



Aviation Investigation Final Report

Location:	South Bend, Indiana	Accident Number:	CHI05LA045
Date & Time:	December 14, 2004, 13:30 Local	Registration:	N922RG
Aircraft:	Pilatus PC-12/45	Aircraft Damage:	Substantial
Defining Event:		Injuries:	5 None
Flight Conducted Under:	Part 91: General aviation - Executive/Corporate		

Analysis

The airplane was substantially damaged during a forced landing following a loss of engine power. The pilot stated that shortly after takeoff, the engine "abruptly and smoothly rolled back." Movement of the power control lever had no effect. He stated that use of the manual override (MOR) system did not restore engine power. He secured the engine and executed a forced landing on a roadway. The airplane's wing struck two utility poles during rollout. Data downloaded from the accident aircraft indicated that the recorded engine interstage turbine temperature (ITT) exceeded published limits during the event. The post accident engine inspection revealed turbine damage consistent with an over-temperature event. The inspection also revealed a leak in the compressor discharge pressure (CDP) sensor bellows within the fuel control unit (FCU). The leak prevented the bellows assembly from responding to throttle inputs and resulted in the FCU providing minimum fuel flow to the engine regardless of the throttle setting. Following this accident an improved FCU design which incorporated a more robust bellows design was released and retrofitted into the entire in-service and production fleet. The airframe manufacturer issued a revision to the pilot's operating handbook to provide an improved procedure for use in the event of an in-flight engine power loss. It also updated information regarding the Manual Override (MOR) system.

Probable Cause and Findings

The National Transportation Safety Board determines the probable cause(s) of this accident to be: Failure of the fuel control unit (FCU) bellows which resulted in a significant loss of engine power and the pilot's encounter with unsuitable terrain during the subsequent forced landing. A contributing factor was the pilot's inadvertent exceedence of the engine temperature limitations during use of the manual override (MOR) system. Additional factors were the roadway and the utility poles struck during the forced landing.

Findings

Occurrence #1: LOSS OF ENGINE POWER

Phase of Operation: CLIMB

Findings

1. (C) FUEL SYSTEM,FUEL CONTROL - FAILURE
2. (F) EMERGENCY PROCEDURE - ATTEMPTED - PILOT IN COMMAND
3. (F) TURBINE ASSEMBLY - OVERTEMPERATURE

Occurrence #2: FORCED LANDING

Phase of Operation: EMERGENCY DESCENT/LANDING

Occurrence #3: ON GROUND/WATER COLLISION WITH OBJECT

Phase of Operation: EMERGENCY LANDING

Findings

4. (C) UNSUITABLE TERRAIN OR TAKEOFF/LANDING/TAXI AREA - ENCOUNTERED - PILOT IN COMMAND
5. (F) TERRAIN CONDITION - ROADWAY/HIGHWAY
6. (F) OBJECT - UTILITY POLE

Factual Information

HISTORY OF FLIGHT

On December 14, 2004, about 1330 eastern standard time, a Pilatus PC-12/45, N922RG, operated by Greenhill Aviation Co. and piloted by an airline transport pilot, was substantially damaged during a forced landing following a loss of engine power near South Bend, Indiana. The corporate flight was being operated under 14 CFR Part 91 on an instrument flight rules (IFR) flight plan. The flight was reportedly in instrument meteorological conditions (IMC) at the time of the loss of engine power, however, visual meteorological conditions (VMC) prevailed at the accident site. The pilot and four passengers reported no injuries. The flight departed South Bend Regional Airport (SBN), South Bend, Indiana about 1315. The flight's intended destination was Westchester County Airport (HPN), White Plains, New York.

The pilot stated that approximately 10 minutes after departing SBN, while climbing through 6,000 feet mean sea level (msl), the engine "abruptly and smoothly rolled back." He noted that smoke and flames were subsequently seen from both exhaust stacks. He reported that movement of the power control lever had no effect. He stated that use of the emergency manual override (MOR) system did not restore engine power. He then secured the engine.

The pilot noted that he declared an emergency with South Bend approach control and requested radar vectors to the nearest airport. The air traffic controller informed him that SBN was the nearest airport and provided a heading. He reported that he configured the airplane at best glide airspeed and remained in IMC until descending through 3,000 feet msl. Upon exiting the clouds, the pilot obtained visual contact with the airport, however, the aircraft's altitude was not sufficient to reach it. According to the pilot, the flight was over the city of South Bend at that time and he ultimately elected to set-up for a landing on a roadway. He noted that traffic cleared at the last minute and he executed a landing on the road. During the rollout the right wing struck two utility poles before the airplane came to a stop.

