National Transportation Safety Board
Aviation Accident Final Report

Location:	Tupelo, MS	**Accident Number:**	ERA16FA185
Date & Time:	05/16/2016, 0835 CDT	**Registration:**	N60RW
Aircraft:	BEECH A36TC	**Aircraft Damage:**	Destroyed
Defining Event:	Sys/Comp malf/fail (non-power)	**Injuries:**	4 Fatal
Flight Conducted Under:	Part 91: General Aviation - Personal		

Analysis

The airline transport pilot was taking off in the turbocharged reciprocating engine-equipped airplane for a personal flight. One witness reported seeing something fall from the airplane as it departed. Shortly after departure, the pilot notified air traffic control of smoke in the cockpit. The airplane then made a left, westbound turn back toward the airport, about 500ft above the ground and then it turned back toward the approach end of the departure runway while descending. Two witnesses also reported seeing fire and smoke coming from the bottom, left side of the airplane before it impacted terrain.

After the accident, airport personnel found the exhaust tailpipe and fractured v-band coupling on the runway. A support clamp, which was intended to support the exhaust tailpipe, was not found. Examination of the v-band coupling revealed stress rupture features at the edge of a spot weld that attached the outer band to the retainer, which led to the v-band fracturing, the exhaust tailpipe separating from the airplane, and an in-flight fire. Review of the maintenance records did not reveal when the v-band coupling was installed or last inspected.

There is a longstanding history of accidents and incidents resulting from v-band coupling failures on both fixed-wing aircraft and rotorcraft. Although before the accident the Federal Aviation Administration (FAA) had issued six v-band-specific airworthiness directives (AD) and other guidance materials and recommendations related to v-band failures, none of them were specific to the accident airplane make and model. Subsequent to the accident, the FAA published a notice of proposed rulemaking to obtain public feedback regarding a proposed AD that would require a repetitive annual inspection of, and would impose a 500-hour life limit on, the exhaust tailpipe v-band coupling on the accident aircraft make and model.

Probable Cause and Findings

The National Transportation Safety Board determines the probable cause(s) of this accident to be:

A preexisting stress rupture that initiated at a spot weld in the turbocharger v-band exhaust clamp, which resulted in the failure of the clamp and separation of the exhaust tailpipe, an in-flight fire, and subsequent impact with terrain.

Findings

Aircraft	Engine exhaust - Failure (Cause)

Factual Information

History of Flight

Takeoff	Sys/Comp malf/fail (non-power) (Defining event) Fire/smoke (non-impact)
Emergency descent	Collision with terr/obj (non-CFIT)

On May 16, 2016, about 0835 central daylight time, a Beech A36TC, N60RW, impacted terrain in Tupelo, Mississippi. The

airline transport pilot and three passengers sustained fatal injuries, and the airplane was destroyed by postcrash fire. The flight was being operated as Title 14 *Code of Federal Regulations* Part 91 personal flight. Visual meteorological conditions prevailed at the airport, and an instrument flight rules flight plan was filed for the flight that originated at Tupelo Regional Airport (TUP), Tupelo, Mississippi, about 0830, and was destined for Charlottesville-Albemarle Airport (CHO), Charlottesville, Virginia.

According to air traffic control recordings, shortly after departing runway 36, the pilot advised the tower controller that there was smoke in the cockpit and that he needed to return to the airport. One witness reported seeing something fall from the airplane as it departed. Several witnesses reported that the airplane made a left, westbound turn toward the airport, at an altitude of about 500-1,000 feet above ground and then turned back toward the approach end of runway 18 while descending. Two witnesses reported seeing the airplane about 50 ft above them with smoke and flames coming from the bottom, left side of the airplane before it impacted terrain. Shortly after the accident, TUP personnel conducted a sweep of the runway and found the exhaust tailpipe and a fractured v-band coupling.

