Log 2606

National Transportation Safety Board

Washington, D.C. 20594

Safety Recommendation

Date: JUL 1 1996

In reply refer to: A-96-35 through -37

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

On September 2, 1995, about 0838 mountain standard time, a Cessna 421C airplane, N6234G, crashed in hilly desert terrain near Beaver Dam, Arizona. All eight occupants were killed, and the airplane was destroyed. The airplane was being operated as a corporate/executive flight under the provisions of Title 14 Code of Federal Regulations (CFR) Part 91, from North Las Vegas, Nevada, to West Yellowstone, Montana. Visual meteorological conditions prevailed.

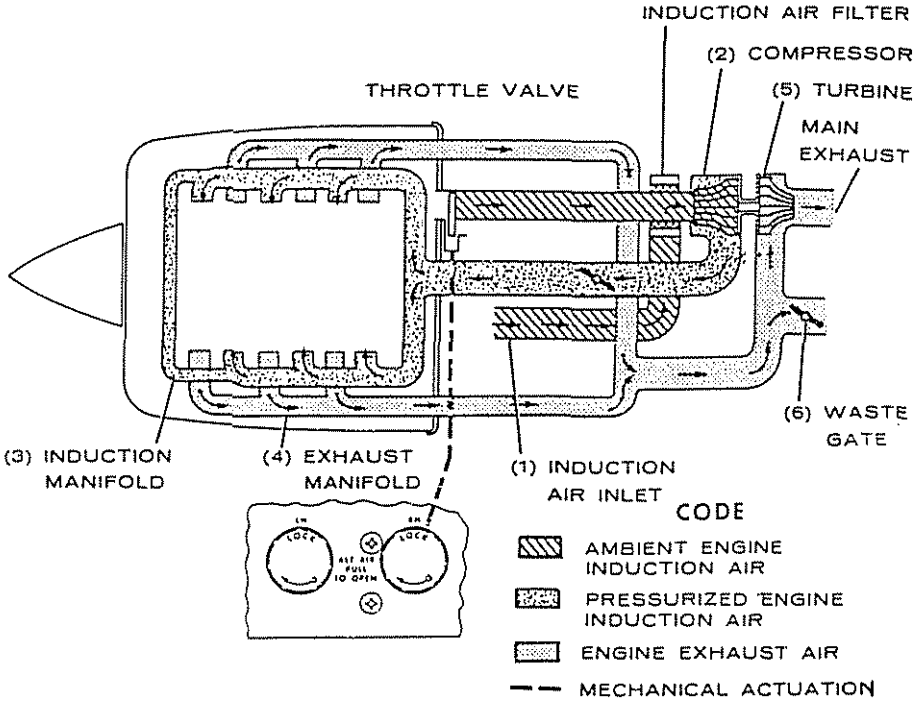
As the airplane was climbing through 18,400 feet, the pilot reported that he had a turbocharger problem and requested clearance to return to North Las Vegas. Air traffic control cleared the airplane to 14,000 feet and then to 10,000 feet. A few minutes later, the pilot reported that he might lose the left engine and that he was unable to maintain 10,000 feet, which was the minimum vectoring altitude in that area. He declared an emergency and diverted towards the Mesquite Airport (elevation 1,975 feet), Mesquite, Nevada. Witnesses observed the airplane overshoot the extended centerline of the runway and enter a steep left bank that tightened to a nose-low left spin. The airplane reportedly made three or four turns in the spin before ground impact.

The National Transportation Safety Board determined that the probable cause of the accident was the pilot's failure to maintain an adequate airspeed while maneuvering on final approach, which resulted in an inadvertent stall/spin and the uncontrolled collision with terrain. Contributing factors included exceeding the aircraft's weight and balance limitations, the pilot's lack of recurrent training in the airplane, inadequate inspection and maintenance of the engine exhaust system, and an exhaust gas leak in the left engine exhaust system.[1]

[1]For more detailed information, see Brief of Accident LAX95FA319 (attached).

