AVIATION OCCURRENCE REPORT

COLLISION WITH TERRAIN

MITCHINSON FLYING SERVICE LIMITED
CESSNA 152 C-GZCT
VANSCOY, SASKATCHEWAN 4 NM S
04 OCTOBER 1997

REPORT NUMBER A97C0195

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Summary

The Cessna 152, serial number 15280919, departed Saskatoon, Saskatchewan, on a training flight. The purpose of the flight was to practice the instruction of spins, stalls, and slow flight. The crew flew the aircraft to the training area, CYA 306(T), in the Saskatoon terminal area. The aircraft's transponder was on mode "C", permitting a radar record of the flight, including altitude, speed, and track information to be stored by the air traffic system (ATS) radar. The recorded information revealed that the aircraft entered the north-east corner of the training area and flew back and forth in the north-east corner as training exercises were accomplished. Several manoeuvres including spins, which took place between 4 000 feet and 4 500 feet above sea level (asl), were recorded. After about 55 minutes of flight, the aircraft entered a spin at 4 000 feet asl. The last recorded transponder signal occurred at 2 000 feet asl in the vicinity of Vanscoy, Saskatchewan. The height of the terrain in the vicinity of the last radar signal is about 1 700 feet asl. The aircraft was observed momentarily by the driver of a vehicle on a road about one-quarter mile from the occurrence site at about the same time as the last transponder signal was recorded by ATS. The witness reported that the aircraft appeared to be at about 200 feet above ground level (agl) and that the aircraft banked rapidly to the left and then crashed in a field beside the road. Both occupants were fatally injured.

Ce rapport est également disponible en français.

Other Factual Information

At the time of the occurrence, the weather at Saskatoon and in the CYA 306(T) training area was 15 statute miles visibility with scattered cloud at 12 000 feet asl and a broken cloud ceiling at 22 000 feet asl. The winds were calm and the temperature was 17 degrees Celsius.

The aircraft crashed in a field located about one-quarter mile south of an east/west gravel road. The wreckage trail was about 80 feet long and was oriented on a south-westerly heading. Ground scars indicated that the aircraft struck the ground in a nose low, slight left bank attitude. Ground scars made by the wings were of equal length on both sides of the impact point. Several propellor cuts were also evident on the ground surface. The propeller blade cut marks at the scene, the abrasion marking on the propeller blades in the direction of rotation, and the bending of one propeller blade indicated that the engine was operating at a moderate to low power setting on ground impact. Damage to the aircraft was consistent with a high vertical rate of descent. The wreckage was examined in-situ to the extent possible, and no pre-impact failures were found that would have lead to a loss of control.

A plastic carbon monoxide detector was found in the wreckage, soaked in fluids. It could not be used to determine the presence of carbon monoxide in the cockpit prior to the accident. This type of carbon monoxide detector, which is commonly installed in small aircraft, is glued to the instrument panel. When mounted, the user directions that are printed on the back of the detector are no longer visible. These directions indicate that the detector will turn dark brown to grey/black when exposed to carbon monoxide and that, even a slight darkening, may indicate a dangerous level of carbon monoxide. The directions also state that, when the air freshens, the detector will return to its original colour. Whether either crew member understood the directions or checked the indicator during flight could not be determined.

Review of the company maintenance records indicated that the aircraft was certified and maintained for flight in accordance with the existing regulations. Some cockpit instruments, the aircraft engine, and the engine exhaust system were forwarded to the TSB Engineering Branch laboratory for detailed examination. The examination of the instruments determined that, at impact, the engine tachometer was registering at least 1 200 revolutions per minute and that the airspeed and vertical speed indicators were indicating 80 knots and a 2 000 feet per minute descent, respectively.

The engine, an Avco Lycoming model 0-235-L2C, serial number L20218-15, had accumulated approximately 779 hours in service since a major overhaul. The most recent engine cylinder differential compression check was completed approximately 76 hours time-in-service prior to the accident, and the results were within prescribed limits. The engine was disassembled at the TSB Engineering Branch laboratory. The compression rings installed in the number 1, 2 and 3 cylinders were determined to have excessive wear. Measurement of the compression ring end gaps, when positioned in their respective cylinders, indicated that the rings were at, or exceeded the service limits published by the engine manufacturer. The cylinder number 4 compression rings

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[1] Units are consistent with official manuals, documents, and instructions used by or issued to the crew.

were approaching the service limit but all oil control rings measured within specification. Exhaust gas by-products were visible on the piston skirts, in and around the piston pin recesses, and at the outer end of the connecting rods. The exhaust gases entering the engine crankcase are vented overboard on the left side of the aircraft's belly. Examination at the occurrence site determined the crankcase vent to be assembled and installed according to the manufacturer's specifications. In summary, the examination revealed no anomalies which would have precluded engine operation.

