National Transportation Safety Board
Aviation Accident Final Report

Location:	Grand Rapids, MN	**Accident Number:**	CHI05FA162
Date & Time:	07/04/2005, 1758 CDT	**Registration:**	N4386G
Aircraft:	Piper PA-46-310P	**Aircraft Damage:**	Destroyed
Defining Event:		**Injuries:**	1 Fatal
Flight Conducted Under:	Part 91: General Aviation - Personal		

Analysis

The airplane was destroyed on impact with terrain during a forced landing following an observed in-flight loss of engine power after takeoff. A witness observed the takeoff and stated that the airplane took off from the end of runway 34. About halfway down the runway the airplane emitted a sound like a rapid misfire, a pop, and then no more audible engine sounds. The airplane was about 300 to 400 feet above ground level at that point. He said that the airplane turned right then turned left to a bank where the wing was straight down. The airplane's wings then leveled, the airplane descended, and it impacted terrain. He stated that the time from the sounds to the impact was about two to three seconds. An on-scene examination revealed no airframe pre-impact anomalies. An engine examination revealed a cracked crankshaft propeller flange. The engine without the turbochargers and with the original crankshaft was test run up to 2,100 RPM. A propeller and governor inspection revealed no anomalies. Examination of the turbocharger system's exhaust bypass valve assembly revealed its butterfly valve was stuck (bound) in the extended closed position. The engine's cracked crankshaft was removed and a serviceable crankshaft was installed. The engine was test run again with a serviceable exhaust bypass valve assembly. The engine produced rated power. The original exhaust bypass valve assembly was reinstalled. The exhaust bypass valve assembly's wastegate bound again during an engine run and a loss of engine power was observed. Sectioning of the bypass valve assembly revealed a bent wastegate shaft. The valve assembly lever arm was bent and exhibited pre-impact toolmarks consistent with pliers loosening a bound wastegate shaft. The airplane's pilot operating handbook and Federal Aviation Administration (FAA) approved airplane flight manual (POH), in part, stated, "ENGINE POWER LOSS DURING TAKEOFF If sufficient runway remains for a normal landing, leave gear down and land straight ahead." The engine manufacturer's maintenance and operator's manual stated that the wastegate is required to be checked for operation and condition during 100 hour inspections. The manual did not specify a procedure for maintenance personnel on how to check the wastegate's operation and its acceptable condition. National Transportation Safety Board Recommendation A-94-081, issued to the FAA in 1994, stated, "Require the amendment of pilot operating handbooks and airplane flight manuals applicable to aircraft equipped with engine turbochargers by including in the 'Emergency Procedures' section information regarding turbocharger failure. The information should

include procedures to minimize potential hazards relating to fire in flight and/or loss of engine power." The airplane's POH latest revision was dated October 14, 2002 and review of the emergency procedures section showed that the POH did not contain information, procedures, or amplified procedures on turbocharger failures. The airplane accumulated 8.7 hours of operation since the last annual inspection.

Probable Cause and Findings

The National Transportation Safety Board determines the probable cause(s) of this accident to be: An observed loss of engine power due to the bound/jammed turbocharger wastegate during takeoff, the pilot not maintaining airplane control, and the stall he inadvertently encountered. A factor was the maintenance personnel not replacing the turbocharger wastegate bypass valve assembly during the last annual inspection 8.7 hours of operation prior to the accident. An additional factor was the manufacturer's insufficiently defined inspection conditions for the bypass valve's proper operation.

Findings

Occurrence #1: LOSS OF ENGINE POWER
Phase of Operation: TAKEOFF

Findings
1. (C) EXHAUST SYSTEM,WASTEGATE - JAMMED
2. (F) MAINTENANCE,REPLACEMENT - NOT PERFORMED - OTHER MAINTENANCE PERSONNEL
3. (F) CONDITION(S)/STEP(S) INSUFFICIENTLY DEFINED - MANUFACTURER
4. CONDITION(S)/STEP(S) NOT LISTED - MANUFACTURER

Occurrence #2: LOSS OF CONTROL - IN FLIGHT
Phase of Operation: EMERGENCY LANDING AFTER TAKEOFF

