CIVIL AVIATION AUTHORITY OF NEW ZEALAND

AIRCRAFT ACCIDENT REPORT

OCCURRENCE NUMBER 99/3689

CESSNA R172K

ZK-FGF

TE WERA, TARANAKI

25 DECEMBER 1999

Glossary of abbreviations used in this report:

AAIB	Air Accidents Investigation Branch (UK)
AD	Airworthiness Directive
ADF	automatic direction finder
avgas	aviation gasoline
CAA	Civil Aviation Authority
Com	communication
DME	distance measuring equipment
E	east
ELT	emergency locator transmitter
ETD	estimated time of departure
FAA	Federal Aviation Administration (USA)
IFR	instrument flight rules
IMC	instrument meteorological conditions
M	magnetic
mm	millimetre(s)
Nav	navigation
nm	nautical mile(s)
NRCC	National Rescue Coordination Centre
NTSB	National Transportation Safety Board (USA)
NZDT	New Zealand Daylight Time
S	south
SAR	search and rescue
UK	United Kingdom
USA	United States of America
UTC	Coordinated Universal Time
VHF	very high frequency
VOR	VHF omni-directional radio range

AIRCRAFT ACCIDENT REPORT

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Aircraft type, serial number and registration:	Cessna R172K, R1723249, ZK-FGF
Number and type of engines:	1 Continental IO-360-HBCKB
Year of manufacture:	1980
Date and time:	25 December 1999, 0250 hours* (approx)
Location:	Te Wera, Taranaki Latitude: S 39° 14.0' Longitude: E 174° 35.8'
Type of flight:	Private
Persons on board:	Crew: 1 Passengers: 1
Injuries:	Crew: 1 fatal Passengers: 1 fatal
Nature of damage:	Aircraft destroyed
Pilot-in-command's licence	Commercial Pilot Licence (Aeroplane)
Pilot-in-command's age	21 years
Pilot-in-command's total flying experience:	346 hours, 85 on type
Information sources:	Civil Aviation Authority field investigation
Investigator in Charge:	Mr A J Buckingham

* Times are NZDT (UTC + 13 hours)

Synopsis

The National Rescue Coordination Centre was notified of the accident by Airways Corporation of New Zealand Limited (Christchurch Centre), at 0252 hours on Saturday 25 December 1999. Search and rescue action was initiated, and the aircraft wreckage was located at approximately 1115 hours. The Transport Accident Investigation Commission was notified shortly thereafter, but declined to investigate. A Civil Aviation Authority site investigation was commenced later the same day.

The aircraft was on an IFR night cross-country flight from Wellington to Rotorua. Between Maxwell and Ohura the pilot reported engine trouble, and diverted towards New Plymouth. The engine failed completely a short time later, and the aircraft collided with terrain in darkness, killing both occupants.

1. Factual information

1.1 History of the flight

1.1.1 The pilot's plan was to fly a friend from Rotorua to Wellington and return, so that the friend could spend some time with family in Wellington on Christmas Eve. The pilot and his friend were workmates, and the flight was a private arrangement between them. The aircraft was hired from an operator for whom the pilot was about to commence part-time employment.

1.1.2 Departure from Rotorua was at 1937 hours, and the IFR flight proceeded apparently normally to Wellington via Ohura and Maxwell. The pilot encountered some delays at Wellington due to traffic and a runway direction change, but landed uneventfully at 2214 hours.

1.1.3 On arrival, the pilot and passenger were met by the passenger's father, who drove them to his home. At 2352 hours, the pilot telephoned the National Briefing Office to amend his ETD Wellington from 0030 to 0115 hours. Before departure the pilot also discussed the curfew limitations on Wellington Airport with the tower controller, and advised that he would "take his chances" as the intended departure time was during curfew hours.

1.1.4 Back at the airport, the passenger's father watched while the pilot performed a pre-flight inspection of FGF and refuelled from the installation adjacent to the Wellington Aero Club. He observed that the passenger occupied the rear seat for departure, and waited for the aeroplane to take off before returning home.

1.1.5 FGF took off from runway 16 at 0117 hours and climbed to the flight planned altitude of 9000 feet. In the Paraparaumu area, some communications difficulties were experienced between FGF and Christchurch Control, and were partially alleviated by a frequency change. The pilot requested some weather information (via the controller) from a Convair inbound to Palmerston North, and on receipt of this, amended his cruise altitude to 6000 feet.

