Transportation Safety Board of Canada

Bureau de la sécurité des transports du Canada

AVIATION INVESTIGATION REPORT
A10C0159

ENGINE SHUT-DOWN AND FORCED LANDING

NORTHERN WATERWORKS SALES AND CONSULTING INC.
PIPER PA 31-310 NAVAJO, C-FWQX
PICKLE LAKE, ONTARIO, 30 NM E
10 SEPTEMBER 2010

Canada

Aviation Investigation Report

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Synopsis

The privately registered Piper PA 31-310 Navajo (registration C-FWQX, serial number 31-92), operated by Northern Waterworks Sales and Consulting Inc., was on a visual flight rules flight from Pickle Lake to Kashechewan, Ontario, with 1 pilot and 3 passengers on board. Shortly after reaching cruise altitude, there was a brief rumble from the left engine, accompanied by decreases in exhaust and cylinder head temperatures. Consequently, the pilot reversed course. While en route to Pickle Lake, the left engine performance deteriorated and the pilot shut the engine down. Unable to maintain altitude, the pilot made a forced landing about 30 nautical miles east of Pickle Lake at 1215 Central Daylight Time. The pilot and 1 passenger sustained minor injuries. The aircraft sustained substantial damage, but there was no post-crash fire. The emergency locator transmitter activated on impact.

Other Factual Information

History of the Flight

The occurrence flight departed Red Lake for Kashechewan, Ontario, on a company flight itinerary, which included a scheduled fuel stop in Pickle Lake. Prior to departing Red Lake, the pilot completed an engine run-up, which included a check of the engine magnetos. No abnormalities were noted. The flight departed Pickle Lake at 0945 [1] for the 310 nautical mile (nm) flight to Kashechewan. The aircraft climbed to the planned cruising altitude of 9500 feet above sea level (asl) and leveled off. The aircraft had just passed the midpoint when a brief rumble from the left engine was heard. This was accompanied by a drop in cylinder head and exhaust gas temperature indications on the number 3 cylinder. The pilot reversed course and descended to 8500 feet asl.

While en route to Pickle Lake, the flight encountered a broken layer of cloud. The pilot commenced a descent to 4500 feet asl, approximately 3300 feet above ground level (agl), in order to remain in visual meteorological conditions. The flight encountered moderate turbulence at that altitude.

Approximately 15 minutes after the first indication of engine problems, a series of loud bangs and other noises emanated from the left engine. In order to preclude catastrophic failure, the pilot shut the engine down by following the Engine Securing Procedure (Feathering Procedure) described in the *Pilot Operating Handbook* (POH) (see Appendix A). Initially, the pilot did not increase power on the operating engine from the cruise power setting of 30 inches of manifold pressure (MP) and 2200 rpm. The airspeed decreased to between 130 and 140 knots indicated airspeed (KIAS). About 15 minutes later, the airspeed dropped further to approximately 100 KIAS; the aircraft was losing altitude by about 100 feet every few minutes. The pilot increased power to 35 inches MP and 2300 rpm and attempted to maintain an airspeed of 92 KIAS. To reduce the rate of descent, the pilot decreased the airspeed to maintain the single engine best angle of climb airspeed (Vxse) of 90 KIAS. Initially, the aircraft was able to maintain altitude, but the airspeed decreased to 83 KIAS, at which point the aircraft began to descend again. Power was increased to 38 inches MP, but in the turbulent conditions, the airspeed fluctuated, directional control became increasingly difficult, and occasional stall buffeting was encountered. The continuing incremental loss of altitude required the pilot to execute a forced landing. The pilot asked the crew of another aircraft to relay that information to the Thunder Bay Flight Service Station.

The aircraft landed in a lightly treed, swampy area located approximately 30 nm east of Pickle Lake. The emergency locator transmitter (ELT) activated at impact and the pilot moved the switch to the ON position prior to exiting the aircraft.

The Trenton Joint Rescue Coordination Centre coordinated the evacuation of the pilot and passengers using a civilian helicopter from Pickle Lake. The helicopter arrived on the site approximately 1 hour after the forced landing.

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[1] All times are Central Daylight Time (Coordinated Universal Time minus 5 hours).

Wreckage Information

The forced landing was accomplished under control in a wings-level attitude. Both wings were damaged outboard of the nacelles and the left wing was almost severed from contact with trees. The cabin area remained intact. Both horizontal stabilizers were badly damaged.

Fuel was evident at the site and present in the aircraft; the fuel lines forward of the firewall contained fuel. Fuel records were reviewed and samples were obtained from the supplier. Fuel contamination was not a factor in the occurrence.