Findings
5. (C) AIRCRAFT CONTROL - NOT MAINTAINED - PILOT IN COMMAND
6. (C) PROCEDURES/DIRECTIVES - NOT FOLLOWED - PILOT IN COMMAND
7. AIRSPEED - NOT MAINTAINED - PILOT IN COMMAND
8. (C) STALL - INADVERTENT - PILOT IN COMMAND

Occurrence #3: IN FLIGHT COLLISION WITH TERRAIN/WATER
Phase of Operation: DESCENT - UNCONTROLLED

Findings
9. TERRAIN CONDITION - GROUND

Factual Information

HISTORY OF FLIGHT

On July 4, 2005, about 1758 central daylight time, a Piper PA-46-310P, N4386G, piloted by a private pilot, was destroyed on impact with terrain during a forced landing following an observed in-flight loss of engine power after takeoff from runway 34 at the Grand Rapids/Itasca County Airport-Gordon Newstrom Field (GPZ), near Grand Rapids, Minnesota. The personal flight was operating under 14 Code of Federal Regulations Part 91. No flight plan was on file. The pilot sustained fatal injuries. The flight was originating at the time of the accident and its destination was unknown.

A witness located at GPZ observed the takeoff and stated that the airplane took off from the end of runway 34. About halfway down the runway the airplane emitted a sound like a rapid misfire, a pop, and then no more audible engine sounds. The airplane was about 300 - 400 feet above ground level at that point. He said that the airplane turned right then turned left to a bank where the wing was straight down. The airplane's wings then leveled, the airplane descended, and it impacted terrain. He stated that the time from the sounds to the impact was about two to three seconds.

PERSONNEL INFORMATION

The pilot held a private pilot certificate with airplane single-engine land and instrument airplane ratings. Federal Aviation Administration (FAA) records show that the pilot's last medical examination was completed on June 22, 2005, when he was issued a third-class medical certificate with the limitation that he shall possess glasses that correct for near vision. On the application for that medical certificate, the pilot reported that he had accumulated 2,200 hours of total flight time. He reported that he had accumulated 50 hours of flight time in the six months prior to that medical certificate application.

The pilot obtained flight instruction for the PA-46-310P from Simcom. Their training records showed that the pilot's last endorsement for a flight review was on July 1, 2004.

AIRCRAFT INFORMATION

N4386G, a 1985 Piper PA-46-310P, Malibu, serial number 46-8508037, was an all-metal airplane with semimonocoque fuselage and empennage construction. The airplane was powered by a six-cylinder, horizontally opposed, turbocharged, air cooled, fuel injected, Teledyne Continental Motors (TCM) TSIO-520-BE(1), serial number 528503, engine. The airplane's propeller was a two-bladed Hartzell BHC-C2YF-1BF model. The airplane was equipped with a pressurized cabin, wing flaps, spoilers, a constant speed propeller, and retractable tricycle landing gear. The airplane had a maximum seating capacity of six occupants, to include two cockpit positions and four cabin positions. The airplane has a certified maximum takeoff weight of 4,100 lbs.

The pilot's operating handbook and FAA approved airplane flight manual (POH), in part, stated:

> Turbocharging is accomplished by two Garrett - A.I.D.

turbocompressors, one located on each side of the engine. Turbochargers extract energy from engine cylinder exhaust gases and use this energy to compress engine induction air. This allows the engine to maintain rated power at altitude. When engine induction air is compressed by the turbocharger, the air temperature is increased. The elevated air temperature is reduced by air aftercoolers located on each side of the engine. This aids in engine cooling and improves engine power and efficiency.