1.1.6 During the descent of FGF from 9000 to 6000 feet, the controller remarked that on radar, FGF appeared to be having some tracking difficulties, and it seemed at one point that the aeroplane was turning back to Wellington. This occurred during a short period of communication problems, so the reason for the track excursions was not established. However, the flight proceeded normally from this point.

1.1.7 Later in the flight, in response to a check call by the controller, the pilot mentioned that his passenger was sound asleep, and the controller suggested that any time the pilot wanted to have a chat to help stay awake, he was welcome.

1.1.8 At 0245 hours, the pilot made a distress call: "Mayday Mayday Mayday, Foxtrot Golf Foxtrot engine trouble thirty three to the north of Maxwell". The controller immediately advised FGF that the radar lowest safe altitude in the area was 3000 feet and that the nearest aerodrome was New Plymouth, 26 miles to the west.

1.1.9 The pilot subsequently reported that he had partial power, but was still descending and was not going to reach New Plymouth. He asked the controller the distance to the coast; this information was not passed, but at this point the distance was about 18 nm. Shortly after this, radio reception from FGF became intermittent and ceased as the aeroplane descended out of coverage, the radar return fading at 0246 with the last indicated altitude 4700 feet and groundspeed 67 knots.

1.1.10 Although the NRCC was advised immediately, and an aerial search commenced at first light, it was not until about 1115 hours that a Te Wera resident noticed the wreckage of FGF near their property and called the Police. The aeroplane had struck the side of a ridge and had burnt out. Both occupants were found dead in the wreckage.

1.1.11 The accident occurred at night, at approximately 0250 hours NZDT, at Te Wera, at an elevation of 650 feet. Grid reference 260-Q20-479180, latitude S 39° 14.0', longitude E 174° 35.8'.

1.2 Injuries to persons

Injuries	*Crew*	*Passengers*	*Other*
Fatal	1	1	0
Serious	0	0	0
Minor/None	0	0	

1.3 Damage to aircraft

1.3.1 The aircraft was destroyed.

1.4 Other damage

1.4.1 Nil.

1.5 Personnel information

1.5.1 The pilot in command, aged 21, held a valid New Zealand Commercial Pilot Licence (Aeroplane) endorsed with Flight Radio Telephone Operator and Instrument ratings. The Instrument Rating was valid for ADF and VOR navigation aids.

1.5.2 He held a current Class 1 medical certificate with no endorsements.

1.5.3 His total flying experience, including the accident flight was 346 hours, with 85 on the Cessna 172 series. Of the latter total, he had flown 13 hours in FGF. Up to 11 December, the pilot had logged 16.5 night flight hours, 46.6 hours instrument flight time and 29.5 instrument ground (simulator) time.

1.5.4 The pilot's most recent biennial flight review and competency check (VFR) was carried out on 4 December 1999. He had passed his Instrument Rating flight test on 8 July 1999, the rating being valid for single and multi-engined aeroplanes, and for single-pilot operation.

1.5.5 The pilot had only recently moved to Rotorua, in anticipation of a part-time position with the operator of FGF. The work was to include a regular freight run, on which he would have operated the aeroplane under IFR.

1.6 Aircraft information

1.6.1 Cessna R172K serial number R1723249, ZK-FGF had accrued 5763.6 hours total flight time up to the time of the accident. The most recent maintenance check was a 200-hourly carried out on 22 December 1999, after which the aircraft was released to service.

1.6.2 The aeroplane had a current Airworthiness Certificate and the most recent annual review of airworthiness was certified in the aircraft logbook as having been performed on 17 September 1999.

1.6.3 Teledyne Continental IO-360-HBCKB[1] engine, serial number 365123-R, was installed in FGF on 3 November 1999 at zero hours since overhaul. At the time of the accident, the engine had run 59.1 hours.

1.6.4 The engine had been overhauled in New Zealand by an approved firm and was released to service on 30 September 1999. Installation in FGF was certified in the engine logbook on 3 November 1999.

1.6.5 The overhaul documentation indicated that the engine had been overhauled in accordance with the manufacturer's requirements, mandatory component replacement had been carried out and that certain components had been subjected to magnetic particle inspection (for detection of cracks). The connecting rods were included in the latter check.

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[1] Indicates that the engine was converted from -HB to -KB specification at overhaul.

1.7 Meteorological information

1.7.1 At the time of the accident flight, a cold front lay over the lower North Island, moving north-eastwards. Associated with the front were areas of convective cloud in the Cook Strait and Wellington areas, but surface and upper winds were light both ahead of and behind the front. It was the passage of this front that caused the runway change (from 34 to 16) at Wellington earlier in the night.

