Transportation Safety Board of Canada

Bureau de la sécurité des transports du Canada

AVIATION INVESTIGATION REPORT
A07C0119

ENGINE POWER LOSS – FORCED LANDING

WAMAIR SERVICE & OUTFITTING INC.
PIPER PA-31-350 CHIEFTAIN C-GRNK
MATHESON ISLAND, MANITOBA
10 JULY 2007

Canada

Aviation Investigation Report

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Summary

The Wamair Service & Outfitting Inc. Piper PA-31-350 Chieftain aircraft (registration C-GRNK, serial number 31-7652112) was departing Matheson Island, Manitoba, on a visual flight rules flight to Poplar River, Manitoba, with one pilot and seven passengers on board. Shortly after lift-off, the pilot noted indications of right-engine power loss. The pilot secured the engine and turned the aircraft to return to the Matheson Island aerodrome. The aircraft did not gain altitude, and the pilot carried out a forced landing in a marsh approximately two nautical miles southwest of the aerodrome. The pilot and passengers exited the aircraft and were taken by boat to the nearest road and from there by ambulance to medical facilities. The aircraft sustained substantial damage. There was no post-crash fire. The accident occurred during daylight hours at 1800 central daylight time.

Ce rapport est également disponible en français.

Other Factual Information

The observed weather at 1800 central daylight time[1] at Winnipeg, Manitoba, 110 nautical miles (nm) south of Matheson Island, was as follows: wind 320° true (T) at 12 knots gusting to 18 knots, visibility 15 statute miles, with a few towering cumulus clouds at 5100 feet. The 1700 temperature was 18°C and dewpoint was 13°C. The observed weather at 1800 at Berens River, 38 nm north of Matheson Island, was as follows: temperature 18°C, winds north-northeast at 4 knots. The winds at Matheson Island were estimated as northwest at 10 knots gusting to 18 knots.

The pilot held a commercial pilot licence endorsed for single- and multi-engine land and sea aeroplanes. The licence was validated by a medical certificate valid to December 2007. The pilot's last pilot proficiency check was completed on 01 June 2007 and was valid to July 2009.

Maintenance records indicated that the aircraft was equipped and maintained in accordance with the current *Canadian Aviation Regulations* (CARs). The aircraft had been modified in 1995 by the incorporation of a Boundary Layer Research, Inc. Super Chieftain I gross weight increase kit. The modification consisted of engine nacelle strakes and 88 vortex generator tabs affixed to the wings and vertical tail. The United States Federal Aviation Administration (FAA) approval of the modification required that a minimum of 84 vortex generator tabs be present on the aircraft. The modification increased the maximum approved gross take-off weight of the aircraft from 7000 pounds to 7368 pounds. The modification revised the centre of gravity limits to 126 to 135 inches aft of datum, at a gross weight of 7000 pounds. With the modification, the aircraft's minimum single-engine control speed is revised to 72 knots and the single-engine best rate of climb speed is 107 knots.

The aircraft load at take-off consisted of a pilot, seven passengers, baggage, and fuel. The aircraft's load was recalculated by TSB investigators using actual passenger weights. The recalculation indicated that the aircraft's gross weight at take-off was 6978 pounds and the centre of gravity was between 133 and 134.2 inches aft of datum.

The pilot conducted a passenger briefing before departure. During the briefing, the pilot mentioned that seat belts were to be worn during the flight. Two of the passengers required seat-belt extensions in order to use the aircraft's seat belts. There was only one seat-belt extension on board. One passenger did not use the seat belt at any time during the flight. The CARs require that aircraft be equipped with a seat belt for each person on board, that passengers comply with crew instructions to secure seat belts, and that all passengers be seated and secured.[2]

Matheson Island is a registered aerodrome, elevation 725 feet, with one gravel-surfaced runway 3500 feet long, oriented 028° to 208° magnetic (M) (Runways 03 and 21). Take-off from Matheson Island in the direction of Poplar River requires over-water operation, some of which is likely beyond gliding distance from land. No over-water equipment was noted in the aircraft

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1 All times are central daylight time (Coordinated Universal Time minus five hours).