Pilot Information

Certificate:	Airline Transport; Flight Instructor; Commercial; Private	**Age:**	75, Male
Airplane Rating(s):	Multi-engine Land; Single-engine Land	**Seat Occupied:**	Left
Other Aircraft Rating(s):	None	**Restraint Used:**	Unknown
Instrument Rating(s):	Airplane	**Second Pilot Present:**	Yes
Instructor Rating(s):	Airplane Multi-engine; Airplane Single-engine; Instrument Airplane	**Toxicology Performed:**	Yes
Medical Certification:	Class 3 With Waivers/Limitations	**Last FAA Medical Exam:**	10/24/2014
Occupational Pilot:	No	**Last Flight Review or Equivalent:**	
Flight Time:	(Estimated) 5675 hours (Total, all aircraft)		

Pilot-Rated Passenger Information

Certificate:	Private	**Age:**	69, Male
Airplane Rating(s):	Single-engine Land	**Seat Occupied:**	Right
Other Aircraft Rating(s):	None	**Restraint Used:**	Unknown
Instrument Rating(s):	None	**Second Pilot Present:**	Yes
Instructor Rating(s):	None	**Toxicology Performed:**	Yes
Medical Certification:	Class 3 None	**Last FAA Medical Exam:**	07/07/2005
Occupational Pilot:	No	**Last Flight Review or Equivalent:**	
Flight Time:	180 hours (Total, all aircraft)		

The pilot held an airline transport pilot certificate and a flight instructor certificate with airplane single-engine land, multiengine land, and instrument airplane ratings. His most recent Federal Aviation Administration (FAA) third-class medical certificate was issued on October 24, 2014, with the limitation that he "must wear lenses for distant and have glasses for near vision." At the time of his last medical evaluation, the pilot reported 5,675 total flight hours. The pilot's logbooks were not available for review, and his total flight experience at the time of the accident could not be determined.

Aircraft and Owner/Operator Information

Aircraft Make:	BEECH	**Registration:**	N60RW
Model/Series:	A36TC UNDESIGNAT	**Aircraft Category:**	Airplane
Year of Manufacture:		**Amateur Built:**	No
Airworthiness Certificate:	Utility	**Serial Number:**	EA-78
Landing Gear Type:	Retractable - Tricycle	**Seats:**	6
Date/Type of Last Inspection:	04/19/2016, Annual	**Certified Max Gross Wt.:**	3651 lbs
Time Since Last Inspection:		**Engines:**	1 Reciprocating
Airframe Total Time:	5204 Hours as of last inspection	**Engine Manufacturer:**	Continental
ELT:	Installed, not activated	**Engine Model/Series:**	TSIO-520
Registered Owner:	On file	**Rated Power:**	300 hp

Registered Owner:	On file	Rated Power:	300 hp
Operator:	On file	Operating Certificate(s) Held:	None

The six-seat, low-wing, retractable tricycle-gear airplane was manufactured in 1980. It was powered by a Continental TSIO-520-UB series, 300-horsepower engine and was equipped with a McCauley three-blade, constant-speed propeller.

A review of maintenance records revealed that the airplane's most recent annual inspection was completed on April 19, 2016. At that time, the airplane had accumulated 2,037 total flight hours. At the time of the annual inspection, the engine had accumulated 242.1 hours since an overhaul completed on December 26, 2012. The exhaust system was not specifically mentioned in the logbook entries for the overhaul or engine reinstallation.

The airplane accumulated 58.6 hours over the 12 months that preceded the April 19, 2016 inspection. The exhaust system, v-band coupling, and exhaust tailpipe support clamp were not specifically discussed in the logbook entries for the annual inspection; therefore, it could not be determined when the coupling and support clamp were last inspected. Due to thermal damage to the cockpit, the airframe and engine total time could not be determined.

The Continental Aircraft Engine Maintenance Manual required a visual inspection at every 100-hour and annual inspection to "Inspect the physical integrity of the turbocharger and exhaust system. Inspect multi-segment v-band clamp spot welds (or rivets) for cracks or physical damage. Inspect the corner radii of the clamp inner segments for cracks with a flashlight and inspection mirror. Inspect the v-band clamp outer band for flatness, especially within two inches of spot-weld tabs that retain the T-bold fastener variance must be less than 0.062 in." The turbocharger and exhaust system inspection portion of the 100-hour inspection criteria stated, "Verify 100% inner and outer band segment contact." The instructions were accompanied by a diagram of the required v-band clamp inspection and instructions for cleaning the v-band clamp.

The preflight checklist did not include an inspection of the exhaust system.