1.7.2 Some shower activity occurred in Taranaki in the early hours of 25 December, but this was generally after the time of the accident.

1.7.3 Moon data[2] for the time and place of the accident were: elevation: 29.6º, azimuth 345º M. The phase was approximately 44 hours past full moon.

1.8 Aids to navigation

1.8.1 FGF was equipped to IFR standard with an avionics suite which comprised: 2 VHF Nav/Com sets, 2 ADF, DME, glideslope receiver, audio panel with marker beacon receiver, and a transponder.

1.8.2 At the time of the distress call, the aeroplane was being navigated between the Maxwell and Ohura VOR stations.

1.8.3 The flight was monitored by radar, the radar data being recorded as a matter of course. This enabled a plot to be made available for SAR purposes, to assist in determining the probable position of the aircraft. The accident location was subsequently determined to be four nautical miles south-west of the last radar position.

1.9 Communications

1.9.1 Normal communication between the pilot and Air Traffic Control took place throughout the flight, although some reception difficulties were experienced by the pilot in the Paraparaumu area (mentioned in 1.1.5). The pilot of a freight aircraft who was asked by the controller to attempt contact with FGF at this time reported that he had also encountered reception problems in the same area.

1.9.2 The pilot's distress call was clear and unambiguous, enabling the controller to carry out the appropriate alerting without delay.

1.10 Aerodrome information

1.10.1 Not applicable.

1.11 Flight recorders

1.11.1 Not applicable.

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[2] Courtesy of the Carter Observatory, Wellington

1.12 Wreckage and impact information

1.12.1 The aeroplane collided with the side of a ridge, on a heading of 240º M, in an attitude consistent with a normal glide. There was considerable longitudinal deformation of the airframe, including crush damage on the leading edge of each wing. Most of the fuselage and inner portions of both wings were consumed by fire.

1.12.2 The propeller showed no signs of power at impact, with major rearward bending of one blade and the stripping out of most of the hub mounting studs from the crankshaft flange. The engine suffered superficial damage from impact and fire, and during preparations for removal, a hole was noticed in the forward upper area of the crankcase. This was not examined on site.

1.12.3 Pre-impact flight and engine control integrity was established at the site prior to the removal of the engine for further examination.

1.12.4 The leading edge of the tailplane, particularly the right-hand side, had a light coating of a deposit that looked and smelt like engine oil. Some ash was found adhering to the deposits, but it was deduced that the ash was blown there by the rotorwash from the rescue helicopter that first attended the scene.

1.13 Medical and pathological information

1.13.1 Although the post-mortem report stated that in the pathologist's opinion the pilot and passenger died of "injuries sustained in a conflagration", subsequent calculation of the impact forces obtained a result indicating that the impact was beyond human tolerance. The absence of soot or other combustion products in the respiratory passages suggested that neither occupant was breathing at the time the fire occurred.

1.13.2 Routine toxicological tests disclosed only negligible blood levels of carbon monoxide in each occupant.

1.14 Fire

1.14.1 An intense fire erupted after impact and consumed most of the fuselage and the inboard two metres (approximately) of each wing. Virtually all of the non-ferrous materials in these areas were melted or reduced to ash. There was sufficient fuel on board at impact for at least three hours of further flight, and it is likely that one or more fuel lines ruptured in the ground impact. The ignition source could not be established, although there was enough impact-related disruption to the electrical system to have caused arcing at some point in the impact sequence.

1.14.2 The upper engine cowl separated at impact and sustained only minor fire damage. This damage was not consistent with an in-flight fire. The oil deposits on the tailplane were also not consistent with in-flight fire, but rather with a spray of oil being expelled through the holes in the crankcase while the propeller was still turning.

1.15 Survival aspects

1.15.1 Discounting the fire, the impact forces were assessed as unsurvivable, by calculation and given the severity of the injuries to both occupants. Both appear to have been seated in the front seats at impact with their harnesses correctly fastened. Two sets of fastened front seat belt buckles were found in the remains of the cabin area.

1.15.2 The pathological evidence indicated that neither the pilot nor the passenger was breathing at the time the fire occurred.

1.15.3 The ELT was found with its antenna cable severed at the connector, and the unit itself had been fire damaged. After the accident, no ELT signal from FGF was received by satellite or search aircraft.

1.16 Tests and research

1.16.1 The engine was removed from the site to an overhaul facility, where it was stripped and examined under CAA supervision.