PERSONNEL INFORMATION

The pilot-in-command held an airline transport pilot certificate with single-engine land and sea airplane, and multi-engine land and sea airplane ratings. He was issued a first-class medical certificate with no limitations in March 2004. The pilot reported a total flight time of 2,879 hours, with 30 hours in a Pilatus PC-12/45. He noted 50 flight hours during the past 30 days, with 30 hours in the PC-12/45.

AIRCRAFT INFORMATION

The accident airplane was a 2001 Pilatus PC-12/45, serial number 409. The aircraft was a single-engine, pressurized airplane, configured with six passenger seats and two flight crew (pilot) seats. The PC-12/45 was certified to operate at a maximum altitude of 30,000 feet, and had a maximum cruise speed of 270 knots.

A Pratt & Whitney PT6A-67B turbo-shaft engine, serial number PCE-PR0271, capable of producing 1,200 horsepower, powered the accident airplane.

According to the operator, the engine and airframe had accumulated 599 hours total time. The most recent inspection was completed on July 8, 2004, at 514 hours.

METEOROLOGICAL INFORMATION

The South Bend Regional Airport (SBN) Automated Surface Observing System (ASOS), at 1254, recorded: calm winds; 9 statute miles visibility; 2,400 feet above ground level (agl) scattered, 3,000 feet agl overcast; temperature and dew point -4 and -7 degrees Celsius, respectively; altimeter setting was 30.48 inches of mercury.

At 1354, the SBN ASOS recorded: calm winds; 7 statute miles visibility in light snow; 3,400 feet agl overcast; temperature and dew point -4 and -7 degrees Celsius, respectively; altimeter setting was 30.47 inches of mercury.

WRECKAGE AND IMPACT INFORMATION

The airplane landed on U.S. Route 933, approximately 3 miles east of SBN. The aircraft came to a stop on the roadway. A section of the right wing from the end of the flap outboard was completely separated and located at the side of the road. An additional area of impact damage was located on the leading edge of the right wing about mid-span. The wing skin was crushed aft exposing the spar and sub-structure. The width of the crushed area was approximately the same as the diameter of a static wire support pole along the side of the roadway.

Two utility poles were damaged. One was knocked down and the other had impact marks consistent with the height and thickness of the wing. The outboard section of the right wing was lying against the intact pole.

TESTS AND RESEARCH

Engine operating parameters were recorded on-board the aircraft during normal operations. Recorded parameters included the interstage turbine temperature (ITT) and fuel flow (FF). Data from the accident flight was downloaded and reviewed. Prior to the rollback, the ITT was stabilized approximately 600 degrees Celsius and the fuel flow maintained about 550 pounds per hour (lbs/hr). Beginning at 1322:24 (HHMM:SS), the ITT and FF decreased from 589 degrees Celsius and 521 lbs/hr, respectively, to 420 degrees Celsius and 79 lbs/hr. The ITT and FF then began to increase, reaching 1,028 degrees Celsius and 432 lbs/hr respectively, about 1322:53. The ITT maintained approximately 900 degrees Celsius, until it peaked again 60 seconds later at 1,283 degrees Celsius. A plot of the data is included in the docket material associated with this accident file.

The pilot's operating handbook (POH) documented limitations related to engine operation. The POH denoted maximum ITT limits as follows: During starting for no more than 5 seconds,

1,000 degrees Celsius; transient for no more than 20 seconds, 870 degrees Celsius; takeoff for no more than 5 minutes, 800 degrees Celsius; and maximum continuous, 760 degrees Celsius.

The engine assembly was removed for examination. A teardown was conducted at Pratt & Whitney Canada facilities under supervision of the Transportation Safety Board of Canada.

Teardown inspection of the engine revealed that the first and second stage power turbine blades were fractured. The first stage blades were fractured approximately mid-span. Approximately one-half of the second stage blades were separated from the blade disc. The compressor blades exhibited damage at the tips, with portions of the blades missing. Noted damage was consistent with exposure to elevated temperatures.

Examination and testing of the fuel control unit (FCU) revealed a leak in the compressor discharge pressure (CDP) sensor assembly bellows. The leak was located in a pit on the outer ply of the bellows. Additional pitting was observed near the leak site and on adjacent convolutions. There was no evidence of intergranular attack into the bellows material. There was no mechanical damage to the bellows.

The CDP sensor consisted of the double-walled, hydro-formed bellows assembly fabricated from beryllium copper. Changes in CDP caused the bellows to expand or contract, which subsequently controlled a fuel valve. A leak in the bellows prevented the assembly from properly responding to pressure variations and resulted in the FCU providing minimum fuel flow to the engine regardless of throttle setting. The resulting power output of the engine at minimum fuel flow was insufficient to maintain level flight.