2 Sections 605.22, 605.26, and 703.38, respectively, of the *Canadian Aviation Regulations*.

during a post-occurrence examination. The operator recently increased the clearway past the north end of the runway to about 1200 feet. On departure, the pilot taxied the aircraft to the south end of the runway and conducted a rolling take-off (to prevent propeller damage) on Runway 03 with a flap setting of 15°. The pilot set engine power to maximum (2575) rpm and 42 inches of manifold pressure, in accordance with his training, and rotated the aircraft near the departure end of Runway 03 at about 72 knots; the landing gear and flaps were raised shortly thereafter.

Almost immediately after lift-off, the right engine began to lose power and trail black smoke. The pilot initially attributed the changing control forces resulting from the power loss to windshear resulting from crosswind over the trees upwind of the runway. Once the aircraft was above the trees, the pilot identified the power loss, shut down the engine and feathered the propeller. The aircraft attained an airspeed of 90 to 100 knots, did not accelerate, and did not climb above its initial altitude of about 200 feet above ground level (agl) during the remainder of the flight. The pilot made a brief radio transmission as to the situation, and then turned the aircraft to the left to initiate a “race track” circuit to return to Runway 03. He chose this procedure in order to land into wind and avoid a 180° return to Runway 21.

During the power loss recovery procedure, the pilot initially increased manifold pressure up to the maximum allowed 49 inches, but then reduced power in order to maintain directional control. Aircraft performance is reduced in a turn. During the turn from downwind to base leg, the aircraft lost altitude. The pilot prepared for a forced landing and called for the passengers to prepare to brace for the impact. The aircraft landed in a marshy area with shallow water and tall reeds. The pilot landed with the landing gear retracted and the flaps up. Landing with the landing gear retracted reduces the risk that the aircraft will overturn in a landing on a soft surface. Landing with the flaps retracted maximizes the aircraft performance during the approach, and tends to lead to a somewhat nose-high attitude on landing, which reduces the risk that the nose will dig into a soft surface and the aircraft will overturn.

After the aircraft came to rest, the pilot initiated a passenger evacuation onto the aircraft wings, when water started to enter the passenger compartment. Some passengers suffered various non–life-threatening injuries as a result of the bumpy landing. Most passengers, including the passenger without a seat belt, were mobile and were able to leave the aircraft unassisted.

Several Wamair Service & Outfitting Inc. staff members responded to the occurrence with vehicles and boats to transport the aircraft occupants to the nearest road, about 0.3 nm from the aircraft’s position in the marsh. The passengers were taken by ambulance for medical attention. One passenger had suffered serious injuries. The pilot and three passengers had sustained minor injuries. Three passengers were not injured.

The aircraft‘s approved aircraft flight manual (AFM) Procedures Section indicates that the take-off procedure is, in part, “throttles – full forward,” and then “manifold pressure (43” normal-static sea level, standard temperature 15°C) – checked.” The AFM Limitations Section indicates that each engine is rated to produce 350 HP at 2575 rpm. The maximum allowed manifold pressure below 15 000 feet is 49 inches. The single-engine climb performance chart in the AFM is based on one engine feathered and a functioning-engine power setting of

2575 rpm and full throttle. The Operating Tips Section appended to the AFM indicates that "Normal take-off manifold pressure is approximately 43 to 44 inches (sea level std. temperatures)."

The AFM emergency procedure for an engine failure during short-field take-off below 106 knots specifies that the engine should be shut down, the fuel and ignition turned off, and the aircraft should be landed avoiding obstacles. The AFM specifies the following for speeds above 106 knots:

- maintain directional control
- power – maximum continuous on the operating engine
- feather the propeller on the inoperative engine
- bank 5° into the operating engine; and
- airspeed, maintain 106 knots until clear of obstacles and then maintain 109 knots.

It does not provide an emergency procedure to deal specifically with a malfunction of the turbocharger.

The manufacturer of the engine (Lycoming LTIO-540-J2BD) has produced a power setting chart to assist maintenance engineers when setting up the engine for correct operation. The chart (Lycoming Service Instruction 1187J) indicates a normal setting of 42.2 to 46.7 inches, depending on compressor discharge temperature. The chart's procedures are designed to allow the engine to automatically provide a minimum of 350 HP at full throttle, at various combinations of temperature and pressure. The aircraft manufacturer advised that 43 inches of manifold pressure and 2575 rpm would yield 350 HP at sea level and 15°C, and that greater manifold pressure would be required, and would be automatically provided, at higher temperatures and altitudes.