1.16.2 The number 6 connecting rod was found to have fractured about halfway along its shank. A second, severely hammered, fracture just above the big end was also evident. The intervening portion of the shank (some 50 mm) was missing, as was the big-end cap, although both bearing shells were found in the crankcase, in a flattened condition. During dismantling of the engine, the torque values for all other big end cap nuts were checked and found to be at the specified figure.

1.16.3 The damage patterns indicated that the fracture about the mid-point was the initial failure, the remainder of the rod then being free to flail within the crankcase while still attached to its crankpin. The flailing end of the rod perforated both crankcase halves at the top, gouged the case adjacent to number 5 cylinder, striking both the (number 5) cylinder and piston skirts, and breaking out a piece of the piston. Strike damage consistent with the flailing rod was also evident on the number 6 cylinder skirt, in the normal plane of rotation of the rod. The rod had subsequently failed again, close to the big end, but no clear fracture surface was visible owing to severe and repetitive impact damage.

1.16.4 During this process both big-end cap bolts failed, and the missing section of rod appears to have been ejected from the crankcase. The big-end cap was later found among the ash and debris removed from the site. No trace of the missing section of rod was found during subsequent searches of the accident site and the aircraft remains.

1.16.5 Additional damage noted was a destroyed cam follower assembly for number 6 inlet valve, and bending of the camshaft in that vicinity.

1.16.6 The failed rod was sent for metallurgical analysis. The initial fracture surface was found to be a fatigue crack originating from a small indentation on one edge of one of the flanges in the "I-beam" section, approximately halfway along the shank. How and when the indentation occurred could not be established, only that it was present before the failure of the rod. It was of sufficient depth to have penetrated the shot-peening marks made at the time of manufacture.

1.16.7 The micro-structure, hardness and the alloy composition of the connecting rod were examined and found to be appropriate for the application.

1.16.8 It was noted that the failed rod and its counterpart from number 5 cylinder were different in appearance from the other 4 rods in the engine. Number 5 was a 626119 series forging and numbers 1 to 4 were 646116 series. The forging number on the number 6 rod was on the missing portion, but it was inferred from the physical similarities with number 5 that it was also of the 626119 series. Rods are fitted in matched pairs.

1.16.9 The metallurgical report indicated that the 646116 rods have a cross-sectional area 1.3 times that of the 626119 series, and as a result of that difference, the stress experienced by the lighter (626119) rods in service would be 1.3 times that of the heavier rods. The report also suggested that, in light of the effects of apparently minor damage, the 626119 rods may be inadequate for the application.

1.16.10 The engine manufacturer was provided with a copy of the report for comment, and responded that the particular series of 626119 rods was considered adequate, provided that they met a specified minimum beam width (see 1.16.11). They also correctly pointed out that damage similar to the indentation described in 1.16.6 could adversely affect the durability of any connecting rod design, including the later 646119 series.

1.16.11 Teledyne Continental Motors Critical Service Bulletin CSB96-13 (issued 14 November 1996) required inspection of 626119 rods and replacement of any with a measured beam width of less than 0.625 inches. The engine overhaul certificate indicated that CSB96-13 had been complied with, and this was confirmed by measurements taken during the metallurgical analysis.

1.16.12 CSB96-13 was an updated version of Service Bulletin M86-11 (issued in 1986), which required replacement of affected rods "at next engine overhaul, top overhaul or anytime the cylinders are removed for any reason". The later bulletin amended the compliance deadline to the next 100-hour or annual inspection, as field reports had indicated that some engines with a low utilisation rate had not reached the end of their overhaul lives and thus had not been required to comply with M86-11.

1.16.13 The beam width criterion has been incorporated in the IO-360 series Overhaul Manual since November 1983. In the early 1980s, according to a FAA General Aviation Airworthiness Alert dated December 1983, "…a disproportionate number of rod failures have occurred with rods marked along the beam section with the letter 'C' enclosed within a circle." It was as a result of this series of failures that the minimum beam width was established.

1.16.14 In this case the number 5, and by inference number 6, connecting rods in the engine were not of "©" manufacture.

1.16.15 As part of this investigation, a search of available US and UK data was undertaken, to identify instances of connecting rod failures on TCM IO-360 series engines. The US data search extended back to January 1981, and the UK to January 1986. The purpose of the search was to assist in determining if a requirement to replace the 626119 rods by 646116 rods was warranted.

1.16.16 The US data yielded 16 accidents (from the NTSB database) and 10 incidents (from the FAA database) in which connecting rods were cited as a factor. Two accidents resulted from rod failures where M86-11 had not been complied with, two were due to fatigue failure and in the remainder the cause was either irrelevant or not specified. There were no related accidents for the period 13 October 1995 to 31 December 1999. None of the 10 incidents cited a specific cause: the most recent of the incidents occurred on 31 January 1988.

