No. 95-014

Cessna T207

ZK-FPM

8 km East of National Park

24 September 1995

Abstract

At approximately 1420 hours on Sunday 24 September 1995, ZK-FPM was mid-downwind for a landing at the Chateau Airstrip near Mt Ruapehu when the engine suddenly lost power. The pilot changed the fuel tank selection and power was restored but on final approach the engine lost power again. Two of the five occupants received back injuries in the ensuing forced landing on undulating ground short of the airstrip. The cause of the initial power loss was not determined.

Transport Accident Investigation Commission

Aviation Accident Report No. 95-014

Aircraft type, serial number and registration:	Cessna T207, 207-00665, ZK-FPM
Number and type of engines:	Teledyne Continental TSIO-520-M
Year of manufacture:	1981
Date and time:	24 September 1995, 1422 hours*
Location:	Near Chateau Airstrip 8 km east of National Park Latitude: 39° 09.1'S Longitude: 175° 29.2'E
Type of flight:	Air Transport - Aerial photography and scientific observation
Persons on board:	Crew: 1 Passengers: 4
Injuries:	Crew: 1 minor Passengers: 2 serious 2 minor
Nature of damage:	Substantial
Pilots in Commands Licence:	Commercial Pilot Licence (Aeroplane)
Pilot in Command's age:	36
Pilot in Command's total flying experience:	1745 hours 106 on type
Information sources:	Transport Accident Investigation Commission Field Investigation
Investigator in charge:	Mr D G Graham

* All times in this report are NZST (UTC + 12 hours)

1. Factual Information

1.1 On the afternoon of Sunday 24 September 1995 the pilot carried out an aerial photography sortie in ZK-FPM to obtain vertical and oblique shots of volcanic activity on Mt Ruapehu. In addition to the photographer and his equipment three scientists were on board to visually monitor the mountain's active state and to observe the development and path of lahars and similar phenomena resulting from the minor eruptions and other volcanic events which were taking place from time to time.

1.2 The aircraft had been chartered from Nelson for the survey flight. The pilot had positioned the aircraft to Wellington in the early morning. On arrival, the pilot and the photographer, (whom he had flown in ZK-FPM on previous surveys), installed the specialist equipment. This included a video camera assembly mounted on the right wing strut, a monitor unit between the two front seats, and a rack of associated equipment secured to the seat rails in place of the third row left seat. The vertical mount and camera hatch, located in the third row, were prepared for use. The photographer and one scientist then boarded the aircraft for the flight to Taupo where two other scientists were to join the flight.

1.3 Between Wellington and Taupo the opportunity was taken to circle over Mt Ruapehu twice, at 10,000 feet, to obtain an initial impression of the volcanic activity. The descent and landing at Taupo were uneventful and shortly after arrival the aircraft was refuelled. The pilot filled both wing tanks to capacity, ensured the fuel tank caps were securely in place, and carried out a fuel drain check. There was no evidence of water or other contamination.

1.4 The rear door of the double 'cargo door' installation on the aircraft's right side was removed to enable the photographer, seated at the left rear of the cabin, to take oblique photographs during the flight. He also operated a vertical camera. Two of the scientists occupied the second row seats, and the third was seated beside the pilot. The photographer and those in the second row seats had lap belt restraints while the pilot and front passenger were provided with a combined lap belt/diagonal upper torso harness.

1.5 ZK-FPM departed from Taupo at 1206 hours. The sortie comprised an initial climb to an operating altitude between 11,000 feet and 12,000 feet over Mt Ruapehu followed by a series of photographic 'runs' at varying heights within the nominated block clearance of 10,000 feet to 13,000 feet amsl. Although the aircraft's height and heading varied frequently to meet the requirements of the survey, climbs and descents were kept to a minimum. The pilot leaned the mixture to an appropriate setting, and selected fuel from the left and right tanks in sequence as the flight progressed.