Each turbocharger extracts exhaust energy from its respective bank of cylinders to pressurize the induction air. Air flows through the induction inlet louvers into the induction air box, where it is filtered and divided for distribution to the left and right turbo compressors. At the compressor, air pressure and temperature are increased. Pressure increases air density making a greater mass of air available to the engine cylinders on each intake stroke. Air then flows through an aftercooler where air temperature is reduced, further increasing the density of air available to each cylinder. Downstream the aftercoolers, air flow joins at the "Y" junction of intake tubes on the top front of the engine, then passes the throttle butterfly valve and is divided to individual intake pipes flowing to each cylinder. Metered fuel is injected into the cylinder head, upstream of the intake valve. After the fuel burns in the cylinder, exhaust gases flow into the exhaust manifold and then to turbocharger turbines where exhaust energy is extracted to drive the compressor. Turbo compressed air is throttled across the throttle butterfly valve as set by the throttle lever. A sloped control system monitors pressure differential and uses engine oil pressure to automatically position the waste gate valve. The waste gate bleeds excess exhaust gas from the exhaust manifold crossover pipe and out the left exhaust stack, bypassing the turbocharger. Thus the controller automatically maintains manifold pressure.

The engine is well protected against overboost damage from excessive manifold pressure. The waste gate controller senses manifold pressure and will continually adjust turbocharger output, maintaining the manifold pressure set by the throttle. The controller automatically protects the engine from overboost damage by limiting manifold pressure to 38 in. Hg. In the event of a controller malfunction, there is a pressure relief valve on the induction manifold which will relieve manifold pressure at 42 in. Hg.

Manifold pressure limits can be exceeded with full throttle operation during certain off standard ambient conditions and low engine oil temperature. During such conditions limit manifold pressure to 38 in. Hg maximum.

Aircraft logbooks show that the last annual inspection was performed on May 6, 2005. The aircraft had accumulated a total time of 1,847.7 hours at the time of that annual inspection.

The airplane's POH, in part, stated:

ENGINE POWER LOSS DURING TAKEOFF

If sufficient runway remains for a normal landing, leave gear down and land straight ahead.

If area ahead is rough, or if it is necessary to clear obstructions:

Landing gear selector ..... UP

METEOROLOGICAL INFORMATION

At 1755, the recorded GPZ weather was: Wind 290 degrees at 11 knots gusting to 17 knots; visibility 10 statute miles; sky condition few 8,000 feet; temperature 21 degrees C; dew point 12 degrees C; altimeter 29.94 inches of mercury.

AIRPORT INFORMATION

The North Central US Region Airport/Facility Directory (A/FD) indicated that the airport elevation at GPZ was 1,355 feet above mean sea level (MSL). GPZ was an uncontrolled airport with two runways, 10/28 and 16/34. The A/FD stated that runway 16/34 was 5,755 feet long and 100 feet wide. That runway's surface was composed of asphalt.

WRECKAGE AND IMPACT INFORMATION

The airplane fuselage came to rest upright northwest of the departure end of runway 34 at

latitude 47 degrees 13.018 minutes North and longitude 93 degrees 30.918 minutes West. A ground scar, about 150 feet long with a 287 degrees magnetic heading, was observed. A radio antenna was found at the start of the scar. The airplane's propeller was detached from the engine propeller flange and was found about 135 feet from the start of the ground scar. The right wing was detached from the fuselage and was found near the end of the ground scar about 150 feet from the start of the scar. The airplane fuselage was about 168 feet from the start of the scar and the fuselage was orientated approximately on a 354-degree magnetic heading.

An on-scene examination was conducted. The propeller blades were marked A and B. The propeller blade marked with a "B" exhibited an s-shaped bend. Both propeller blades exhibited chordwise abrasion. The inboard section of the detached right wing exhibited rearward crushing. The wing's landing gear was extended and locked in the extended position. The right wing's fuel tank contained a blue liquid consistent with aviation gasoline. The right wing's fuel pump operated and pumped a liquid when the airplane's battery power was applied to it. The right wing's aileron control cables were separated from the aileron bell crank. The separation was consistent with overload.