1.16.17 A manual search of the UK AAIB reports disclosed no accidents attributable to connecting rod failures on TCM IO-360 series engines.

1.17 Organisational and management information

1.17.1 Not applicable.

1.18 Additional information

1.18.1 On 24 December 1999, CAA received advice from Mobil Oil that a batch of possibly contaminated avgas had been landed in New Zealand and distributed to some lower North Island outlets. CAA and the oil companies (others had been supplied by Mobil) took action to contain the distribution, and the affected outlets were quarantined.

1.18.2 Investigation on the day of the accident determined that FGF had not been refuelled from any of the suspect outlets, and it was subsequently determined that the batch of avgas under suspicion was not contaminated as was first thought.

1.19 Useful or effective investigation techniques

1.19.1 Nil.

2. Analysis

2.1 With the failure of the engine, the pilot found himself in a precarious position. It was night-time, he was possibly in IMC initially, and he was over inhospitable terrain. Initially, when he had partial power available, he considered the options of tracking to New Plymouth or to the coast, but when the engine failed altogether, he was committed to making a forced landing.

2.2 The location of the wreckage in relation to the last observed radar position suggests that the pilot may have sighted and followed the Mangaotuku Valley, along which the Stratford - Okahukura railway and Highway 43 (Stratford – Taumarunui) run. There would have been sufficient moonlight for the pilot to discern at least the gross features of the terrain beneath, but his south-westerly track meant that he was flying down-moon, making it difficult for him to make out the finer detail.

2.3 It is possible therefore that he did not sight the ridge that the aeroplane struck; the impact point was only about 200 m from the road and adjacent flat ground, and had the aeroplane cleared the ridge, there was at least 2000 m of flat ground ahead, albeit with a variety of obstacles such as trees and fences.

2.4 The pilot's clear and unambiguous distress call and subsequent communications, together with the radar evidence suggesting that he configured the aeroplane correctly for the glide, indicate a professional approach to dealing with the very difficult situation in which he found himself. The outcome was largely a matter of chance in the circumstances.

2.5 There is no doubt as to the cause of the actual engine failure: the number 6 connecting rod failed and the portion that remained attached to the crankshaft caused further internal damage to the engine.

2.6 The failed rod was one of a forging series (626119) that had been the subject of manufacturer's Service Bulletins. The bulletins required replacement of those rods with a beam width of less than 0.625 inches, and this criterion has been incorporated in the overhaul manuals since 1983. The failed rod and its opposite number both met the dimensional requirement, and neither was of the "©" manufacture that had been cited in failures in the early 1980s.

2.7 The point of origin of the fatigue failure of the rod was a small indentation in one edge of the I-beam section. How and when this indentation was made could not be determined; the rod was crack-tested at overhaul and the crack appears to have developed in the 59 hours of operation since overhaul. (In that time, the rod would have made some 8,300,000 strokes.)

2.8 The possibility of connecting rod fatigue failure due to shank damage is not limited to the 626119 series of rod. Stress risers on the shank of any connecting rod, particularly where the shot-peened surface has been disrupted, can ultimately cause a fatigue failure.

3. Conclusions

3.1 The pilot was appropriately licensed, rated and experienced to undertake the flight.

3.2 The aeroplane had a valid Airworthiness Certificate and had been maintained and released to service in accordance with current CAA requirements.

3.3 The engine failed in a situation that left the pilot with little chance of executing a safe forced landing.

3.4 The engine failure was due to a connecting rod fracture and consequent damage.

3.5 The connecting rod failed as a result of fatigue, the crack originating from a small indentation on the shank.

3.6 At overhaul, no connecting rod defect sufficient to cause rejection was identified.

3.7 Failure from this cause is not limited to the type of connecting rods discussed in this report.

4. Safety actions

4.1 As a result of this investigation, an Airworthiness Directive (DCA/CON/184) was issued, effective 26 October 2000, and applicable to connecting rods in Teledyne Continental IO-360, TSIO-360 and LTSIO-360 series engines. The AD was issued after consultation with the engine manufacturer and the aviation industry.

4.2 The AD required visual inspection, with a 10-power magnifying glass, of the surface of each connecting rod before reassembly, rejecting any rod with stress raisers such as nicks or dents. It also indicated particular care not to damage the shot-peened surfaces during handling, especially on the 626119 series rods.

Richard White
Manager Safety Investigation
11 December 2000