ADDITIONAL INFORMATION

Pratt & Whitney Canada, the manufacturer of the engine, issued Service Information Letter PT6A-128 in September 2004, regarding a prior in-flight engine power roll back on a PC-12 aircraft. The cause of the loss of engine power was attributed to a "loss of Fuel Control Unit (FCU) authority caused by leakage of the FCU bellows." The service letter noted that the leak was due to a perforation of the bellows at an inclusion in the material. The letter noted four previous events with similar malfunctions. Two of the events occurred in-flight, however, in those instances power was successfully recovered by using the MOR system.

Pilatus Aircraft Ltd., the manufacturer of the airframe, issued service letter no. 81 in conjunction with the Pratt & Whitney letter. In addition to informing operators of the engine power roll back event, Pilatus issued a revision to the pilot's operating manual regarding use of the MOR. The revision combined previous emergency procedures into one Engine Partial Power Loss in Flight procedure.

Pratt & Whitney Canada issued Service Information Letter PT6A-131 in January 2005. The letter informed operators of the occurrence of the engine power roll back involved in this accident. It also reminded pilots of the importance of being familiar with the use of the MOR and noted Pilatus' release of Pilot's Operating Handbook (POH) Temporary Revision No. 13.

POH Temporary Revision No. 13 stated that the previous Engine Power Loss and Fuel Control Unit Failure procedures specified that the power control lever (PCL) was to be placed in the forward position. The revision noted, "It has been [found] during flight tests that following the procedure incorrectly could possibly lead to engine parameter exceedences." The temporary revision provided a revised Engine Partial Power Loss In Flight procedure which combined the two previous procedures. Information regarding the MOR system was also updated. The temporary revision was subsequently incorporated into the POH in February 2005.

The revision also stated that "the MOR lever is an emergency device and it is possible to exceed engine limits if the MOR lever is operated too fast." It stated that the MOR "directly operates the fuel metering valve by . . . compressing the pneumatic bellows . . . in the FCU."

Woodward and PWC released an improved FCU design in April 2005. The revised design included a more robust bellows configuration, in which both bellows plies are sealed. In the original design, only one of the plies was sealed. In addition, a baffle was placed in the compressor discharge air (P3) stream to prevent the airflow impingement on the bellows. The survey of in-service bellows observed a tendency for pitting to be located near the area where the compressor discharge air (P3) impinged on the surface of the bellows.

Pratt & Whitney Canada issued Service Bulletin No. 14371 in April 2005. Alert Service Bulletin No. A14371R1 was issued in May 2005 and superseded the previous bulletin. Each of these recommended replacement of the FCU with one that incorporated the improved bellows design. Compliance with the alert bulletin was recommended within 250 flight hours or 6 months for the date of the letter.

Concurrent with the release of the enhanced FCU design, Pilatus, and PWC initiated a retrofit campaign for PC-12 operators. The PC-12 in-service fleet, production aircraft, and rental engines were retrofitted with FCU's which incorporated the new bellows design.

Woodward conducted a post-accident audit of the bellows manufacturer. As a sub-contractor, oversight of the bellows manufacturer was the responsibility of Woodward. The audit identified several process deficiencies. These deficiencies included incomplete internal fabrication documents, improper concentration of solutions used for cleaning and finishing the bellows, and an inadequate quality control system related to maintaining those solutions. Woodward stated that corrective action was implemented for the noted discrepancies. In addition, 100-percent quality control inspections were introduced both prior to shipment from the bellows manufacturer and when received at Woodward.

Parties to the investigation were the Federal Aviation Administration, Transportation Safety Board of Canada, Pilatus Business Aircraft, Pratt & Whitney, Woodward Governor Company, and Greenhill Aviation.

Pilot Information

Certificate:	Airline transport; Flight instructor	Age:	25, Male
Airplane Rating(s):	Single-engine land; Single-engine sea; Multi-engine land; Multi-engine sea	Seat Occupied:	Left
Other Aircraft Rating(s):		Restraint Used:	
Instrument Rating(s):	Airplane	Second Pilot Present:	No
Instructor Rating(s):	Airplane multi-engine; Airplane single-engine; Instrument airplane	Toxicology Performed:	No
Medical Certification:	Class 1 Without waivers/limitations	Last FAA Medical Exam:	March 1, 2004
Occupational Pilot:	Yes	Last Flight Review or Equivalent:	October 1, 2004
Flight Time:	2879 hours (Total, all aircraft), 30 hours (Total, this make and model), 2385 hours (Pilot In Command, all aircraft), 115 hours (Last 90 days, all aircraft), 50 hours (Last 30 days, all aircraft), 4 hours (Last 24 hours, all aircraft)		