The operator was using a quick reference handbook (QRH) compiled by another aircraft operator, obtained from that operator when the aircraft was purchased by Wamair Service & Outfitting Inc. The QRH listed various procedures and limitations, including a take-off power setting of 2575 rpm and 37 to 42 inches of manifold pressure. The QRH was not approved by Transport Canada for Wamair Service & Outfitting Inc.'s operation, and it does not supersede the AFM.

The aircraft was not equipped with flight data or cockpit voice recorders, nor were such recorders required by regulation. The certification basis of the aircraft does not require the aircraft to be capable of a positive rate of climb in the event of an engine failure. There is no requirement for the aircraft to meet engine-inoperative accelerate-stop or accelerate-go performance specifications.

The aircraft performance charts indicate that the aircraft's take-off distance, at maximum rated power, and the aircraft weight and atmospheric conditions applicable to the accident aircraft should be about 1500 feet, and that the aircraft should be capable of a positive single-engine rate of climb of about 190 feet per minute at best rate of climb airspeed. Take-off performance is predicated on a paved, level, dry surface and full power set before beginning the take-off roll. No performance charts were available for rolling take-offs or for take-off performance from gravel runways, although these conditions are known to increase aircraft take-off distances.

The aircraft was recovered from the marsh and was examined by TSB investigators. No structural or control anomalies were noted. The right engine was removed for examination. The engine had been overhauled in February 2003 at a total accumulated flight time of 1997 hours. The engine had been repaired in November 2005 and December 2006 at accumulated times of 624 and 820 hours, respectively. The engine could not be run because of internal corrosion resulting from submersion in water during the occurrence.

The aircraft's fuel and fuel delivery system was examined to the extent possible. Several parts of the system had been damaged during the forced landing. However, the aircraft's fuel tanks contained sufficient fuel for the intended flight and no anomalies were noted. The engine's spark plugs were black and sooty.

The right engine's turbocharger system was examined. The differential pressure controller was removed and disassembled. The adjustment of the controller was checked by attempting to turn the poppet valve. The valve is held in place by a threaded shaft and is normally secured by fibre sealant. The valve was found to turn so easily on its shaft that the security of its adjustment was not assured. Oil was found on the air side of the valve, and its adjustment was found at the upper limit of its allowable range. The controller incorporates a rubber bellows diaphragm, which was also tested. It was found to leak air from a hole, and was loose on its base. As a result, it bypassed air and failed the test. The combination of the poppet valve setting and the loose and defective diaphragm would have signalled the engine's turbocharger waste gate to open and drop the turbocharger off line. Records indicated that the differential pressure controller was overhauled with the engine in February 2003 and had been repaired in September 2004 at an accumulated time of 350 hours.

The engine's turbocharger system is designed to provide positive air pressure to the engine's intake manifold, up to the maximum prescribed limit. The air pressure is provided automatically, in response to scheduled fuel, as controlled by throttle input. The pilot controls throttle setting, and as the throttle setting is increased, the turbocharger comes on line to an increasing extent to provide sufficient air to maintain an efficient mixture of fuel and air in the intake manifold, and from there, into the cylinders. If the turbocharger drops off line, the volume of fuel delivered to the engine intake manifold will continue unchanged at a given rpm. However, the volume of air will be drastically reduced at higher power settings because the engine no longer receives pressurized air, and must draw it through the intake system past the non-functioning turbocharger. As a result, the manifold pressure drops and the fuel-air mixture in the engine becomes significantly richer and may become too rich for the engine to burn, resulting in a loss of engine power.

Analysis

The AFM procedure for setting full engine power (throttles – full forward, check manifold pressure 43 inches) would have produced a higher engine power output on take-off than the operator's method of setting take-off power. The airport elevation and the higher-than-standard ambient temperatures would have increased induction temperatures and thereby reduced induction air density. This would have required increased manifold pressure during the take-off, which could have been produced automatically by the turbocharger controllers had the throttles been fully advanced. The engines were likely capable of greater than 42 inches manifold pressure; the left engine produced up to 49 inches manifold pressure during the return to Matheson Island. The operator's use of the procedures in the QRH had the effect of reducing manifold pressure and engine power during take-off.