Weather

The reported weather for Pickle Lake at the time of the occurrence was as follows: wind 120° at 11 knots gusting to 18 knots, visibility of 15 statute miles, a few clouds at 8000 agl feet and scattered cloud at 26 000 feet agl. The temperature was 15°C, the dew point at 6°C and the altimeter setting was 29.98 inches of mercury.

Pilot Information

The pilot was certified and qualified for the flight in accordance with existing regulations. The pilot held a Commercial Pilot License with a multi-engine and instrument rating and had a total flight time of approximately 1200 hours, with 560 hours on the Navajo.

The pilot's instrument rating was renewed in January 2010 on a Beech D95 Travel Air aircraft. This training included engine failures and shutdowns. The training that the pilot had received on the Navajo at Northern Waterworks consisted of approximately 70 hours accompanying the chief pilot on normal operational flights. The pilot did not receive any type-specific emergency procedures training on the Navajo at Northern Waterworks, nor was such training required by regulation.

Aircraft

The aircraft was owned by Northern Waterworks Sales & Consulting Inc. and was used to transport company personnel and equipment to various job sites in northern Ontario. The aircraft, powered by 2 Textron Lycoming TIO-540 engines, had been inspected at 100-hour intervals, according to manufacturer recommended checklists that contained the items listed in the *Canadian Aviation Regulations* (CARs) Standard (STD) 625 Appendix B [2] and Appendix C [3]. A review of available documentation indicated that the Navajo was maintained on a schedule that met the regulatory requirements for a private aircraft.

The right engine had been replaced during the last inspection and had accumulated approximately 6 hours since overhaul. The left engine was overhauled and installed in 2006 and had accumulated 1669 hours prior to the accident flight.

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[2] CARs STD 625 Appendix B - Maintenance Schedules.

[3] CARs STD 625 Appendix C - Out of Phase Tasks and Equipment Maintenance Requirements.

Notable performance information includes:

- Max continuous power for the TIO 540 is 40.5 inches MP and 2575 rpm;
- The left engine is the critical engine [4];
- The single engine service ceiling for the conditions was 15 800 feet asl [5];
- Minimum single engine control speed (Vmc) is 76 KIAS;
- Best single engine rate of climb speed (Vyse) is 94 KIAS; and
- Best single engine angle of climb speed (Vxse) is 90 KIAS.

The aircraft's weight and centre of gravity were within prescribed limits.

Left Engine

The left engine, propeller and an engine temperature indicator were recovered for examination and testing. Inspection of the engine revealed that the piston crowns exhibited a clean, shot-blasted appearance. One sparkplug fired by the left magneto and several fired by the right magneto were fouled. Initially, it was not possible to start the engine. Although the points of both magnetos were opening at the correct time, the left magneto distributor rotor was rotating intermittently and was out of synchronization with the engine. After replacing the left magneto, the engine functioned normally at all power settings.

Left Magneto

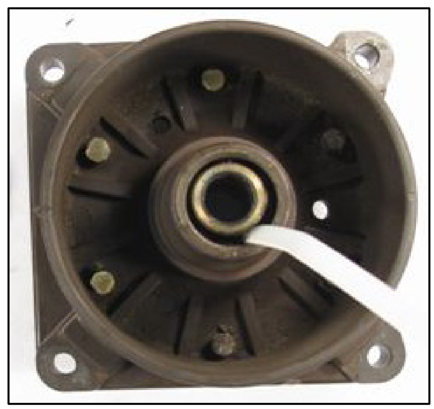

Photo 1. Loose distributor block bushing held askew by Tyrap

The left magneto was a Bendix Model S6LN-1208 that had been overhauled and installed with the left engine in 2006 and had accumulated 1669 hours of operation. Since installation, the magneto had been inspected every 100 hours, as required by the Piper Navajo service manual checklists.

Disassembly of the magneto revealed that the bronze bushing molded into the centre of the distributor block (P/N 10-391586) was loose (see Photo 1). The distributor rotor gear is supported in a cantilever fashion by the distributor rotor gear shaft, which rotates in the distributor

4 A propeller develops more thrust on the downward travelling side of the propeller disc and, in the case of a clockwise rotating propeller, results in a yawing moment to the left. In this model of Navajo, with 2 clockwise rotating propellers, the thrust line of the right hand engine is further from the aircraft's centre-line than the left hand engine. Consequently, the left engine is referred to as the "critical engine" because the loss of this engine results in the greatest yawing moment. At low airspeeds, this yawing moment can lead to difficulty in maintaining directional control if the right hand engine is brought to full power.

5 Service ceiling is the pressure altitude where the airplane has capability of climbing 50 feet/minute with 1 propeller feathered. Single engine service ceiling is dependent on weight and temperature. *Pilot Operating Handbook* and *FAA Approved Airplane Flight Manual - Piper Navajo*, Section 5, p. 5-22.

block bushing and is retained by a circlip.