The empennage exhibited a downward bend aft of the fuselage. Flight control cable continuity was traced to all flight control surfaces. Engine control continuity was established. The left wing's fuel tank contained a blue liquid consistent with aviation gasoline. The left wing's fuel pump operated and pumped a liquid when the airplane's battery power was applied. Fluid was found in the gascolator and it was drained into a glass container. That fluid was blue in color and did not contain any visible contamination. The fuel line from the gascolator to the engine driven fuel pump was torn at the gascolator's b-nut. The fuel line to the engine driven fuel pump was removed and a liquid was observed exiting that line when air pressure was applied to the torn line at the gascolator b-nut. The engine driven fuel pump was removed from the engine. A liquid was observed exiting the engine driven fuel pump when the pump was rotated by hand. The shear shaft was intact. The top sparkplugs were removed. The plugs exhibited a brown color. Engine continuity was established and each cylinder produced a thumb compression. The magnetos produced sparks. The Hobbs meter read 1856.4 hours. No pre-impact anomalies were detected with the airframe.

MEDICAL AND PATHOLOGICAL INFORMATION

The Itasca County Medical Examiner performed an autopsy on the pilot on July 5, 2005.

The FAA Civil Aeromedical Institute prepared a Final Forensic Toxicology Accident Report. The toxicology results for the pilot were negative for all tests performed.

TESTS AND RESEARCH

The collected fuel sample from the gascolator was taken to the 148th Fighter Wing, near Duluth, Minnesota. That Air National Guard unit forwarded the fuel sample to the Aerospace Fuels Laboratory at Wright Patterson Air Force Base, Ohio. The laboratory tested the fuel and their report stated that the sample met the specifications of 100 low lead aviation gasoline. The laboratory's test results are appended to the docket material associated with this investigation.

The airplane's engine was examined at TCM, Mobile, Alabama, on September 13, 2005. The examination revealed cracks in the engine's crankshaft propeller flange. The exhaust system

exhibited impact crush and deformation. The shroud around the turbocharger wastegate assembly did not exhibit impact damage. The engine was test run without the turbochargers. The engine was run up to 2,100 RPM. A RPM drop was noted with each respective magneto during a check of the magnetos.

A representative from Hartzell Propeller inspected the blades and hub section on September 13, 2005. Both of the propeller blades exhibited damage from impact. The "B" blade was loose and could be manually turned. The propeller hub was intact. The propeller's mounting flange was intact. Four studs were stripped out and one dowel was pulled from the mounting flange. After the disassembly, the propeller pitch change rod exhibited no anomalies. The "B" blade pitch change knob was sheared and both shear faces were smeared. Marks were present on the "A" preload plate from contact with the opposing blade pitch change knob. This mark was calculated to have occurred at an approximate 12.5-degree blade angle. Remaining propeller component parts were intact and unremarkable.

A governor inspection and test run was performed at Hartzell under supervision of the FAA. The governor inspection revealed no anomalies and the governor operated during the test run.

Hartzell's propeller and governor report, in part, stated:

> The propeller was rotating at the time of impact. The power output could not be determined. There were no discrepancies noted in either the propeller or governor that would preclude normal operation. All damage was consistent with impact damage.

The turbocharger system's exhaust bypass valve assembly, controller, and overboost valve were examined at Kelly Aerospace Power Systems on September 15, 2005, in Fort Deposit, Alabama. Testing of the controller and overboost valve revealed that both operated. Kelly's report on the exhaust bypass valve assembly, in part, stated:

> The butterfly valve was stuck (bound) in the extended closed position.
>
> There was evidence of damage to the butterfly shaft assembly at the clevis connection (Could be indicative of tool marks on the arm and end of shaft).
>
> Butterfly shaft axial movement was .053 inch., almost twice allowable (allowable tolerance .015-.027 inch).
>
> The Turnbuckle/Clevis Assembly appeared to be forced out of alignment due to the partially bent shaft arm.
>
> The butterfly valve was not concentrically positioned within the bore of the valve housing and was in intimate contact with the side of the housing that the tension spring is on.
>
> The Damper Assembly was bent toward the housing with the bottom