1.6 There was considerable scientific and media interest in Mt Ruapehu's unusual and extensive activity, and a number of aircraft and helicopters were operating in the area. During the flight, at about 1400 hours, a request was received by cellular telephone for the photographer to attend a briefing at Whakapapa and join a scientific group who were to depart by helicopter for low-level observation of events on the mountain.

1.7 To avoid undue delay, and facilitate transfer of the photographer's equipment, it was suggested that the pilot of ZK-FPM land at the Chateau Airstrip, where the helicopter was already positioned. This was the operating base for a local scenic/charter company and due to its proximity to the mountain served as the most convenient rendezvous for scientific personnel monitoring the volcanic activity from the air. The airstrip was private but could be used by visiting aircraft on a non-commercial basis subject to the local operator's permission.

1.8 The pilot of ZK-FPM was aware of the airstrip's location but had not landed there previously. After receiving the request he established RTF contact with one of the local operator's aircraft, flown by a senior pilot, and obtained details of the airstrip's elevation, length, slope and other pertinent information. He understood that, given the scientific purpose involved, there was no objection to the proposed landing.

1.9 The airstrip was oriented 150°/330°M and had a length of 800 m (2900 feet), with an upslope of approximately 3.5% towards the south-east. Threshold elevation was 2850 feet amsl. Landings were to be upslope. The boundaries, and threshold, were clearly marked with white tyres.

1.10 The pilot carried out a routine descent via Mt Ngauruhoe and Mt Tongariro and approached the airstrip from the south-east. During the descent he richened the mixture progressively. He flew a wide left circuit to familiarise himself with the layout and characteristics of the airstrip, and noted the wind as a light southerly/south-westerly prior to descending to approximately 3850 feet amsl (1,000 feet agl) on a left downwind leg for vector 15.

1.11 The pilot had completed his standard downwind checks and was about mid-downwind, assessing the airstrip surface, when the engine suddenly lost power. He "put the fuel pumps ON" immediately, and changed the fuel selector to the opposite tank. These actions appeared to rectify the situation, in that the engine surged to a high rpm then ran smoothly, leading the pilot to conclude at the time that a fuel starvation problem had occurred.

1.12 Following the unexpected power loss, and to allow for his unfamiliarity with the airstrip, the pilot extended the downwind leg before carrying out a left turn and setting up the final approach. At this stage the engine seemed to be running satisfactorily.

1.13 The pilot had selected full flap, and all indications appeared normal when the engine suddenly lost power again. The aircraft's height and position was such that, unless power could be regained, it would not reach the airstrip. Attempts to regain power were unsuccessful. The pilot recalled checking the airspeed as 80 knots as he prepared to make a forced landing on the undulating ground short of the airstrip.

1.14 Prior to touchdown on a steep rise the pilot closed the throttle, flared the aircraft to a high nose-up attitude, and applied rudder in an effort to direct the aircraft up the slope. He recalled the stall warning sounding, the aircraft striking the ground and bouncing once, and then a further bounce before it came to rest.

1.15 Once ZK-FPM had stopped the front seat passenger attempted to open the forward doors but they were both jammed closed. He and the other occupants vacated the aircraft through the rear door. All managed to make their way from the aircraft without assistance but the two occupants of the second row of seats had sustained back injuries and proceeded only far enough to ensure their safety if fire occurred.

1.16 The accident was observed from the air by the local operator who was positioning his aircraft to land behind ZK-FPM. Immediately after landing, while his wife contacted the emergency authorities, he assembled rescue equipment and personnel and flew the short distance to the accident site in his helicopter which was kept at the airstrip ready for charter flights. The survey helicopters, waiting at the airstrip, also assisted in the rescue operation.

1.17 Subsequently the pilot and passengers were transferred by helicopter and fixed wing aircraft to Waikato Hospital. The pilot, front passenger, and the photographer were discharged after minor treatment but the two occupants with back injures remained in hospital for four days and eighteen days respectively.

1.18 The passengers confirmed the pilot's recollection of events. The flight, up to the time of the initial power loss downwind, had been completely uneventful. The aircraft had not flown through, or near, any volcanic ash or smoke, or any other disturbance resulting from the volcanic activity. There had been no indication of incipient malfunction in relation to the engine. No unusual manoeuvres had been carried out and the turns to join the circuit and enter the downwind leg had involved only modest bank angles.

