FAA-approved repair station), had received FAA authorization to perform machining and chrome plating of AlliedSignal turbocharger turbine shafts in accordance with Federal Specification QQ-C-320B.[6] The Safety Board is extremely concerned that the FAA approved a repair procedure that is not consistent with the manufacturer's overhaul procedure--the Safety Board is especially concerned because, if applied incorrectly, the chrome plating of the AlliedSignal turbocharger turbine shaft may adversely affect the balance and fatigue life of the shaft, resulting in an in-flight failure of the turbocharger. The Safety Board believes that the FAA should prohibit repairs to AlliedSignal turbochargers that

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[4]For more detailed information, read Brief of Accident LAX92FA092 (attached).

[5]The metallurgical examination report of N22592's turbocharger turbine shaft by Gary J. Fowler, Ph.D., of Fowler Incorporated, is titled "Metallurgical Analysis of Fractured Turbocharger Turbine Shaft" and is included in the Safety Board's report of the accident.

[6]On June 19, 1985, FAA Special Programs Branch, ASW-190, approved Process Number SWU-001 from Southwest United Industries, Inc., for the chrome plating of AlliedSignal turbocharger turbine wheel shafts in accordance with 14 CFR 43.13, "Performance Rules (general), Maintenance, Preventative Maintenance, Rebuilding, and Alteration."

are contrary to the procedures recommended by the manufacturer--procedures that have already been approved by the FAA.

Another accident involving the use of automotive parts in aircraft turbochargers occurred on February 22, 1995, at 2030 mountain standard time. A Beech 60 Duke, N100BL, was substantially damaged during a night forced landing after losing power on both engines near Santa Rosa, New Mexico. The pilot reported that after takeoff, while climbing through flight level 220, the right engine lost power. While initiating an emergency descent, the left engine also lost power, and the pilot executed a forced landing in rough terrain 1/3 mile west of Santa Rosa Airport. The pilot and two passengers were not injuried. The intended personal, cross-country flight was being conducted under 14 CFR Part 91. At the time of the accident, visual meteorological conditions prevailed. The Safety Board determined that the probable cause of this accident was the failure of the right engine's turbocharger resulting in oil starvation and subsequent failure of the No. 5 connecting rod, which penetrated the crankcase, and the failure of the left engine's turbocharger, resulting in the loss of power on both engines. A factor contributing to the accident was the installation of unapproved turbocharger parts.[7]

Examination of the airplane's right engine by the Safety Board revealed that the turbine shaft of the AlliedSignal Model T1823 turbocharger had separated from the turbine wheel. Examination of the left engine's turbocharger also revealed separation of the turbine wheel from the turbine shaft.[8]

Further examination of the right and left engine turbochargers found that the journal bearings were not approved AlliedSignal aircraft turbocharger parts. The turbine inlet temperature probes from both turbochargers were installed at shallow depths, resulting in excessive heat erosion and operation of the turbochargers at temperatures above specifications. Both turbocharger center housing thrust bearings contained diesel-application roll pins, instead of the split pins used in aviation turbochargers.

Another accident that resulted from unapproved repairs and the use of automotive parts in an aircraft turbocharger occurred on December 20, 1995, at 2030 eastern standard time. The pilot of N5083C, a Cessna T210N equipped with a Teledyne Continental Motors TSIO-520-R engine and an AlliedSignal TE0659 turbocharger, reported a total loss of power shortly after takeoff from Indianapolis International Airport, Indianapolis, Indiana, on an intended 14 CFR Part 135 cargo flight. The pilot reported that after takeoff, the engine surged, and then continued to operate normally; after reaching 4,000 feet, there were "large power fluctuations" and a loud bang, followed by a total loss of engine power. The airplane was substantially damaged during the emergency landing in darkness. The pilot was not injured. The Safety Board determined that the probable cause of this accident was the failure of the turbocharger, caused by an unapproved

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[7]For more detailed information, read Brief of Accident FTW95LA119 (attached).