end bowed out and was in contact with the butterfly shaft.
Cylinder assembly was functional, and no leaks were detected.
All external components were identified as being in accordance with the assembly print.
NOTE: One cotter pin (400143-96), a washer (400138-45), and a flat head clevis pin (400142-817) were removed in an attempt to determine if the butterfly/shaft assembly would become unbound if unattached from the actuator shaft. A lubricant (LPS-TKS) was applied liberally to the bearings and shaft region. The end of the shaft was tapped with a rubber mallet in an attempt to re-center the butterfly valve assembly within the bore of the valve housing. The shaft became partially unbound after several attempts to turn it with an adjustable flat-faced wrench.
The Wastegate Actuator was tested on the Exhaust Bypass Valve Assembly Test Bench without the valve body affixed to determine if there was any evidence of binding of the actuator assembly. No binding was evidenced. The actuator shaft began to move toward the closure position with approximately 12 PSI of pressure and was in its fully extended position at 33 PSI. This action was repeated with no evidence of hysteresis or unusual resistance.
The valve body was then reattached to the Actuator Assembly and the test was repeated. With the clevis reinstalled, the gate would not fully close under 55 PSI of pressure in the actuator body until the clevis and shaft assembly was tapped on with the rubber mallet to re-center the butterfly in the bore, the fully assembled unit would then actuate under normal pressures.

The engine's cracked crankshaft was removed and a serviceable crankshaft was installed. The engine was test run again under FAA supervision with the turbocharger's original controller, overboost valve and a serviceable exhaust bypass valve assembly. The engine produced rated power. The original exhaust bypass valve assembly was reinstalled. The exhaust bypass valve assembly's wastegate bound again during an engine run and a loss of engine power was observed.

The exhaust bypass valve assembly was sectioned for examination under FAA supervision. According to the Kelly report on the sectioned exhaust bypass valve assembly, the wastegate shaft was bent. The wastegate's lever arm was bent. The lever arm exhibited marks consistent

with toolmarks. The wastegate's shaft appeared to be an after market shaft. The Kelly report is appended to the docket material associated with this investigation.

ADDITIONAL DATA/INFORMATION

The Piper maintenance manual for the airplane was reviewed. The scheduled maintenance section checklist for the 100, 500, and 1,000 hour inspections, in part, stated, "Check wastegate actuator linkage, rod ends, springs, butterfly, and bushings for condition. (Replace as required)" The manual did not specify what an acceptable condition was for the linkage, rod ends, springs, butterfly, and bushings.

The TCM maintenance and operator's manual for the TSIO-520-BE engine, in part, stated:

> Do not continue to advance the throttle if it is apparent that overboost will occur beyond the limits specified above. An increase in manifold pressure beyond the limits specified above indicates a need to have the turbocharger controller readjusted. ... During climb (immediately after takeoff) observe manifold pressure and, if necessary, retard throttle to stay below maximum manifold pressure limits (red line). ... 100 hour inspection ... Wastegate: Check operation and condition.

The TCM maintenance and operator's manual did not specify a procedure for maintenance personnel on how to check the wastegate's operation and its acceptable condition.

A note in the TCM engine overhaul manual, that included the TSIO-520-BE engine, stated, "Hydraulic wastegates are not field serviceable or adjustable devices and should be replaced when found defective." A turbocharger troubleshooting chart from that overhaul manual, in part, stated, "TROUBLE ... Manifold pressure higher than normal ... PROBABLE CAUSE ... Binding wastegate ... CORRECTION ... Replace wastegate."

National Transportation Safety Board Recommendation A-94-081, issued to the FAA in 1994, cited, in part, the following recommendation relating to emergency procedures of engine turbocharger failures:

> Require the amendment of pilot operating handbooks and airplane flight manuals applicable to aircraft equipped with engine turbochargers by including in the 'Emergency Procedures' section information regarding turbocharger failure. The information should include procedures to minimize potential hazards relating to fire in flight and/or loss of engine power.

Section three of the airplane's POH, emergency procedures, was reviewed. The POH's latest revision was dated October 14, 2002. The review of the emergency procedures section showed that the POH did not contain information, procedures, or amplified procedures on

turbocharger failures.

The Teledyne Continental Motors maintenance and operator's manual contained a section on "turbocharger failure."

The airframe and all retained items were released to a representative of a recovery company.

Parties to the investigation were the FAA, Hartzell Propellers, New Piper Aircraft, Inc., Kelly Aerospace, and Teledyne Continental Motors.