1.19 ZK-FPM had come to rest 300 m short of the airstrip threshold. Touchdown on the rising ground had resulted in detachment of the noseleg assembly and distortion of the main undercarriage with damage to the lower fuselage. The mid-fuselage impact forces were the probable cause of the back injuries experienced by the occupants of the second row of seats. Ground marks showed that the aircraft had slid for an overall distance of 60 m in a direction of 133°M. The right wingtip had contacted the ground briefly before the aircraft slewed through 90° to the left and came to rest.

1.20 Personnel first on the scene observed fuel flowing from beneath the aircraft's fuselage. Some 40 litres were collected from this area soon after the accident in an endeavour to minimise the fire hazard. Fuel was also noted draining from the left tank vent pipe due to the aircraft's left wing low attitude. The fuel caps on each tank were secure. The fuel selector was positioned to the right tank.

1.21 Approximately 48 litres of fuel were recovered from the left tank during the on-site examination the day after the accident. No fuel remained in the right tank, due to the combination of impact damage which had fractured the fuel lines on the fuselage lower right side, the right tank selection, and the attitude in which the aircraft had come to rest. The major portion of the fuel recovered from beneath the aircraft was likely to have come from the right tank.

1.22 The aircraft was disassembled to the extent necessary for road transportation and taken to an approved aircraft engineering facility. Subsequent detailed examination of the airframe fuel system, including the wing tanks, venting arrangements, system plumbing and individual components disclosed no abnormality or defect to account for the sudden power loss. There was no evidence to suggest that either fuel tank held potential for undiscovered entrapment of water. A considerable quantity of uncontaminated fuel remained in the fuel gascolator, left reservoir tank and associated fuel lines. Damage to the right fuel reservoir tank precluded an assessment of its pre-impact condition but there was no evidence of residual contamination.

1.23 Examination of the engine before it was test run established that the spark plugs were in normal operating condition, and the engine driven fuel pump drive was intact. Some flaky contamination present in the fuel inlet filter of the fuel/air control unit was assessed by engine overhaul personnel as unremarkable and consistent with the type and extent of contamination frequently observed in similar engines with no detriment to their operation. The engine and its accessories remained otherwise undisturbed apart from removal of the side mounted turbo charger unit to enable it to be accommodated in the test cell frame. Stub exhaust stacks were fitted and a damaged engine mount replaced.

1.24 The engine was started without difficulty, and its operation over the full power range yielded performance figures consistent with previous tests of a TSIO-520 M series engine in a normally aspirated configuration. Slow and rapid acceleration checks were made. The engine accelerated without hesitation and at the expected rate for the throttle movement. The engine was then operated at idle RPM. With the installed test "club" the operation was slightly lumpy necessitating a minor mixture adjustment. Further checks of all aspects of the engine functions were satisfactory. Test running comprised 30 minutes of satisfactory operation. The test report concluded that the engine functioned normally. Following the test run the fuel/air control unit, the engine-driven fuel pump, and the manifold valve were disassembled and inspected. There was no evidence of contamination in any of the components. The metering faces of the fuel/air control unit were not scored or damaged. All components performed to specification when re-assembled and tested.

1.25 A report was received from a pilot who had flown ZK-FPM during 1992, describing an approach to Nelson Aerodrome in which power had been reduced to a low figure on final, and after touchdown the engine had stopped. The pilot could not recall the quantity of fuel on board, or which tank was selected. The engine had restarted without difficulty and no significant delay in vacating the runway had been involved. The occurrence was reported by the pilot to Aero Club personnel, but the extent or scope of follow-up action was not known.