The exhaust pipe and the gasket from cylinder number 3 were removed during the initial occurrence site engine-condition examination, and there was no evidence of an exhaust leak at the cylinder number 3 exhaust stack. The remainder of the exhaust system, identified by the data plate installed on the muffler shroud as KMR IND., 1-1000, 01542 LYC 0-235 L2C, 1452, was removed from the engine at the TSB Engineering Branch facility. Visual examination showed that exhaust gas was leaking between the exhaust gasket and the cylinder head at the cylinder number 4 exhaust port. The number 4 exhaust port is located to the left rear of the engine. The leak was identified by the staining of the exhaust port, adjacent engine baffle, and cylinder cooling fins; however, the leak was slight as there was no observed erosion of the port or fins. Cylinders number 1 and 2 appeared to have been sealed as required to the exhaust pipe by the exhaust gasket.

Disassembly and examination of the exhaust system revealed no corrosion of the muffler or staining of the muffler shroud that would have indicated that exhaust gases were leaking from the muffler into the cabin heat system. Examination of a chafed area on the number 4 exhaust pipe, 3/4 of an inch below the exhaust attachment flange, revealed three holes in the pipe wall with exhaust gas staining radiating from one hole. Detailed examination revealed that two of the holes were a result of the buckling and tearing of the thin material in the chafed area during the impact sequence. Only the hole with the associated staining existed prior to the accident. Exhaust gases, leaking from this small hole, collected within the engine cowling from where they could potentially migrate into the aircraft cabin.

The 53-year-old pilot-in-command had in excess of 10 000 hours flying time and had instructed for nine years. He held a Class 1 instructor endorsement. He was held in high regard among other staff members as a professional instructor and was well liked by students. There was no evidence that he engaged in risky flying practices. The 30-year-old student instructor was a recent commercial licence graduate of the flying school. Staff of the flying school had suggested that the student instructor obtain an instructor rating, and school management had intended to employ him as an instructor. The flight school management attempts to hire pilots that have been trained at their school as a method of ensuring high instructional standards. The pilot-in-command had conducted the previous flying training of the student instructor, and a friendly relationship of mutual respect had reportedly developed.

Both pilots had valid medical certificates and had no reported history of medical problems. Post-mortem examination found microscopic pathologic evidence that the pilot-in-command had mild atherosclerosis of the coronary arteries. Such a condition would not normally affect performance and would not be detectable during routine examinations. While there was no
pathological evidence of hyperglycemia, stroke, or myocardial infarction in either of the crew members, not all types of incapacitation, such as angina for example, can be reliably detected by post-mortem examination and cannot, therefore, be ruled out.

There was no toxicological evidence of alcohol or illicit drugs; however, spectrophotometry indicated blood saturation levels of carbon monoxide of six percent in the pilot and of two percent in the student. The toxicologist estimated that the tests performed for carbon monoxide have an accuracy of plus or minus three percent when the levels of carbon monoxide are this low. There is no appreciable decrease in the level of carbon monoxide after death because there is no respiration or blood circulation. Thus, the carbon monoxide levels found are in the range of three to nine per cent in the pilot-in-command and zero to five per cent in the student instructor. Neither pilot smoked, and the flight school maintains a smoke-free environment.

Levels of carbon monoxide saturation of less than ten per cent are not considered to have a major effect on performance, although such a level would have a greater effect on non-smokers than on smokers. Cigarette smokers, for example, may routinely have saturation levels of six to eight per cent. When saturation levels exceed ten percent, headache and shortness of breath can occur. Lower saturation levels of five to ten per cent can decrease the threshold for angina for those individuals who have an atherosclerosis condition.

The Health Canada publication *Carbon Monoxide* states that "High altitude exposure interacts with CO poisoning. At moderate altitudes, an ascent of 300 metres (approximately 1 000 feet) may be equated to one per cent increase of blood COHb (carboxyhemoglobin) contents. Thus, individuals living above 1 000 metres are particularly vulnerable to small doses of CO."
That is, the hypoxic effect of the decreased availability of oxygen in the atmosphere as altitude increases has a similar degradation effect on some aspects of crew performance as an increase in carbon monoxide level of one per cent for each 1 000 feet of increase in altitude. Taking this altitude factor into account, the effective carbon monoxide level of the pilot was in the range of seven to thirteen per cent, while the student pilot had four to nine per cent.