Pilot Information

Certificate:	Private	**Age:**	51, Male
Airplane Rating(s):	Single-engine Land	**Seat Occupied:**	Left
Other Aircraft Rating(s):	None	**Restraint Used:**	Seatbelt, Shoulder harness
Instrument Rating(s):	Airplane	**Second Pilot Present:**	No
Instructor Rating(s):	None	**Toxicology Performed:**	Yes
Medical Certification:	Class 3 With Waivers/Limitations	**Last FAA Medical Exam:**	
Occupational Pilot:		**Last Flight Review or Equivalent:**	07/01/2004
Flight Time:	2200 hours (Total, all aircraft)		

Aircraft and Owner/Operator Information

Aircraft Make:	Piper	**Registration:**	N4386G
Model/Series:	PA-46-310P	**Aircraft Category:**	Airplane
Year of Manufacture:		**Amateur Built:**	No
Airworthiness Certificate:	Normal	**Serial Number:**	46-8508037
Landing Gear Type:	Retractable - Tricycle	**Seats:**	6
Date/Type of Last Inspection:	05/01/2005, Annual	**Certified Max Gross Wt.:**	4100 lbs
Time Since Last Inspection:	8.7 Hours	**Engines:**	1 Reciprocating
Airframe Total Time:	1856.4 Hours at time of accident	**Engine Manufacturer:**	Teledyne Continental
ELT:	Installed, not activated	**Engine Model/Series:**	TSIO-520-BE1
Registered Owner:	Stephen D. Jensen	**Rated Power:**	310 hp
Operator:	Stephen D. Jensen	**Operating Certificate(s) Held:**	None

Meteorological Information and Flight Plan

Conditions at Accident Site:	Visual Conditions	**Condition of Light:**	Day
Observation Facility, Elevation:	GPZ, 1355 ft msl	**Distance from Accident Site:**	0 Nautical Miles
Observation Time:	1755 CDT	**Direction from Accident Site:**	0°
Lowest Cloud Condition:	Few / 8000 ft agl	**Visibility**	10 Miles
Lowest Ceiling:	None	**Visibility (RVR):**	
Wind Speed/Gusts:	11 knots / 17 knots	**Turbulence Type Forecast/Actual:**	/
Wind Direction:	290°	**Turbulence Severity Forecast/Actual:**	/
Altimeter Setting:	29.94 inches Hg	**Temperature/Dew Point:**	21°C / 12°C
Precipitation and Obscuration:	No Obscuration; No Precipitation		
Departure Point:	Grand Rapids, MN (GPZ)	**Type of Flight Plan Filed:**	None
Destination:	MINNEAPOLIS, MN (FCM)	**Type of Clearance:**	None
Departure Time:	1758 CDT	**Type of Airspace:**	

Airport Information

Airport:	GRAND RAPIDS/ITASCA CO-GORDON (GPZ)	**Runway Surface Type:**	Asphalt
Airport Elevation:	1355 ft	**Runway Surface Condition:**	Dry
Runway Used:	34	**IFR Approach:**	None
Runway Length/Width:	5755 ft / 100 ft	**VFR Approach/Landing:**	None

Wreckage and Impact Information

Crew Injuries:	1 Fatal	**Aircraft Damage:**	Destroyed
Passenger Injuries:	N/A	**Aircraft Fire:**	None
Ground Injuries:	N/A	**Aircraft Explosion:**	None
Total Injuries:	1 Fatal	**Latitude, Longitude:**	47.211111, -93.509722

Administrative Information

Investigator In Charge (IIC):	Edward F Malinowski	**Report Date:**	12/28/2006
Additional Participating Persons:	Larry Landis; Federal Aviation Administration; Minneapolis, MN Michael McClure; The New Piper Aircraft, Inc.; Prosper, TX Tom McCreary; Hartzell Propellers; Piqua, OH Eric Thomas; Teledyne Continental Motors; Mobile, AL Randy Knuteson; Kelly Aerospace; Fort Deposit, AL		
Publish Date:			
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