The examination of the wreckage showed that the left engine exhaust system Wye duct collector (which was made from Inconel 601),[2] part of the engine turbocharger system (see schematic shown below), had a warped flange at the outlet to the waste gate, with evidence of exhaust gas leakage in the warped area of the flange. The airplane structure next to the Wye duct collector also showed impingement from exhaust gases leaking from the warped flange.

TURBO-SYSTEM SCHEMATIC



In the Cessna 421C Pilot's Operating Handbook, the manufacturer states, in part, that changes in the flow of exhaust gases into the turbine will increase or decrease the speed of the turbocharger. A leak in the exhaust system, such as the one noted at the left engine waste gate outlet flange of the accident airplane, would cause a decrease in the turbine speed, and consequently, a loss of engine power.

In 1975, because of a series of stainless steel exhaust system problems in certain Cessna series aircraft, the Federal Aviation Administration (FAA) issued Airworthiness Directive (AD) 75-23-08, which set forth the inspections and parts replacements required to improve the reliability of the exhaust systems of Cessna twin-engine, turbocharged airplanes, which include the

[2]The Cessna 300 and 400 series airplanes have exhaust systems made from stainless steel; Inconel 601, a nickel alloy that is similar in appearance to stainless steel; or a combination of both. Despite the failure of the Inconel Wye duct collector in the Beaver Dam accident, Inconel is superior to stainless steel for use in an exhaust system for several reasons. Inconel has greater tensile and fatigue strength properties at elevated temperatures than stainless steel. Inconel is also able to maintain that strength if nicked or eroded.

T310, 320, 340, 401, 402, 402A, 402B, 411, 414, 421, 421A, and 421B. On November 4, 1986, the FAA issued revision 5 (R5) of the AD, to identify new replacement parts available for installation and to add the 421C airplane to the list of affected airplanes. The revision also identifies the exhaust system components and defines a schedule to accomplish a visual inspection of the parts. Some of the parts specified in the AD require a 50- or 100-hour reinspection interval; some of the listed parts, including Inconel exhaust components, do not require recurrent inspections.

In 1985, the Safety Board investigated two fatal Cessna 402 airplane accidents involving leaking stainless steel engine exhaust systems that precipitated catastrophic in-flight fires. In one accident, a broken flange on the inboard side of the left engine exhaust manifold header assembly had allowed hot exhaust gases to burn through fuel and oil lines and the engine mounting structure. The inboard flange of the exhaust manifold header for the right engine contained areas that were corroded completely through the wall thickness, and outboard flanges of both manifold header assemblies were corroded and worn thin by exhaust gas corrosion. In the other accident, a portion of the right engine exhaust manifold assembly had ruptured, allowing the hot exhaust gases to act as a blow torch melting the adjacent wing spar and engine support structure. The right wing, outboard of the engine nacelle, subsequently failed and separated from the airplane in flight.

A review of service difficulty reports (SDRs) for 1980 through 1985 revealed 69 reports that addressed Cessna twin-engine, turbocharged, stainless steel airplane exhaust system defects. Two of those reports identified in-flight fires involving stainless steel components in the exhaust systems of Cessna 414 and 320D airplanes. The Cessna 414 sustained an engine fire because of a broken exhaust Wye assembly, and the Cessna 320 airplane sustained an engine fire as a result of a ruptured manifold tube. The Safety Board concluded that the SDRs reflected a failure of operators to adequately inspect and promptly replace exhaust system components with those identified in AD 75-23-08.

On February 11, 1986, as a result of the occurrences and SDRs noted above, the Safety Board issued Safety Recommendations A-86-04 and -05 to the FAA concerning the need for more detailed inspections of engine exhaust systems on Cessna 300 and 400 series airplanes. Safety Recommendation A-86-04 asked the FAA to either require more detailed inspections of the exhaust systems than those set forth in AD 75-23-08 R4 or require scheduled replacement of the Cessna 300 and 400 series airplane engine exhaust manifold assemblies, Wye assemblies, turbo inlet elbow assemblies, and collector assemblies. The recommendation stated that the inspection should require the removal of attaching clamps and assembly components or complete assemblies, as required. Safety Recommendation A-86-05 asked the FAA to amend AD 75-23-08 R4 to include the Cessna 421C airplane.