The *Civil Aviation Regulations*(CARs) define an aerobatic manoeuvre as a manoeuvre in which a change in the attitude of an aircraft results in a bank angle greater than 60 degrees, an abnormal attitude, or an abnormal acceleration not incidental to normal flying. A spin is thus an aerobatic manoeuvre. CAR 602.27, Aerobatic Manoeuvres -Prohibited Areas and Flight Conditions, states that no person shall conduct aerobatic manoeuvres below 2 000 feet agl without a special flight operations certificate. To conform with this regulation, pilots operating in the CYA 306(T) area would have to terminate aerobatic manoeuvres at or above 3 700 feet asl. Review of the stored ATS radar data revealed that after the aircraft entered CYA 306(T), several exercises were undertaken that resulted in vertical manoeuvring, but, at no time, did the crew descend below 3 700 feet asl prior to the accident manoeuvre.

The ATS radar tape showed that a manoeuvre was entered at low airspeed at about 4 000 feet asl and that a high vertical descent rate developed. tThe recorded speed remained very low and the aircraft heading rotated rapidly. The total elapsed time from 4 000 feet asl until ground impact was estimated to be about 45 seconds. The last three ATS radar signals indicated that the aircraft tracked in a westerly direction for about 15 seconds just before the impact with the ground. A witness, driving in a westerly direction beside the field in which the impact occurred, observed the aircraft for several seconds prior to the impact. Initially, the aircraft appeared in his peripheral field of vision through the side window of the vehicle. He noticed the aircraft was momentarily in a level attitude at about 200 feet agl. The aircraft did not appear to be overtaking the road vehicle which was travelling at about 60 mph. Almost instantly thereafter, the left wing dropped abruptly and the aircraft banked and descended into the terrain.

Analysis

The weather conditions at the time of the occurrence were ideal for flying training and were not a factor in the accident.

The ATS radar information indicates that during the last vertical manoeuvre that originated at about 4 000 feet asl, the aircraft descended rotationally at a high descent rate. The observed low speed indicated that the aircraft was in a spin and not in a spiral dive. The last three ATS radar returns showing the aircraft continuing its descent while tracking in a westerly direction, together with the ground witness observation of the aircraft appearing to be momentarily level on a westerly heading, support the hypothesis that at least one of the pilots may have succeeded in recovering the aircraft from the spin and was attempting to recover from the ensuing aircraft descent. The subsequent abrupt wing drop and nose-down descent observed by the witness on the ground shortly prior to ground impact likely indicate that a secondary stall was induced during the attempted spin recovery. The very low altitude precluded recovery from the stall.

It is not known why a spin would have been continued below 3 700 feet asl. Based on the experience level and reputation of the instructor, it is unlikely that he would have engaged in a dangerous training practice or intentionally allowed the aircraft to continue spinning below the minimum altitude specified in CARs. Until the occurrence manoeuvre, the pilot had adhered to the minimum altitude required by CARs and shown airmanship consistent with his professional reputation. It is unlikely that either pilot would have intentionally allowed the spin to continue to a low altitude above the ground. It is more likely that some other factor intervened and caused recovery action to be delayed until ground contact was imminent.

It is possible for confusion or conflict to occure with regard to which pilot has control of the aircraft and is taking corrective action, particularly in a scenario involving an instructor pilot and a student instructor; as a result, a manoeuvre could inadvertently be continued unsafely. Given the experience level of the instructor and the reported harmonious relationship between the pilots, it is unlikely that a poor instructor/student relationship developed during the flight that could have affected their judgement or ability to control the aircraft.

No pre-impact mechanical failure was found in the aircraft control system which would have caused a loss of control or control difficulties. Additionally, the observed probable recovery attempt indicates that the aircraft control system was functioning. Although the amount of power being produced by the engine could not be

determined accurately, the engine was functioning and would not have prevented recovery from either the spin or a subsequent stall. The only technical anomaly found was the exhaust gas leak at the number 4 cylinder which could have potentially leaked past the firewall and introduced carbon monoxide into the cabin. Because both crew members were nonsmokers, they were found to have carbon monoxide levels of about three to nine per cent for the pilot-in-command and zero to five per cent for the student pilot; it is likely that some exhaust gases had been introduced into the aircraft cabin from the exhaust leak during the flight and was absorbed in their blood as they breathed the cabin air. Because of the location of the exhaust leak, to the left rear of the engine, it is possible that the concentration of carbon monoxide was greater near the pilot-in-command, and that his blood saturation level was consequently higher than that of the student pilot.