The aircraft was within its weight and centre of gravity limits, although it was near its maximum allowable weight. The operator's power setting procedure, operation from a gravel strip, and the use of a rolling take-off all contributed to a lengthened take-off roll. Performance information is not available to calculate the increased distance required. The lift-off, near the departure end of the runway, provided a limited distance for aircraft acceleration and climb before the aircraft crossed the trees located north of the runway end. Crosswind turbulence would also have reduced aircraft performance during initial climb. As a result, the aircraft did not attain its best rate of climb airspeed after take-off, and did not have enough altitude to be able to descend in order to accelerate after the loss of engine power. The increased drag resulting from low airspeed reduced the aircraft's performance, from the value provided in the AFM, to the point where it was barely able to maintain airspeed in level flight and lost altitude in the turns required to return to Matheson Island. The pilot's decision to force-land the aircraft in the marsh allowed him to maintain control and place the aircraft in a landing site where its speed could be gradually dissipated and the aircraft would not submerge. These actions reduced the risk of injury to passengers during the forced landing.

The right-engine turbocharger differential pressure controller was defective and near the limit of its adjustment range. These anomalies significantly reduced available engine power at a critical time in the take-off sequence. The black smoke produced by the engine and the condition of the spark plugs indicate that the fuel-air mixture in the engine was too rich to produce power efficiently.

After the engine power loss was noted, some measure of engine power could have been restored by reducing the right throttle, which would have had the effect of leaning the fuel-air mixture. However, the pilot did not have sufficient time to troubleshoot the system and no procedure to recognize or handle a turbocharger system malfunction was provided. After the engine power loss was recognized, the pilot faced a difficult choice: the aircraft was below its single-engine best rate of climb airspeed, but following the AFM procedure for engine failure below 106 knots would have required a landing into the trees north of the runway, likely resulting in significant injuries. The pilot chose to attempt to fly the aircraft away, albeit at reduced airspeed and impaired performance. The pilot maintained airspeed above the minimum single-engine control speed and directed the aircraft to a safer landing site. As a result, it can be concluded that the pilot's action in securing the engine and propeller and continuing flight was appropriate under the circumstances.

The aircraft's seat belts and seat-belt extension were not sufficient to restrain all the passengers, increasing the risk of injury during a forced landing. The aircraft was based on an island. Its equipment was not adequate for a water landing, increasing the risk to occupants during the over-water portion of the planned flight had such a landing become necessary.

Findings as to Causes and Contributing Factors

1. The operator used an unapproved power-setting procedure in its Piper PA-31-350 operation. This reduced engine power during take-off, and combined with the gravel runway and rolling take-off, resulted in an increased take-off distance.

2. The right-engine turbocharger differential pressure controller malfunctioned at a critical time in the take-off sequence, resulting in a loss of engine power.

3. The length of the take-off run and the timing of the engine power loss did not allow the aircraft to accelerate to its best single-engine rate of climb airspeed. As a result, the aircraft did not climb after the engine power loss.

4. There was insufficient altitude and airspeed to manoeuvre the aircraft to a successful landing at the Matheson Island aerodrome following the loss of engine power.

Findings as to Risk

1. The aircraft was not equipped with seat-belt extensions to accommodate all the passengers who required them. As a result, one passenger was not restrained during the flight, increasing the risk of injury.

2. The aircraft was not adequately equipped for over-water operation, increasing the risk to the occupants during such operations.

Other Finding

1. The pilot's selection of the forced-landing site in a marsh reduced the risk of injuries or fatalities as a result of this occurrence.

Safety Action Taken

On 27 September 2007, the TSB issued Aviation Safety Advisory A07C0119-D1-A1 *(Use of Incorrect Power-Setting References)* to Transport Canada (TC). The Advisory suggested that TC may wish to take action to ensure that operators are aware of the need to use approved flight operations reference material, and that they ensure that crews are using the correct flight operations references.

On 01 November 2007, TC responded to the above Advisory. TC indicated that it had reviewed the Advisory and had decided to publish it in an upcoming issue of its *Aviation Safety Letter* to ensure that operators are aware of the need to use approved flight operations reference material.

This report concludes the Transportation Safety Board's investigation into this occurrence. Consequently, the Board authorized the release of this report on 30 January 2008.

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