The loose distributor block bushing allowed the distributor rotor gear to be displaced radially (see Photo 2). The resulting misalignment caused reduced gear tooth mesh and fracture of 2 distributor rotor gear teeth.

The intermittent engagement of the distributor rotor gear with the drive pinion gear of the input shaft resulted in the distributor rotor becoming out of synchronization with the engine. The out-of-time, intermittently-turning rotor would have caused the rough running, backfiring, power decrease and drop of exhaust gas temperature. This was further illustrated by data recovered from the engine temperature indicator that showed that the engine was running poorly on 3 cylinders when it was shutdown.

Photo 2. Displaced distributor rotor

Service bulletins (SB) related to Bendix magnetos are issued by Teledyne Continental Ignition Systems (TCIS). Of particular interest is TCIS SB 643, which is currently at revision B. This bulletin contains maintenance recommendations for Bendix magnetos and refers the reader to the *Service Support Manual* for detailed instructions. A review of technical records revealed that the recommendations contained in SB 643B had not been completed.

Checking the distributor block bushing for looseness is a specific task described in the 500-hour inspection of the *Service Support Manual* and any looseness requires distributor block replacement. As the engine manufacturer, Textron Lycoming issues bulletins that are essentially a reprint of all original equipment manufacturer SBs with the intent of bringing them to the attention of aircraft owners. Textron Lycoming issued Mandatory SB 515 in 1994 to introduce TCIS SB 643. The cover page of SB 515 reminds the reader to "[e]nsure that this reprint of Teledyne Continental Motors Service Bulletin No. 643 is still current at time of compliance".

SBs issued by an original equipment manufacturer are advisory in nature. Compliance is optional unless mandated by an airworthiness directive (AD). [6]

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6 CARs Standard 625 App H – "(ii) In states where the civil aviation authorities issue ADs separately from the applicable service bulletins, aeronautical product manufacturers occasionally mark their service bulletins "mandatory". Such categorization simply indicates the manufacturer's opinion of the importance of the bulletin and has, by itself, no regulatory obligation, even if the bulletins are shown to be approved by those authorities. (The latter approval applies only to the work description section of the bulletins and indicates that the aircraft or component will still conform to its type certificate following the work.) In short, service bulletins themselves are not mandatory unless mandated by the foreign civil aviation authority, or referenced by an AD."

Emergency Procedures

The Navajo POH, Section 3.3, Emergency Procedures, contains a number of engine-inoperative procedures. The pilot must determine which procedure to use based on the nature of the emergency, stage of flight and airspeed. Section 3.3 does not contain a precautionary engine shutdown checklist.

The Engine Securing Procedure (Feathering Procedure) directs the pilot through the various steps required to secure an engine (see Appendix A) and is supposed to be accomplished in conjunction with the appropriate emergency procedure. Unlike other procedures in Section 3.3 (see Appendix B), it does not prompt the pilot to adjust the power on the operative engine or provide specific power settings required to sustain level flight.

Asymmetric Flight

When a twin engine aircraft such as the Navajo experiences an engine failure, the resulting loss in performance can be as great as 80%. [7] When 1 engine fails, the aircraft not only loses power, but the drag forces increase considerably because of asymmetric thrust, rudder position, bank angle and fuselage drag. [8] The operating engine must then carry the full burden alone, which may require 75% or more of its rated power, leaving little excess power for climb or acceleration. As airspeed decreases, more rudder deflection is required to maintain directional control. Acceleration in an asymmetric condition requires more power due to increased drag. The asymmetric condition is further aggravated if it is caused by the loss of the critical engine. Some factors that affect aircraft controllability during asymmetric flight are:

- Airspeed;
- Power output of the remaining engine;
- Whether or not the failed engine is the critical engine;
- Weather conditions. The presence of turbulence can cause airspeed fluctuations leading to difficulty in maintaining altitude and directional control; and
- Drag – gear, flaps, etc.

The following TSB laboratory report was completed:

LP 139/2010 – Recovery of Non-volatile Memory (NVM) JP Instruments, Model EDM-760, Temperature Indicator

This report is available from the Transportation Safety Board of Canada upon request.

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7 FAA flight training handbook, Chapter 16, Light twin performance characteristics.

8 Commercial Aviation Safety Team, "Asymmetric Flight": http://www.cast-safety.org/pdf/5_asymmetric_flight.pdf. Website address confirmed accessible as of report release date.

Analysis

The initiating event of the occurrence was a magneto failure in the left engine. This failure was the result of the loss of retention of the bushing in the distributor block of the left magneto. The subsequent misalignment of the distributor rotor caused the rotor to become out of synchronization with the engine. This caused the left engine to run rough, backfire and lose power. The clean, shot-blasted appearance of the piston crowns indicates that the rough running and back firing likely released combustion products that contaminated sparkplugs of both magneto systems. It could not be determined whether the engine would have been capable of producing significant power running on the right magneto alone.