The carbon monoxide saturation levels found in both pilots, as detected by the toxicology testing, are not normally considered of significance in relation to an individual's performance; however, when a factor of four per cent is added because of the effects of decreased oxygen availability at 4 000 feet asl, the range becomes seven to thirteen per cent for the pilot-in-command and four to nine per cent for the student pilot. Although these carbon monoxide levels would not be expected to have a large effect on their performance, some effect cannot be ruled out. Additionally, the mild atherosclerosis found during the microscopic analysis of the pilot-in-command's coronary arteries, in conjunction with the low level of carbon monoxide, may have triggered some degree of incapacitation from angina. If any such incapacitation occurred, particularly during a critical manoeuvre such as a spin, control of the aircraft could have been affected. This hypothesis could not be corroborated.

The user directions for the carbon monoxide detector are printed on the back of the detector and are obscured when the detector is installed. Because the carbon monoxide detector returns to its unexposed colour when the air freshens, checking the detector only during pre-start cockpit checks does not alert the crew of any previous carbon monoxide leaks into the cockpit. The detector would have to be checked periodically during flight to alert the crew of the presence of carbon monoxide. It is not known if the crew were aware of the detector's operating characteristics, or whether the crew noted the condition of the carbon monoxide detector during the flight.

The following Engineering Branch reports were completed:

LP 2/98 - Exhaust System Examination
LP 196/97 - Instrument Examination

Findings

1. Records indicate that both crew members were certified and qualified for the flight in accordance with existing regulations.

2. Weather was not a factor.

3. The company maintenance records indicate that the aircraft was certified and maintained for flight in accordance with existing regulations.

4. There was no evidence found of any airframe or engine malfunction prior to or during the flight.

5. The engine cylinder compression rings were worn beyond manufacturer's specifications thereby allowing combustion gases to escape into the crankcase, and the combustion byproducts were being exhausted overboard through the crankcase manifold venting system.

6. Exhaust gases leaking from a small hole in the number N4 cylinder exhaust stack resulted in a build-up of carbon monoxide in the engine compartment. Some of the carbon monoxide likely leaked past the engine firewall and exposed the crew to a low level of carbon monoxide in the cabin.

7. Toxicology tests for the presence of illicit drugs or alcohol were negative.

8. Toxicology tests for the presence of carbon monoxide revealed a level of zero to five per cent for the student pilot and three to nine per cent9% for the pilot-in-command.

9. The decreased oxygen availability with altitude would have had the equivalent effect on the crew's physiology as would a carbon monoxide range of seven to thirteen per cent7-13% for the pilot and up to four to nine per cent4-9% for the co-pilot.

10. The crew would have been experiencing some mild physiological effects from a low level of carbon monoxide in the cabin, although normally such low carbon monoxide levels would not be expected to have a large effect on performance.

11. The microscopic examination during the postmortem indicated that the pilot-in-command had mild atherosclerosis of the coronary arteries.

12. Although the pilot-in-command's mild atherosclerosis condition could have made him somewhat more susceptible to angina because of the effects of carbon monoxide in the cabin, whether such incapacitation took place could not be determined.

13. The manoeuvre initiated at 4 000 feet asl was continued below the CARs minimum aerobatic recovery altitude for unknown reasons.

14. An attempt appears to have been made to recover from a secondary aerodynamic stall at low level but could not be accomplished in the altitude remaining.

15. The user directions for the carbon monoxide detector are printed on the back of the detector and are obscured when the detector is installed.

Causes and Contributing Factors

During the recovery from a training manoeuvre that was continued below a safe altitude, the aircraft entered a secondary stall at an altitude from which recovery was not possible. It was not determined why the training manoeuvre was continued below a safe altitude. The level of carbon monoxide detected in both pilots would have had some physiological effect on their performance, but the extent could not be determined.

Safety Action

The Flight Training Division of Transport Canada is conducting a study regarding stall/spin accidents in pilot training.

This report concludes the Transportation Safety Board's investigation into this occurrence. Consequently, the Board, consisting of Chairperson Benoît Bouchard, and members Maurice Harquail, Charles Simpson and W.A. Tadros, authorized the release of this report on 10 February 1999.