In its response to Safety Recommendation A-86-04, the FAA stated that the wide variation in the times to failure precluded establishing a replacement interval that would provide any better assurance for preventing additional failures than the inspection process required by AD 75-23-08 R4. Additionally, the FAA stated that the partial disassembly of the exhaust system to facilitate an inspection of the system components could result in greater problems by creating

loads and stress risers in those components that could lead to premature metal fatigue, which is the leading cause of exhaust system failures. In addition, the FAA stated that as time progressed and the exhaust system components were replaced, the new Inconel components would provide improved service. Based on the FAA's actions, the Safety Board classified Safety Recommendation A-86-04 "Closed—Unacceptable Action" on October 2, 1987. In replying to Safety Recommendation A-86-05, the FAA issued revision 5 to AD 75-23-08 to include the Cessna 421C airplane, and the Board subsequently classified Safety Recommendation A-86-05 "Closed—Acceptable Action" on May 14, 1987.

In the year following the issuance of Safety Recommendations A-86-04 and -05, the Safety Board investigated one fatal and two non-fatal accidents involving Cessna 300 and 400 series airplanes that were caused by stainless steel exhaust system failures. Those accidents involved an engine exhaust manifold header assembly that was cracked along a seam weld that allowed the burn through of the firewall and control cables routed behind the engine firewall; a missing segment of an exhaust system waste gate that allowed fire damage to the cowling and underside of the wing; and a missing segment of exhaust piping to the turbocharger that allowed exhaust gases to melt a fuel line, which then ignited.

Such accidents have not stopped occurring, as illustrated by two ongoing Safety Board investigations of accidents involving failures of the stainless steel engine exhaust systems. On August 16, 1995, a Cessna T310R airplane, N2640L, crashed at Altoona, Pennsylvania, killing the two occupants during an attempted forced landing after the pilot reported a fire in the right engine.[3] The Safety Board's investigation of this accident has revealed that the aft section of the stainless steel exhaust pipe had completely separated from a circumferential break permitting the exhaust gases to enter the nacelle and burn through the firewall and fuel lines located behind the firewall. On May 21, 1996, a Cessna 401 airplane, N701CJ, diverted to Great Bend, Kansas, for a precautionary landing after the pilot observed smoke and vapor venting from the left engine nacelle louvers.[4] The Safety Board's investigation of this accident has revealed that the inboard exhaust header had broken completely at a slip joint where it was under a heat shield and behind the canted bulkhead. It leaked exhaust gases that caused extensive heat damage to the engine support structure and firewall and ruptured a crossfeed fuel line behind the firewall. The location of the failure would have been impossible to see during a visual inspection. The Safety Board believes that exhaust systems made of stainless steel parts should be required to undergo detailed inspections that include disassembly of the exhaust system to access those areas obscured by clamps, heat shields, slip joints, or bulkheads.

The Board has also reviewed recent SDR data dating back to mid-1994 that lists several reports of Cessna 300 and 400 series airplanes with exhaust system discrepancies. One of the events involved a Cessna 421C airplane, with an all-Inconel exhaust system, in which the Wye duct collector had a 1-inch crack.

The Safety Board believes that because even exhaust system parts made from Inconel can and do fail, the FAA should amend AD 75-23-08 R5 to require the recurring visual inspection set

[3] NTSB Accident No. NYC95LA195; the investigation of this accident has not been completed.
[4] NTSB Accident No. CHI96FA171; the investigation of this accident has not been completed.

forth in the AD for all-Inconel exhaust systems in Cessna twin-engine, turbocharged airplanes. In addition, the Inconel exhaust system parts should be permanently marked to demonstrate that they are made from Inconel material. In addition, the Safety Board believes that the FAA should amend AD 75-23-08 R5 to require that all Cessna twin-engine, turbocharged engine exhaust system components that are made from stainless steel or that cannot be conclusively determined to be made with Inconel receive repetitive visual inspections of the disassembled exhaust system.