1.26 ZK-FPM had been the subject of an incident in December 1994, in which the engine had stopped on base leg while landing at Timaru at the conclusion of an extended survey flight. The pilot carried out a successful forced landing in a paddock. Subsequent fuel system and engine checks disclosed no abnormality. Total fuel remaining on board was probably about 30 litres. It was concluded at the time that the relatively low fuel level in the aircraft's long range tanks combined with the banked attitude during the base turn had resulted in uncovering of the tank outlets and consequent engine fuel starvation. The fuel selector had been positioned to the left tank for the landing.

1.27 ZK-FPM had flown 176.5 hours uneventfully since this incident, including some 15 aerial survey flights. The aircraft's most recent maintenance inspection, a Cessna Progressive Care Operation #1, was carried out in June 1995. 54 hours had been flown since this inspection. There were no outstanding defects, or reported problems concerning the operation of the aircraft or its engine, during this period.

1.28 On departure from Taupo for the survey flight the pilot had positioned the fuel selector of ZK-FPM to the left tank. His flight log showed that between 1245 hours and 1334 hours he had selected fuel from the right tank. The left tank had then been selected and the engine was operating from this tank when the power loss occurred downwind.

2. Analysis

2.1 ZK-FPM was fitted with long range fuel tanks. The total usable fuel in each tank, when filled to capacity, was placarded as 141.9 litres. This provided a nominal endurance of 5 hours based on a consumption of 55 litres/hour. ZK-FPM had departed Nelson with full tanks and the flight time versus fuel uplift at Taupo confirmed an average consumption of about 54 litres/hour.

2.2 The elapsed time between departure from Taupo and the initial power loss was approximately 2 hours 14 minutes. This suggested that the total fuel on board when the pilot entered the downwind leg prior to landing at the Chateau Airstrip should have amounted to approximately 160 litres. Calculation based on the fuel selections as recorded by the pilot indicated that the left tank was likely to have contained some 74 litres and the right tank 86 litres.

2.3 While the actual fuel consumption during the survey flight may have been greater than 55 litres/hour for various reasons, there was probably a substantial quantity of fuel on board ZK-FPM at the time of the initial sudden loss of power. Despite fuel system examination and engine tests no reason was found to explain the occurrence satisfactorily. Whether or not the power loss on this occasion was related to the earlier incident at Timaru was not determined.

2.4 In the latest event the pilot achieved a brief restoration of power by changing the fuel tank selection and switching 'ON' the auxiliary fuel pump. On final approach, however, the engine lost power again. The second power loss may have been caused by a recurrence of the original undetermined 'downwind' problem. Alternatively it may have resulted from an over-rich mixture due to prolonged operation of the auxiliary fuel pump at a high flow rate with the mixture control in the "FULL RICH" position.

2.5 The Cessna Model T207A Pilot's Operating Handbook in Section 7 Airplane and Systems Descriptions - Fuel System, included the following information (reproduced in part only)

> "... To ensure a prompt engine restart in flight after running a fuel tank dry, immediately switch to the tank containing fuel at the first indication of fuel pressure fluctuation and/or power loss. Then place the right half of the auxiliary fuel pump switch in the ON position momentarily (3 to 5 seconds) with the throttle at least 1/2 open. Excessive use of the ON position at high altitude and full rich mixture can cause flooding of the engine as indicated by a short (1 to 2 seconds) period of power followed by a loss of power. This can later be detected by a fuel flow indication accompanied by a lack of power. If flooding does occur, turn off the auxiliary fuel pump switch, and normal propeller windmilling should start the engine in 1 to 2 seconds ..."

2.6 In the recent occurrence involving ZK-FPM both tanks were likely to have contained adequate fuel but given the circumstances, the necessity for caution in regard to sustained use of the auxiliary fuel pump following a suspected fuel starvation problem was relevant. Similar information, relating to potential for the auxiliary fuel pump, if left in the 'ON' position with the engine - driven fuel pump functioning, to produce an excessively rich fuel/air mixture was contained in other sections of the Pilot's Operating Handbook.