Meteorological Information and Flight Plan

Conditions at Accident Site:	Visual Conditions	Condition of Light:	Day
Observation Facility, Elevation:	TUP, 361 ft msl	Distance from Accident Site:	2 Nautical Miles
Observation Time:	0847 CDT	Direction from Accident Site:	189°
Lowest Cloud Condition:		Visibility	10 Miles
Lowest Ceiling:	Overcast / 5000 ft agl	Visibility (RVR):	
Wind Speed/Gusts:	6 knots /	Turbulence Type Forecast/Actual:	/ None
Wind Direction:	70°	Turbulence Severity Forecast/Actual:	/ N/A
Altimeter Setting:	30.17 inches Hg	Temperature/Dew Point:	16°C / 5°C
Precipitation and Obscuration:	No Obscuration; No Precipitation		
Departure Point:	TUPELO, MS (TUP)	Type of Flight Plan Filed:	IFR
Destination:	CHARLOTTESVILLE, VA (CHO)	Type of Clearance:	IFR
Departure Time:	0830 EDT	Type of Airspace:	Class D

The 0847 weather conditions reported at TUP, located about 2 nautical miles south of the accident site, included wind from 130° at 9 knots, 10 statute miles visibility, temperature 19°C, dew point 5°C, and altimeter setting of 30.17 inches of mercury.

Airport Information

Airport:	TUPELO RGNL (TUP)	Runway Surface Type:	Asphalt
Airport Elevation:	346 ft	Runway Surface Condition:	Dry
Runway Used:	18	IFR Approach:	None
Runway Length/Width:	7150 ft / 150 ft	VFR Approach/Landing:	Forced Landing

Wreckage and Impact Information

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Crew Injuries:	1 Fatal	**Aircraft Damage:**	Destroyed
Passenger Injuries:	3 Fatal	**Aircraft Fire:**	In-Flight and On-Ground
Ground Injuries:	N/A	**Aircraft Explosion:**	None
Total Injuries:	4 Fatal	**Latitude, Longitude:**	34.291111, -88.765278

The wreckage, which was mostly consumed by fire, was located on flat terrain with trees nearby. Tree cuts, which began about 50 ft above the terrain, descended in about a 20° angle for about 165 ft along a magnetic heading of 110°.

All flight controls surfaces were accounted for at the accident site, and flight control continuity was confirmed from the cockpit to their respective control inputs. The outboard portion of the right wing was found about 80 ft past the initial tree strike; it was separated from the airframe and heavily burned. The right aileron remained attached, but the right flap was separated. The left wing remained attached at the forward spar but sustained extensive fire damage.

One of the three propeller blades exhibited S-bending, leading edge gouging, and chordwise scratches. The second blade exhibited tip curling and aft bending. The third blade displayed aft bending and minor chordwise scratches.

The engine exhaust pipe was missing from the exhaust side of the turbocharger. A subsequent examination of the engine at a recovery facility did not reveal any other preexisting mechanical anomalies that would have precluded normal operation. Thumb compression was obtained on all cylinders, and continuity was confirmed throughout the drive train. The magnetos were removed and rotated, and a spark was observed at each of their respective terminal leads.

The exhaust tailpipe was separated at the exhaust flange of the turbocharger. The exhaust tailpipe flange was crushed, consistent with it impacting the runway. The separated v-band coupling, which is intended to attach the tailpipe to the turbocharger, was attached at the ends by a bolt and safety wire but was fractured through its band. The tailpipe support clamp, which is intended to hold the tailpipe to a bracket that is attached to the engine for support, was missing/not attached to the support clamp bracket, and it was not located in the wreckage or on the runway.

Medical And Pathological Information

The Mississippi State Medical Examiner's Office, Pearl, Mississippi, performed autopsies on all of the airplane's the occupants. The autopsy reports listed the cause of death for all occupants as "blunt force injuries."

The FAA's Bioaeronautical Sciences Research Laboratory, Oklahoma City, Oklahoma, performed toxicological testing on the pilot. No cyanide, ethanol, or drugs were detected in the samples submitted for testing. Toxicology testing indicated 3% carbon monoxide in the blood.

Tests And Research

The recovered exhaust tailpipe and v-band coupling were forwarded to the National Transportation Safety Board's Materials Laboratory, Washington, DC, for further examination.

The v-band coupling consisted of a flat band with fastening hardware and two inner flange retainers located on flanges on the turbocharger housing and the exhaust tailpipe. Each flange retainer was spot welded to the inner surface of the band at two locations.

