AVIATION INVESTIGATION REPORT
A00C0260

COLLISION WITH TERRAIN

KEYSTONE AIR SERVICE LTD.
PIPER PA-31-350 CHIEFTAIN C-GZFK
WINNIPEG INTERNATIONAL AIRPORT, MANITOBA, 2 NM S
06 NOVEMBER 2000

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Summary

The Keystone Air Service Piper PA-31-350 Chieftain aircraft, serial number 31-7752107, was on an instrument flight rules flight from Pukatawagan, Manitoba, to Winnipeg, with an en route refuelling stop at Flin Flon. One pilot and seven passengers were on board. The aircraft left Flin Flon with a full load of fuel. At 1741 central standard time, while the aircraft was on an instrument landing system approach to runway 36 at Winnipeg International Airport, radar contact and radio communication with the aircraft were lost. The airport crash alarm was activated, and emergency response services began searching for the aircraft. Shortly thereafter, a passenger of the aircraft contacted the 911 police service by cellular phone to report that the aircraft had crashed and to request assistance. Winnipeg city police located the aircraft, about an hour later, in a wooded area approximately two nautical miles south of the airport. Two of the eight occupants were seriously injured; several others sustained minor injuries. The aircraft was substantially damaged. There was no post-crash fire.

Ce rapport est également disponible en français.

Other Factual Information

The Winnipeg airport weather at the time of the accident was as follows: temperature 2 degrees Celsius; wind 010 degrees magnetic at 22 knots, gusting to 30 knots; overcast clouds at 500 feet above ground level; and visibility 3 statute miles in light rain and mist. Icing in cloud was not observed or reported by aircraft landing at Winnipeg.

The pilot held a valid commercial pilot licence with a Group 1 instrument rating. He had completed a pilot proficiency check with a Transport Canada inspector in September 2000 and met the recency and currency requirements for carrying passengers. The pilot had a total time of approximately 1500 hours, with about 200 hours on the occurrence type. He had joined Keystone Air Service Ltd. in late August 2000. He had flown approximately 47 hours in the last 30 days, including 19 hours in the last 7 days. The pilot had a day of rest on the day before the occurrence. At the time of the occurrence, the pilot had been on duty about 10.5 hours and had flown about 4.6 hours. The flight was conducted under Canadian Aviation Regulation (CAR) 703—Air Taxi Operations, and the aircraft was certified for flight into light-to-moderate icing conditions.

Radar data tapes were used to determine the actual approach profile flown and to estimate the ground speed of the aircraft during the approach. Aircraft ground speed, as displayed on radar, is derived from the aircraft's position versus time. The aircraft's true airspeed is estimated from the wind velocity and the aircraft ground speed. The indicated airspeed can then be estimated by adjusting for the pressure altitude and the temperature. For the ambient conditions at Winnipeg at the time of the occurrence, the true and indicated airspeeds can be considered equivalent. Indicated airspeeds in this report were estimated using this procedure.

The aircraft was in instrument meteorological conditions at 2500 feet above sea level (asl) on radar vectors when it was cleared for a straight-in instrument landing system (ILS) approach to runway 36 at Winnipeg. When the clearance was issued, the aircraft was 2 miles from the localizer and positioned to intercept the localizer at 11 miles from the runway. The aircraft descended to 2200 feet asl as the localizer was intercepted. After localizer interception, the aircraft gradually descended and reached 1900 feet asl 1.5 miles before the Whiskey beacon. The final approach fix (Whisky beacon) minimum crossing altitude is 2000 feet asl, and the glidepath check altitude is 2110 feet asl. Until reaching the Whiskey beacon, the pilot maintained 105 to 110 knots indicated airspeed (KIAS). The radar data tapes showed that the indicated airspeed of the aircraft decreased to about 80 to 90 KIAS before the aircraft crossed the beacon. The aircraft then descended to 1700 feet asl with a further speed reduction to 70 to 80 KIAS. The aircraft's landing gear were extended and the flaps were in approach setting.

In the vicinity of the Whiskey beacon, the right fuel flow warning light illuminated. The pilot confirmed that the fuel boost pump switches were selected ON and that the main fuel tanks were selected. The fuel quantity of the right main fuel tank was observed as three-quarters full. About 20 seconds after the aircraft crossed the beacon, the aircraft yawed suddenly to the right when the right engine lost power. The pilot rechecked the position of the fuel boost pump and the fuel selector switches and attempted to restart the engine. Although the pilot accomplished these actions quickly, their accomplishment delayed the basic response of "Control, Power, Drag" when the aircraft was at critical airspeed and altitude.