Also, because neither the stainless steel or Inconel exhaust system parts currently in use are permanently marked, they cannot be readily identified visually to determine what level of recurring inspection is required. Neither the ADs nor the Cessna service letter provide a means to differentiate between the stainless steel and Inconel exhaust system components. Advisory Circular (AC) 65-9A, "Airframe and Powerplant Mechanics General Handbook," which was last updated in 1976, provides a nondestructive procedure to distinguish Inconel alloys from stainless steels. The procedure uses a solution of cupric chloride and hydrochloric acid, which should cause a copper-colored spot on stainless steel.

However, the Safety Board's materials laboratory staff tested this procedure on several exhaust system parts from the Cessna 421C airplane that crashed at Beaver Dam, Arizona. The solution did not create any copper-colored discoloration on the oxidized exhaust system parts that were later determined, through x-ray energy dispersive (XED) analysis, to be stainless steel. Additional chemical tests on the stainless steel parts after they were cleaned and polished to bare metal also produced inconclusive results. Therefore, the Safety Board believes that the FAA should remove from AC 65-9A, "Airframe and Powerplant Mechanics General Handbook," the ineffective acid test currently specified in the AC to distinguish Inconel from stainless steel materials and replace it with a practical and effective test, if possible.

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

> Amend Airworthiness Directive (AD) 75-23-08 R5 to require the recurring visual inspection set forth in the AD of all-Inconel exhaust system components in Cessna twin-engine, turbocharged airplanes. In addition, the Inconel exhaust system parts should be permanently marked to demonstrate that they are made with Inconel material. Any worn, damaged, or otherwise defective exhaust system components or assemblies should be replaced before any further flight. (Class II, Priority Action) (A-96-35)
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> Amend Airworthiness Directive (AD) 75-23-08 R5 to require that all Cessna twin-engine, turbocharged engine exhaust system components that are made from stainless steel or that cannot be conclusively determined to be made with Inconel receive repetitive visual inspections of the disassembled exhaust system. Any worn, damaged, or otherwise defective exhaust system components or assemblies should be replaced before any further flight. (Class II, Priority Action) (A-96-36)

Remove from Advisory Circular (AC) 65-9A, "Airframe and Powerplant Mechanics General Handbook," the ineffective acid test currently specified in the AC to distinguish Inconel from stainless steel materials and replace it with a practical and effective test, if possible. (Class II, Priority Action) (A-96-37)

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

By: Jim Hall
Chairman

National Transportation Safety Board
Washington, D.C. 20594

Brief of Accident

LAX95FA319
FILE NO. 1521 09/02/95 BEAVER DAM, AZ AIRCRAFT REG. NO. N6234G TIME (LOCAL) - 08:38 MST

MAKE/MODEL - CESSNA 421C
ENGINE MAKE/MODEL - CONTINENTAL GTSIO-520-L
AIRCRAFT DAMAGE - Destroyed
NUMBER OF ENGINES - 2

	FATAL	SERIOUS	MINOR/NONE
CREW	1	0	0
PASS	7	0	0

OPERATING CERTIFICATES - On-demand air taxi
TYPE OF FLIGHT OPERATION - Executive/corporate
REGULATION FLIGHT CONDUCTED UNDER - 14 CFR 91

LAST DEPARTURE POINT - LAS VEGAS, NV
DESTINATION - W. YELLOWSTONE, MT

AIRPORT PROXIMITY - Off airport/airstrip
AIRPORT NAME - MESQUITE
RUNWAY IDENTIFICATION - 19
RUNWAY LENGTH/WIDTH (Feet) - 5100/ 75
RUNWAY SURFACE - Asphalt
RUNWAY SURFACE CONDITION - Dry

CONDITION OF LIGHT - Daylight

WEATHER INFO SOURCE - Weather observation facility

BASIC WEATHER - Visual (VMC)
LOWEST CEILING - None
VISIBILITY - 0010.000 SM
WIND DIR/SPEED - 280 /003 KTS
TEMPERATURE (F) - 76
OBSTR TO VISION - None
PRECIPITATION - None

PILOT-IN-COMMAND AGE - 50

CERTIFICATES/RATINGS
Commercial, Airline transport
Single-engine land, Multiengine land
Helicopter
INSTRUMENT RATINGS
Airplane, Helicopter