[8]The Beech 60 airplane is equipped with two Lycoming TIO-541-E1A4 engines and two AlliedSignal Model T1823 turbochargers.

rebuild of the turbocharger, which contained automotive parts. Debris from the failed turbocharger damaged the oil scavenge pump, resulting in lack of engine lubrication.[9]

Examination of the airplane's engine by the Safety Board revealed that the engine-driven oil scavenge pump drive shaft failed where the splines attach to the accessory gear. A piece of the AlliedSignal turbocharger snap ring was found jammed between the oil scavenge pump gears and the case.[10] Examination of the turbocharger found that a portion of the bearing area in the center of the turbine shaft was the same diameter as the adjacent bearing journals. The metal used to build up the turbine shaft was not identified; however, examination revealed that the shaft had been plated and then machined to the final diameter. Excessive end play was also found, and the compressor and turbine blades exhibited damage that matched rub damage found on the internal surface of the turbocharger housing. Further examination revealed that the turbine bearing journal was oversized, and the center housing journal bearing mount surface had been bored oversized, to accept the larger turbine bearing. The AlliedSignal overhaul manual for the Model TE0659 turbocharger states that reboring of the center housing bearing bores is prohibited. Examination of the turbocharger center housing in the Safety Board's materials laboratory revealed that the microstructure of the part contained graphite flakes, typical of the diesel-application version of the turbocharger. The center housing thrust collar locating pins were a spiral design, also typical of a diesel-application turbocharger. The turbine bearings were also diesel-application parts.

The engine logbooks from N5083C indicated that the turbocharger had been overhauled by KelPak Industries (an FAA-approved repair station) in Visalia, California, on December 13, 1988. The KelPak work order for the overhaul of the accident turbocharger indicated that all of the parts that had been replaced were AlliedSignal aircraft turbocharger part numbers. Although automotive parts were found in the turbocharger after the accident, a representative of the FAA's Los Angeles Aircraft Certification Office reported that the FAA found no evidence that KelPak had knowingly installed unapproved automotive parts in N5083C's turbocharger.

The Safety Board is concerned that the installation of unapproved automotive components in AlliedSignal aircraft turbochargers may be a widespread practice. The Board is also concerned that it is difficult to identify turbocharger center housings and internal components in AlliedSignal turbochargers that may have been improperly overhauled or repaired, and that may contain unapproved and less reliable automotive parts. Further, the chrome plating of AlliedSignal aircraft turbocharger turbine shafts, which does not comply with the manufacturer-recommended overhaul procedures, can result in the in-flight failure of the turbocharger. Finally, Allied Signal's current ink stamp identification of the turbocharger center housing is not adequate as a means of identifying the parts in service.

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[9]For more detailed information, read Brief of Accident CHI96LA060 (attached).

[10]The oil scavenge line runs from the turbocharger to the oil scavenge pump on the Cessna T210N airplane, equipped with a Continental TSIO-520-R engine and an AlliedSignal Model TE0659 turbocharger.

Therefore, the National Transportation Safety Board recommends that the Federal Aviation Administration:

Require operators of all AlliedSignal aircraft turbochargers overhauled or repaired by repair stations other than the manufacturer's to inspect those turbochargers for unauthorized parts or for chrome plating that is not recommended by the manufacturer. Require the removal and replacement of these component parts when found. (A-96-124)

Examine the policy that allowed the FAA to approve machining and chrome plating of AlliedSignal aircraft turbocharger turbine shafts when such repairs were contrary to the procedures recommended by the manufacturer. Rescind that approval and issue an airworthiness directive requiring the removal of all chrome-plated turbine shafts and replacement with approved AlliedSignal aircraft turbocharger turbine shafts. (A-96-125)

Inform repair stations that overhaul and repair AlliedSignal turbochargers for aircraft applications that the installation of diesel-application components in lieu of aircraft components can inadvertently occur. Determine and disseminate to turbocharger repair facilities or aircraft operators who maintain or operate AlliedSignal turbochargers a non-destructive method of identifying diesel-application parts installed in AlliedSignal aircraft turbochargers. (A-96-126)

Require AlliedSignal to permanently and clearly mark all new turbocharger center housings, intended for aircraft installations, designating the part number and serial number, and the intended installation of the component. (A-96-127)

Chairman HALL, Vice Chairman FRANCIS, and Members HAMMERSCHMIDT, GOGLIA and BLACK concurred in these recommendations.

By: Jim Hall
Chairman