The pilot then carried out an engine-out drill—increasing power on the left engine, raising the landing gear, and feathering the right engine—but he left the flaps in the approach setting. Although raising the flap was likely essential to reach the runway, the flaps could not be raised safely until the airspeed was increased. During this time, the stall warning tone sounded repeatedly, and the pilot was unable to control the aircraft when left engine power was increased. The aircraft descended through the cloud base at an average rate of 800 feet per minute and at approximately 80 KIAS. Whenever the pilot applied left engine power, the aircraft yawed and rolled to the right, which he controlled by reducing power on the left engine. The pilot selected the landing gear down and retarded the left throttle to idle as the aircraft settled into the trees.

The aircraft came to rest upright, with the landing gear down and the flaps partially extended. The right inboard fuel cell was ruptured, but a considerable amount of aviation fuel remained trapped within the right surge tank. A large globule of ice (which when melted was approximately one cup of water) was removed from inside the right surge tank at the site. The left inboard fuel tank was approximately three-quarters full; some fuel had escaped from this tank, after the crash, through an impact-damaged fuel drain. The left and right outboard fuel tanks contained a small amount of fuel. The cockpit fuel selector switches were at the inboard position. All four fuel caps were securely fastened.

Each inboard fuel tank is partitioned into two segments (see Appendix A). The small segment, or surge tank, has a capacity of about four gallons and a purge (drain) valve; the engine draws fuel from this tank. A one-way flapper valve on the partition between the surge tank and the large segment allows fuel to flow into the surge tank. There is no purge valve in the large segment. A low-fuel sensor, installed in each surge tank, activates the respective fuel flow warning light in the cockpit when fuel starvation is imminent. Analysis of the cockpit warning lights indicated that the right fuel flow warning light was illuminated when the aircraft struck the ground. Examination of the inside of the large segment of the right inboard fuel tank bladder revealed a rust line up to the level of the flapper valve (see Appendix B). Fuel samples from the inboard fuel tanks were analyzed and found to be of normal quality.

Tests were conducted at the regional Transportation Safety Board office to try to simulate water buildup and freezing of the flapper valve. The test was conducted in sub-zero temperatures. Water was allowed to collect outside the surge tank and adjacent to the flapper valve and spill over into the surge tank. The water froze and immobilized the flapper valve in the closed position (see Appendix B, Figure 2).

Both aircraft engines were recovered from the crash site. No pre-impact anomalies were found on the right engine, and it was successfully test run at a local engine overhaul facility. It was found that the turbocharger of the left engine would not rotate, but no other anomalies were found. The left engine was test run with the non-functioning turbocharger, and, as expected, it achieved approximately 75 per cent power. While removing the turbine housing during teardown of the turbocharger at the manufacturer's facility, the turbine shaft and turbine became free enough to rotate, although not very freely. The turbine housing of the turbocharger was found to exhibit swirl markings formed by engine exhaust gases flowing through the stationary turbine. A small pellet of lead was found during disassembly; the manufacturer does not believe that this pellet stopped the rotation of the turbine.

The turbocharger was then examined at the TSB Engineering Laboratory. Examination of the swirl markings revealed that they were extremely light and likely deposited during the engine test run. Though discoloured, the turbocharger shaft showed no sign of seizure and is believed to have been operating before impact. The microstructure of the shaft appeared normal. If one engine was operating without its turbocharger, a power differential would be expected, but the pilot did not notice any power differential during the flight. A particle of contamination, such as the small pellet found, may have been dislodged during the impact and jammed the turbocharger. No other reason for the jammed turbocharger was found.

The wings of the occurrence aircraft had been modified to control boundary layer airflow and to improve stall and minimum control speeds. With the modification, approved by the Federal Aviation Authority, the maximum allowable aircraft gross weight is 7368 pounds and the maximum landing weight is 7000 pounds.

The aircraft weight at the time of the accident was approximately 6816 pounds. This figure was derived from the actual weight of the aircraft, the aircraft occupants, and their baggage. With the modification, the single-engine minimum control speed (V_{MCA}) is 70 KIAS and the optimum single-engine climb speed is 107 KIAS. The power-off stall speed at 7000 pounds is 69 KIAS with approach flaps selected and 72 KIAS with flaps up. The position of the landing gear has no effect on the stall speeds.

The company aircraft manual of standard operating procedures states that it is mandatory to use the correct order and terminology of an emergency drill, as it appears in the company emergency procedures checklist. In the event of an engine failure, the immediate checklist actions are maintain direction and adequate airspeed, apply maximum power, reduce aerodynamic drag by retracting the landing gear and the flaps, turn on the boost pumps, and identify and feather the inoperative engine. The pilot's operating handbook indicates that 76 KIAS is needed before applying maximum power and that 106 KIAS should be attained.