2.7 The Teledyne Continental TSIO-520 Engine Operator's Manual also contained relevant information concerning "In-Flight Restarting" as follows: (reproduced in part only)

> "... Whenever a turbocharged engine is shut down in flight, or when fuel flow is interrupted the turbocharger will "run down" due to lack of mass flow through the exhaust system. If the mixture is placed in "FULL RICH" during restart attempts at high altitude the fuel flow may be excessive and the engine may fail to start due to an over-rich mixture. The amount of richness will depend primarily on altitude.
>
> The key point in restarting is to increase fuel flow gradually from idle cut-off so the engine will start when a proper mixture is reached. As the mass flow through the exhaust system increases the turbocharger will spin up and provide increased manifold pressure. The mixture may then be increased and power adjusted as desired ... "

2.8 Unexplained fuel system malfunctions in Cessna 200 series aircraft have occurred world-wide in earlier years.

2.9 Some fifteen years ago the United States' National Transportation Safety Board (NTSB) was concerned about accidents resulting from power loss caused by probable fuel starvation, involving Cessna 206, 207 and 210 aircraft.

2.10 The NTSB requested the manufacturer to construct a representative fuel system mock-up of those models so that its operation could be studied. In the course of the tests that followed, it was found that all systems worked satisfactorily most of the time, but under some not clearly understood conditions, vapour locking of the fuel feed system would occur. In an aircraft this would result in complete power loss. The tests established that the action of selecting another fuel tank could cause the vapour locking to occur, but it also revealed that this same action could clear an established vapour lock. However, the occurrence of vapour locking was seen to be unpredictable. Experimentation revealed that the problem could be solved by the installation of separate vapour return lines from the fuel selector to each tank. This discovery suggested that the condition arose from fuel vapour and released air returned from the fuel injection unit accumulating in, and finally filling, the fuel collector tank and supply lines.

2.11 The manufacturer has, at various times, issued Service Letters and other instructions detailing fuel system modifications and engine handling instructions to prevent fuel system vapour locking and also suitable emergency procedures to clear the fuel system should it occur. But the research suggested that the only fully reliable remedy was modification of the fuel system by the incorporation of vapour return lines from the fuel selector direct to the main fuel tanks.

2.12 Reported incidents and accidents which could have been attributed to vapour locking provided insufficient evidence from an airworthiness view point to warrant an Airworthiness Directive, or similar action, requiring the mandatory installation of a separate vapour return line to each tank.

2.13 The manufacturer incorporated a redesigned fuel system in the Cessna 210 aircraft type in 1982. The fitment of locally approved modifications introducing separate vapour return lines to the main tanks was an option for the operators of Cessna 206, 207, and earlier model 210 aircraft, who were concerned that their type of operation could give rise to vapour locking problems.

2.14 The possibility that vapour locking caused, or contributed to, the sudden power loss in ZK-FPM could not be discounted.

2.15 The cause of the initial 'downwind' loss of power was not established. Any significant information involving defects or abnormalities in the engine or airframe of ZK-FPM discovered during future rebuild, overhaul, or repair, which might assist in explaining the occurrence will be published as an addendum to this report.

3. Findings

3.1 The pilot was appropriately licensed and experienced to conduct the flight.

3.2 The aircraft's Certificate of Airworthiness and Maintenance Release were valid.

3.3 A sudden loss of power occurred on the downwind leg as the pilot prepared to land during a scientific survey flight.

3.4 Power was restored but the engine lost power again on final approach.

3.5 The pilot carried out a forced landing but the aircraft was substantially damaged due to the undulating terrain.

3.6 Two of the passengers sustained back injuries as a result of the ground impact.

3.7 There was an adequate total quantity of fuel on board the aircraft when the power loss occurred.

3.8 The pilot had selected fuel progressively from the left and right tanks. Each tank should have contained an adequate quantity of fuel at the time of the power loss.

3.9 The fuel selector was selected to the left tank when the loss of power occurred.

3.10 Examination of the aircraft and subsequent engine and component tests and inspections disclosed no defect or abnormality to explain the downwind power loss satisfactorily.