Further examination of the coupling revealed that the fracture occurred at the edge of a spot weld attaching the outer band to the retainer. The fracture occurred due to a stress rupture initiating at the edge of a spot weld between the band and the retainer and extending across about 60% of the width of the band. Examination with a scanning electron microscopy further revealed that much of the fracture surface was oxidized with crack propagation at the grain boundaries, consistent with the existence of a preexisting crack. Cracks and local deformation were also observed at the edge of another spot weld on the coupling.

No part number or manufacturer identification marks were found on the on the v-band coupling. Because there are multiple manufacturers of v-band clamps/couplings, the manufacturer and installation date of the accident airplane's v-band coupling

could not be determined.

Additional Information

A v-band coupling is a common way of attaching portions of an exhaust system and are widely used throughout the aviation industry on reciprocating turbocharged engines. V-band couplings are exposed to extremely high exhaust temperatures and heat cycles. High temperatures and corrosive conditions can lead to cracks and failures of the couplings, which result in hot exhaust gases escaping the exhaust system and subsequently can result in smoke in the cockpit, in-flight fires, and fatal accidents.

Since the mid-70s, v-band coupling failures have resulted in a significant number of nonfatal and fatal incidents and accidents involving both fixed-wing aircraft and rotorcraft. Since 1974, NTSB accident and incident investigations have led to the development and issuance of at least seven NTSB safety recommendations concerning exhaust systems and/or exhaust v-band coupling/clamps. In response, the FAA has issued 20 aircraft-model-specific airworthiness directives (AD) in which v-band coupling/clamps were included, six of which were v-band specific. In 1979, the FAA issued the first AD that was aircraft make and model specific. The AD required the inspection of, and provided replacement intervals for, v-band couplings. However, there are many airplanes and helicopters, including the accident airplane, equipped with v-band couplings susceptible to fractures and failure that were not covered by the AD. In 2001, the FAA issued AD 2001-08-08 for Beech A36 airplanes with the Tornado Alley Turbo conversion; however, the accident airplane was not equipped with this conversion; therefore, it was exempt from the AD.

The FAA has also provided guidance and recommendations in at least 10 special airworthiness information bulletins (SAIB), published numerous advisory circular (AC) 43-16A Maintenance Alert articles, and updated existing AC guidance. Many of these products result from specific accidents and only addressed a specific accident airframe or engine.

In 2013, the FAA issued an SAIB to inform owners, operators, and mechanics about the potential for in-flight fires due to the failure of the exhaust system v-band on turbocharged engines. The SAIB urged pilots to include the exhaust system in preflight inspections, establish a replacement schedule of 400 hours of time in service, adhere to inspection criteria from the manufacturers, and use new FAA-approved parts and appropriate maintenance documentation for replacement of v-band couplings.

The General Aviation Joint Steering Committee (GA-JSC) developed a System Component Failures – Power Plant (SCF-PP) working group to examine general aviation accident causes. The SCF-PP working group reviewed 70 randomly selected fatal accidents that occurred between 2001 and 2010 and found that three of the selected cases resulted from v-band coupling/clamp failures. Due to the findings, the SCF-PP working group asked the GA-JSC to examine the feasibility of implementing fleetwide inspection requirements and life-limits for v-band coupling/clamps on *all* turbocharged, reciprocating engine-powered aircraft not already covered by an existing AD, regardless of make or model. The accident in Tupelo occurred shortly after the completion the SCF-PP working group effort.

On November 8, 2017, the FAA published a notice of proposed rulemaking (NPRM) to obtain public feedback regarding a proposed AD that would require a repetitive annual inspection of, and would impose a 500-hour life limit on, the exhaust tailpipe v-band coupling. The NPRM was specifically written for the accident aircraft make and model and included other turbocharged Beech Bonanza models.

Industry has also taken action to raise awareness of the concerns associated with v-band coupling/clamp failures by publishing articles in various trade magazines and user group newsletters, issuing installation guidance, and clarifying installation requirements for v-band coupling/clamps.

Administrative Information

Investigator In Charge (IIC):	Millicent M Hill	**Report Date:**	04/17/2018
Additional Participating Persons:	Steve Flickner; FAA/FSDO; Jackson, MS Kurt Gibson; Continental Motors; Mobile, AL Jon Hirsch; Textron; Wichita, KS		
Publish Date:	04/17/2018		
Note:	The NTSB traveled to the scene of this accident.		
Investigation Docket:	http://dms.ntsb.gov/pubdms/search/dockList.cfm?mKey=93172		