The aircraft should have been able to sustain level cruising flight with a single engine. This analysis will consider why the aircraft was unable to do so.

The pilot had not received emergency procedures training on the Navajo and was unfamiliar with its handling characteristics while 1 engine was inoperative. This unfamiliarity may explain why the pilot did not increase the power on the right engine to maximum when the left engine was shut down. The airspeed decreased incrementally, requiring a corresponding increase in rudder to maintain directional control, which in turn, increased drag. The airspeed continued to decrease and subsequent power increases on the operating engine were insufficient to maintain altitude. The aircraft became difficult to control as it entered the turbulent air and altitude was gradually lost. Eventually, the pilot was required to execute a forced landing.

The Navajo POH, Section 3, Engine Inoperative Procedures, does not contain a precautionary engine shutdown procedure. Unlike the Engine Securing Procedure (Feathering Procedure), other engine inoperative procedures in Section 3 contain specific guidance with respect to engine power settings. Consequently, pilots using only this procedure to perform a precautionary shutdown may not apply sufficient power to the operating engine to sustain level flight. The Navajo emergency procedures that pertain to engine failures require the pilot to be practiced and familiar with the procedures for them to be used effectively in a single engine situation.

The aircraft magnetos had been inspected every 100 hours, as required by Piper Navajo service manual checklists. These inspections are sufficient to satisfy the routine maintenance that is required as the magneto accumulates hours in service. However, the inspections were not sufficient to detect an incipient failure that had developed over many hours of operation. If the SB 643B 500-hour inspection recommendations had been completed by following the procedures contained in the *Service Support Manual*, there would have been several opportunities to detect and correct any distributor block bushing looseness before the magneto failed.

Findings as to Causes and Contributing Factors

1. The left magneto distributor rotor gear teeth uncoupled from the input pinion gear, placing the distributor rotor out of time with the engine. As a result, the left engine began to run rough, backfire and lose power.

2. The pilot shut down the left engine, but did not immediately adjust the power on the operating engine. Airspeed then decreased to a point where the addition of power resulted in the aircraft becoming difficult to control in the turbulent conditions.

3. The gradual loss of altitude eventually required a forced landing.

Findings as to Risk

1. If the Navajo *Pilot Operating Handbook*, Section 3, Engine Inoperative Procedures, Engine Securing Procedure (Feathering Procedure), is used as a stand-alone procedure, there is a risk that sufficient power may not be applied to the operative engine to maintain flight.

2. If the 500-hour magneto inspection recommendation of Service Bulletin 643B is not followed, there is a risk that the looseness of the distributor block bushing will go undetected and uncorrected.

This report concludes the Transportation Safety Board's investigation into this occurrence. Consequently, the Board authorized the release of this report on 04 July 2011.

Visit the Transportation Safety Board's website (www.bst-tsb.gc.ca) for information about the Transportation Safety Board and its products and services. There you will also find links to other safety organizations and related sites.

Appendix A - Engine Securing Procedure (Feathering Procedure)

ENGINE INOPERATIVE PROCEDURES

ENGINE SECURING PROCEDURE
(FEATHERING PROCEDURE)

Throttle……….……………………………………………...close

Propeller……………………….FEATHER (1000 RPM min.)

Mixture……………………………………IDLE CUT-OFF

Cowl flaps……………….……………………………..close

Magneto Switch………………………………………..OFF

Emergency fuel pump……………………..…………...OFF

Fuel selector…………..…………………….OFF (detent)

Alternator CB switch……………………..…………….OFF

Prop Sync. …………………..…………………………..OFF

Electrical load……………………………………...reduced

Crossfeed………………………………………..considered

Appendix B - Engine Failure During Flight (Above 76 KIAS)

ENGINE INOPERATIVE PROCEDURES

ENGINE FAILURE DURING FLIGHT
(Above 76 KIAS)

Inop. eng……….………….…………………………….…..……...identify

Operative eng…...……….………….………………………..adjust as required

Before securing inop. engine:

Fuel flow………...…check (if deficient – emergency fuel pump ON)

Fuel quantity…………………………….……..………………..check

Fuel Selector (inop. eng…...…….switch to other tank containing fuel

Oil pressure and temp........................….…..………….………….check

Magneto switches…………….……………….………….…..…….check

If engine does not start, complete Engine Securing Procedure

Power (operative eng.)………………………….………….as required

Mixture (operative eng.)…………….…...……..……...adjust for power

Fuel quantity (operative eng. tank)……………….…….…sufficient

Emergency fuel pump (operative eng.)………………...….as required