Aircraft and Owner/Operator Information

Aircraft Make:	Pilatus	Registration:	N922RG
Model/Series:	PC-12/45	Aircraft Category:	Airplane
Year of Manufacture:		Amateur Built:	
Airworthiness Certificate:	Normal	Serial Number:	409
Landing Gear Type:	Retractable - Tricycle	Seats:	8
Date/Type of Last Inspection:	July 1, 2004 Annual	Certified Max Gross Wt.:	9921 lbs
Time Since Last Inspection:	84 Hrs	Engines:	1 Turbo prop
Airframe Total Time:	599 Hrs at time of accident	Engine Manufacturer:	Pratt & Whitney Canada
ELT:	Installed, not activated	Engine Model/Series:	PT6A-67B
Registered Owner:	Riversville Aircraft Corp.	Rated Power:	1200 Horsepower
Operator:	Greenhill Aviation Co., LLC	Operating Certificate(s) Held:	None

Meteorological Information and Flight Plan

Conditions at Accident Site:	Visual (VMC)	Condition of Light:	Day
Observation Facility, Elevation:	SBN,799 ft msl	Distance from Accident Site:	3 Nautical Miles
Observation Time:	12:54 Local	Direction from Accident Site:	270°
Lowest Cloud Condition:	Scattered / 2400 ft AGL	Visibility	9 miles
Lowest Ceiling:	Overcast / 3000 ft AGL	Visibility (RVR):	
Wind Speed/Gusts:	/ None	Turbulence Type Forecast/Actual:	/
Wind Direction:	0°	Turbulence Severity Forecast/Actual:	/
Altimeter Setting:	30.47 inches Hg	Temperature/Dew Point:	-4°C / -7°C
Precipitation and Obscuration:	No Obscuration; No Precipitation		
Departure Point:	South Bend, IN (SBN)	Type of Flight Plan Filed:	IFR
Destination:	White Plains, NY (HPN)	Type of Clearance:	IFR
Departure Time:	13:15 Local	Type of Airspace:	

Airport Information

Airport:	South Bend Regional SBN	Runway Surface Type:	
Airport Elevation:	799 ft msl	Runway Surface Condition:	
Runway Used:		IFR Approach:	None
Runway Length/Width:		VFR Approach/Landing:	Forced landing

Wreckage and Impact Information

Crew Injuries:	1 None	Aircraft Damage:	Substantial
Passenger Injuries:	4 None	Aircraft Fire:	None
Ground Injuries:	N/A	Aircraft Explosion:	None
Total Injuries:	5 None	Latitude, Longitude:	41.70861,-86.250556

Administrative Information

Investigator In Charge (IIC): Sorensen, Timothy

Additional Participating Persons: Timothy J Sokol; FAA-South Bend FSDO; South Bend, IN
Elaine Summers; Transportation Safety Board of Canada; Gatineau, Quebec
Douglas R Hardy; Pratt & Whitney Canada; Longueuil, Quebec
Steven A Krugler; Woodward Governor Company; Rockford, IL
Robert Renshaw; Pilatus Business Aircraft Ltd.; Broomfield, CO
Sven Slattberg; Greenhill Aviation; White Plains, NY

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Last Revision Date:

Investigation Class: [Class](#)

Note:

Investigation Docket: <https://data.nts.gov/Docket?ProjectID=60730>

The National Transportation Safety Board (NTSB) is an independent federal agency charged by Congress with investigating every civil aviation accident in the United States and significant events in other modes of transportation—railroad, transit, highway, marine, pipeline, and commercial space. We determine the probable causes of the accidents and events we investigate, and issue safety recommendations aimed at preventing future occurrences. In addition, we conduct transportation safety research studies and offer information and other assistance to family members and survivors for each accident or event we investigate. We also serve as the appellate authority for enforcement actions involving aviation and mariner certificates issued by the Federal Aviation Administration (FAA) and US Coast Guard, and we adjudicate appeals of civil penalty actions taken by the FAA.

The NTSB does not assign fault or blame for an accident or incident; rather, as specified by NTSB regulation, “accident/incident investigations are fact-finding proceedings with no formal issues and no adverse parties ... and are not conducted for the purpose of determining the rights or liabilities of any person” (Title 49 *Code of Federal Regulations* section 831.4). Assignment of fault or legal liability is not relevant to the NTSB’s statutory mission to improve transportation safety by investigating accidents and incidents and issuing safety recommendations. In addition, statutory language prohibits the admission into evidence or use of any part of an NTSB report related to an accident in a civil action for damages resulting from a matter mentioned in the report (Title 49 *United States Code* section 1154(b)). A factual report that may be admissible under 49 *United States Code* section 1154(b) is available [here](#).