FLIGHT TIME (Hours)

TOTAL ALL AIRCRAFT - 18628
LAST 90 DAYS - 29
TOTAL MAKE/MODEL - 86
TOTAL INSTRUMENT TIME - 1344

After climbing to 18,400' msl, the pilot reported a turbocharger problem & reversed course. He said he "may lose the left engine" & that he was unable to maintain altitude. He diverted to an alternate airport. During a right turn onto final approach, the airplane was observed to cross (overshoot) the extended centerline of the runway. It continued in a right turn back toward the centerline, and then entered a left turn to intercept the inbound course. The turn steepened, and then the airplane entered a spin & crashed 1/2 mile short of the runway. A warped flange & evidence of exhaust gas leakage were found on the Inconel exhaust system Wye collector, at the wastegate outlet of the left engine. Neither propeller was in a feather position. There was evidence that the left engine was providing low power during impact. A note on the pilot's clipboard indicated that the (left engine) fuel flow & cylinder head temperature went to zero. & the manifold pressure dropped to 10 inches. The note also indicated that the pilot switched the "boost pump" to high, the fuel flow went to 260 psi, & manifold pressure increased to 18.5 inches. Calculations showed that the airplane's gross weight (GW) & center-of-gravity (CG) were 7,645 pounds & 158.32 inches. The maximum allowable GW & CG were 7,450 pounds & 158 inches. During impact, the flaps were fully extended. The "Engine Inoperative Landing" procedure stated, "Wing Flaps - DOWN when landing is assured." Most of the pilot's flight time in the Cessna 421 was before 1985; no record was found of recurrent training in the airplane since 1984. Annual and turbocharger inspections were made at 78 and 120 flight hours, respectively, before the accident, but no logbook entries were made concerning maintenance or replacement parts for the exhaust system.

LAX95FA319
FILE NO. 1521 09/02/95 BEAVER DAM, AZ AIRCRAFT REG. NO. N6234G TIME (LOCAL) - 08:38 MST

Occurrence# 1 LOSS OF ENGINE POWER
Phase of Operation CLIMB - TO CRUISE

Findings
1. - 1 ENGINE
2. - EXHAUST SYSTEM, MANIFOLD/PIPE - WARPED
3. - EXHAUST SYSTEM, MANIFOLD/PIPE - LEAK
4. - EXHAUST SYSTEM, TURBOCHARGER - OUTPUT LOW
5. - MAINTENANCE, INSPECTION OF AIRCRAFT - INADEQUATE

Occurrence# 2 FORCED LANDING
Phase of Operation EMERGENCY DESCENT/LANDING

Findings
6. - AIRCRAFT WEIGHT AND BALANCE - EXCEEDED - PILOT IN COMMAND
7. - INADEQUATE RECURRENT TRAINING - PILOT IN COMMAND

Occurrence# 3 LOSS OF CONTROL - IN FLIGHT
Phase of Operation APPROACH - VFR PATTERN - BASE LEG/BASE TO FINAL

Findings
8. - PROPELLER FEATHERING - NOT PERFORMED - PILOT IN COMMAND
9. - FLAPS - IMPROPER USE OF - PILOT IN COMMAND
10. - AIRSPEED(VREF) - NOT MAINTAINED - PILOT IN COMMAND
11. - STALL/SPIN - INADVERTENT - PILOT IN COMMAND

Occurrence# 4 IN FLIGHT COLLISION WITH TERRAIN/WATER
Phase of Operation DESCENT - UNCONTROLLED

The National Transportation Safety Board determines that the Probable Cause(s) of this Accident was:
Failure of the pilot to maintain adequate airspeed, while maneuvering on approach, which resulted in an inadvertent stall/spin and uncontrolled collision with terrain. Factors relating to the accident were: the pilot allowed the aircraft weight and balance limitations to be exceeded; the pilot's lack of recurrent training in the make and model of airplane; inadequate maintenance/inspection of the engine exhaust systems; a warped and leaking exhaust system flange on the left engine, which resulted in a loss of power in that engine; and the pilot's improper use of the flaps.