Analysis

Illumination of the right fuel flow warning light and the serviceable condition of the right engine following the accident suggest that the right engine stopped because of fuel starvation. Rust in the surrounding segment of the right fuel tank indicates the presence of water up to the level of the flapper valve. This segment of the tank does not have a drain valve; water can therefore accumulate to the level of the flapper valve. Ice was found in the surge tank after the accident. It is probable that the water froze around the one-way flapper valve in the right inboard tank, obstructing the flow of fuel into the surge tank. When the inboard tanks were selected, the fuel in the surge tank was quickly depleted, the low-fuel sensor activated the right fuel flow warning light, and the right engine stopped because of fuel starvation. After the accident, the right surge tank refilled with fuel when the flapper valve began to move freely again as a result of either the ice melting or impact forces.

Before the engine stoppage, the pilot deviated from the glideslope and allowed the airspeed to decrease well below the required 105 KIAS, probably in an effort to compensate for the strong gusty winds. Given that he had been trained in the appropriate procedures, his performance on approach indicates that he was task saturated.

Engine stoppage at low altitude and low airspeed requires that the checklist procedure be applied without delay to ensure maximum aircraft performance. In this occurrence, the pilot took the time to check the position of the fuel switches and tried to restart the engine. The inappropriate initial reaction to the emergency was likely a result of task saturation. Additionally, the pilot did not stabilize the aircraft on the ILS glideslope at an approach airspeed of 105 KIAS. The aerodynamic drag from the partially extended flaps—which should have been retracted, according to the checklist—exacerbated the effect of the low approach airspeed and the delay in executing the engine-out drill. These factors, collectively, prevented an increase in airspeed even as the aircraft lost altitude at 800 feet per minute.

The airspeeds on approach are estimates. Based on the pilot's difficulty controlling the aircraft when power was applied to the left engine, and that the airspeed estimates after engine stoppage are close to the predicted V_{MCA}, the aircraft was operating close to and possibly below the airspeed at which it could be controlled with full power on the operating engine. Insufficient altitude remained for the aircraft to descend and attain a greater airspeed. As indicated by the manner in which the aircraft was flown after the engine stopped, the pilot was in a condition of task saturation, affecting his ability to react to the critical emergency. The pilot's decision to reduce power in the final moments of flight enabled him to retain control of the aircraft and descend upright into the trees. This decision likely reduced the level of injury.

Findings as to Causes and Contributing Factors

1. The right inboard fuel tank contained a substantial amount of water, which froze and probably impeded the flow of fuel to the right engine, causing it to stop.

2. After the right engine stoppage, the pilot did not maintain the aircraft at a safe airspeed and altitude.

3. The pilot did not fly a stabilized approach, and the airspeed of the aircraft was allowed to decrease below that required for safe flight.