26 June 1996

M F Dunphy
Chief Commissioner

Glossary of Aviation Abbreviations

AD	Airworthiness Directive
ADF	Automatic direction-finding equipment
agl	Above ground level
AI	Attitude indicator
AIC	Aeronautical Information Circular
AIP	Aeronautical Information Publication
amsl	Above mean sea level
AOD	Aft of datum
ASI	Airspeed indicator
ATA	Actual time of arrival
ATC	Air Traffic Control
ATD	Actual time of departure
ATPL (A *or* H)	Airline Transport Pilot Licence (Aeroplane *or* Helicopter)
AUW	All-up weight
°C	Degrees Celsius
CAA	Civil Aviation Authority
CASO	Civil Aviation Safety Order
CFI	Chief Flying Instructor
C of A	Certificate of Airworthiness
C of G (*or* CG)	Centre of gravity
CPL (A *or* H)	Commercial Pilot Licence (Aeroplane *or* Helicopter)
DME	Distance measuring equipment
E	East
ELT	Emergency location transmitter
ERC	Enroute chart
ETA	Estimated time of arrival
ETD	Estimated time of departure
°F	Degrees Fahrenheit
FAA	Federal Aviation Administration (United States)
FL	Flight level
ft	Foot/feet
g	Acceleration due to gravity
GPS	Global Positioning System
h	Hour
HF	High frequency
hPa	Hectopascals
hrs	Hours
IAS	Indicated airspeed
IFR	Instrument Flight Rules
IGE	In ground effect
ILS	Instrument landing system
IMC	Instrument meteorological conditions
in	Inch(es)
ins Hg	Inches of mercury

kg	Kilogram(s)
kHz	Kilohertz
KIAS	Knots indicated airspeed
km	Kilometre(s)
kt	Knot(s)
LAME	Licenced Aircraft Maintenance Engineer
lb	Pounds
LF	Low frequency
LLZ	Localiser
Ltd	Limited
m	Metre(s)
M	Mach number (e.g. M1.2)
°M	Degrees Magnetic
MAANZ	Microlight Aircraft Association of New Zealand
MAP	Manifold absolute pressure (measured in inches of mercury)
MAUW	Maximum all-up weight
METAR	Aviation routine weather report (in aeronautical meteorological code)
MF	Medium frequency
MHz	Megahertz
mm	Millimetre(s)
mph	Miles per hour
N	North
NDB	Non-directional radio beacon
nm	Nautical mile
NOTAM	Notice to Airmen
NTSB	National Transportation Safety Board (United States)
NZAACA	New Zealand Amateur Aircraft Constructors Association
NZDT	New Zealand daylight time (UTC + 13 hours)
NZGA	New Zealand Gliding Association
NZHGPA	New Zealand Hang Gliding and Paragliding Association
NZMS	New Zealand Mapping Service map series number
NZST	New Zealand Standard Time (UTC + 12 hours)
OGE	Out of ground effect
okta	Eighths of sky cloud cover (e.g. 4 oktas = 4/8 of cloud cover)
PAR	Precision approach radar
PIC	Pilot in command
PPL (A *or* H)	Private Pilot Licence (Aeroplane *or* Helicopter)
psi	Pounds per square inch
QFE	An altimeter subscale setting to obtain height above aerodrome
QNH	An altimeter subscale setting to obtain elevation above mean sea level
RNZAC	Royal New Zealand Aero Club
RNZAF	Royal New Zealand Air Force
rpm	revolutions per minute
RTF	Radio telephone or radio telephony

s	Second(s)
S	South
SAR	Search and Rescue
SSR	Secondary surveillance radar
°T	Degrees True
TACAN	Tactical Air Navigation aid
TAF	Aerodrome forecast
TAS	True airspeed
UHF	Ultra high frequency
UTC	Coordinated Universal Time
VASIS	Visual approach slope indicator system
VFG	Visual Flight Guide
VFR	Visual flight rules
VHF	Very high frequency
VMC	Visual meteorological conditions
VOR	VHF omnidirectional radio range
VORTAC	VOR and TACAN combined
VTC	Visual terminal chart
W	West