4. The pilot was task saturated during the approach.

Finding as to Risk

1. A large portion of the inboard fuel tank does not have a drain valve, thus allowing water to accumulate in the tank.

Other Finding

1. The pilot's decision to reduce power in the final moments of flight likely reduced the level of injury.

Safety Action Taken

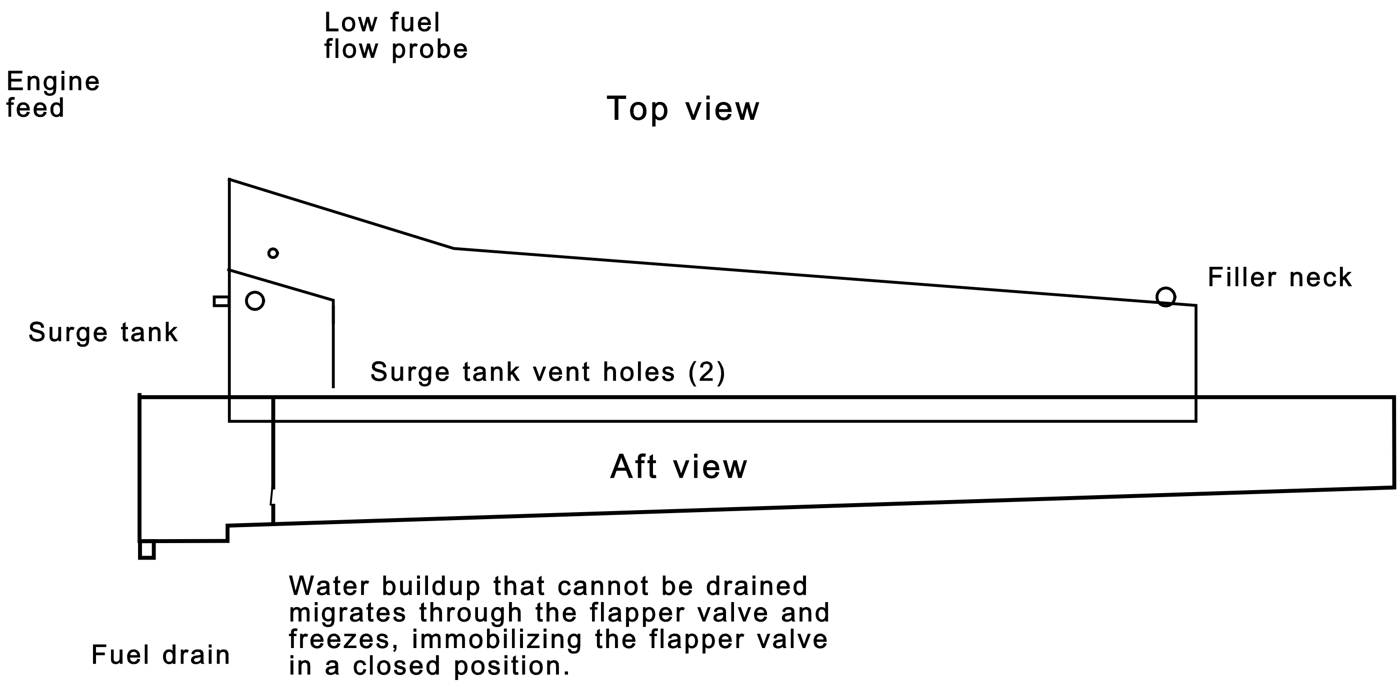
On 01 June 2001, the TSB issued two aviation safety advisories to Transport Canada (TC). Aviation Safety Advisory A010021 suggested that TC may wish to review the adequacy of the existing design certification of the PA-31's inboard fuel tank drains. The fuel tank drains do not allow water contamination to be removed from the larger section of the inboard fuel tank below the level of the flapper valve. Aviation Safety Advisory A010022 suggested that TC may wish to review the adequacy of the information, provided in the PA-31 pilot's operating handbook, on the fuel flow warning light and pilot response to illumination of this light.

TC communicated the content of these advisories to the United States Federal Aviation Administration (FAA), the certification authority of the PA-31-350 Chieftain aircraft. TC will take appropriate action once it receives the FAA's comments.

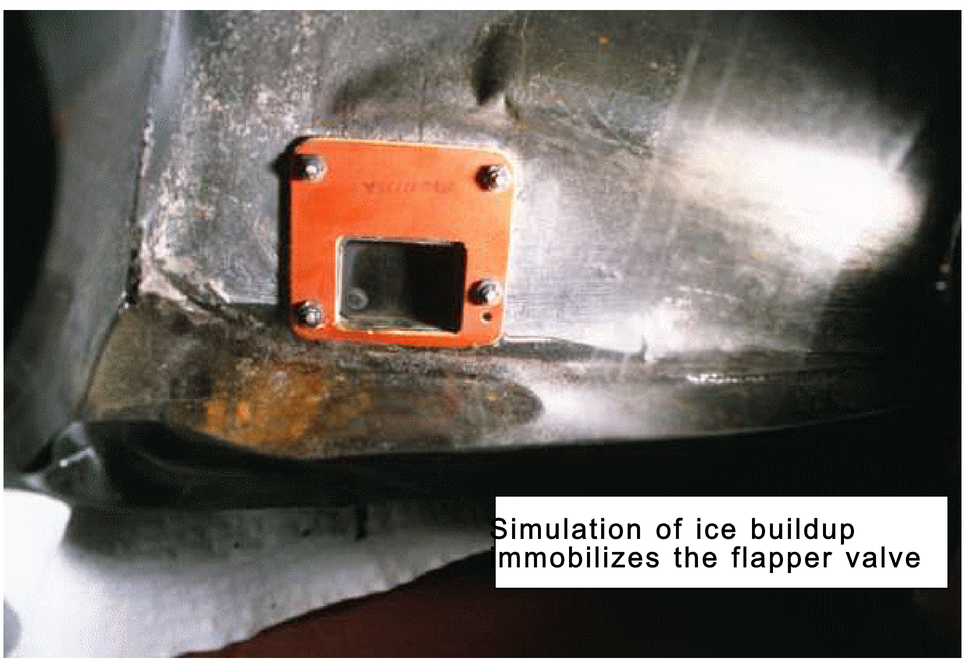
This report concludes the Transportation Safety Board's investigation into this occurrence. Consequently, the Board authorized the release of this report on 23 October 2001.

Appendix A—Fuel Cell Schematic

Right inboard fuel cell



Appendix B—Fuel Cell Photographs



Simulation of ice buildup immobilizes the flapper valve