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# Double Engine Failure Leads to Ditching of Cessna 402C

***The investigation concluded that fuel exhaustion might have caused both engines to fail while the airplane was on a scheduled flight in New Zealand. Five of the 10 occupants were rescued. Four occupants were unable to find their life jackets and died before rescuers arrived. Another occupant was missing and presumed dead.***

*FSF Editorial Staff*

On Aug. 19, 1998, a Cessna 402C was on a scheduled flight from Stewart Island, New Zealand, to Invercargill, New Zealand, when both piston engines failed. The pilot was not able to restart the engines and ditched the aircraft in Foveaux Strait. None of the 10 occupants was seriously hurt during the ditching, but four of the occupants were not able to find their life jackets before the aircraft sank, and they died before rescuers arrived. Another occupant, who had donned a life jacket, was not found and was presumed dead.

The New Zealand Transport Accident Investigation Commission (TAIC), in its final report on the accident, said, "The cause of the double engine failure was not conclusively established but may have been associated with systemic fuel management."

The accident investigation identified the following safety issues:

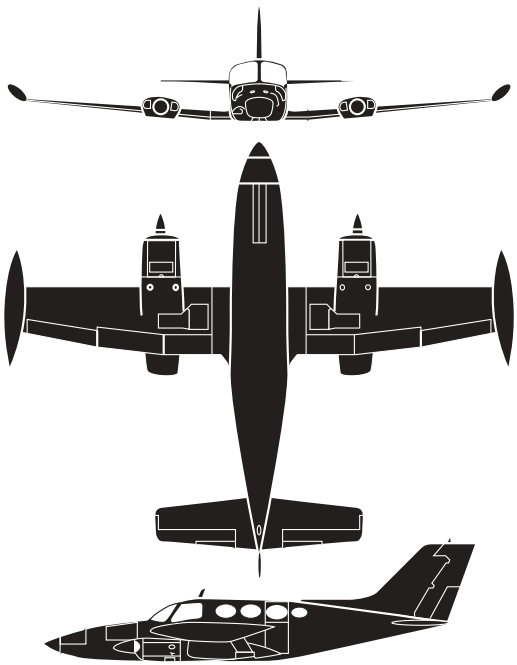
- "The need for operators to use a fuel-quantity-measuring system to supplement fuel-gauge indications; [and,]
- "The need for individual aircraft flight manuals [AFMs] to clearly indicate what optional equipment of operational significance is installed in the aircraft."

The aircraft was operated by Southern Air, which conducted scheduled visual flight rules (VFR) flights between Invercargill Airport, on New Zealand's South Island, to an airstrip that the company built at Ryans Creek on Stewart Island, a relatively small island south of South Island. The company normally used Britten-Norman Islanders for these flights.

In May 1998, the company purchased the Cessna 402C, ZK-VAC, for use in conducting scheduled flights between Invercargill and Dunedin. The aircraft had been modified with a Robertson short-takeoff-and-landing (STOL) kit; the modification replaced the plain flaps with Fowler flaps.

"The Dunedin service with ZK-VAC had not prospered as intended, and, consequently, had been discontinued in July 1998, after three months," the report said. "ZK-VAC had not been specifically intended for use on the Stewart Island service, but the [aircraft's] takeoff and landing performance with the Robertson STOL kit enabled it to comply with performance requirements at Ryans Creek. After the Dunedin service was discontinued, it was decided to use ZK-VAC to supplement the Britten-Norman Islanders when needed."

The aircraft was manufactured in 1981 and was operated in Papua New Guinea until 1996. The aircraft then was operated



## Cessna 402C

The Cessna 402C was designed for use as a nine-seat or 10-seat convertible passenger/freight transport or as a six-seat to eight-seat business aircraft. The original 402s, announced in 1966, were made with convertible cabins and reinforced cabin floors and were designed to be changed quickly from 10-seat commuters to light cargo transports. The separate line of business aircraft became available in 1971.

The airplane is powered by two 325-horsepower (242-kilowatt) Continental TSIO-520-VB flat-six turbocharged piston engines. Each engine drives a three-blade, constant-speed, fully feathering metal propeller. The aircraft's integral wing fuel tanks have a total capacity of 213 gallons (808 liters) of which 206 gallons (780 liters) are useable. The refueling point is on the upper surface of each wing.

The aircraft has a maximum takeoff weight of 6,850 pounds (3,107 kilograms). The 402C has a range of 915 nautical miles (1,695 kilometers) when operating at 72 percent power at 10,000 feet. At economy cruising power, and 10,000 feet, range is 1,273 nautical miles (2,359 kilometers). The aircraft's maximum cruising speed, at midcruise weight, is 194 knots (359 kilometers per hour) at 10,000 feet and 72 percent power. Economy cruising speed is 166 knots (307 kilometers per hour) at 20,000 feet.

Source: *Jane's All the World's Aircraft*

in Wellington, New Zealand, for almost two years before being purchased by Southern Air. It was equipped and approved for single-pilot instrument flight rules (IFR) operations.

The aircraft had accumulated 13,472 hours in service. The left engine had been operated for 1,239 hours since overhaul, and the right engine had been operated for 697 hours since new.

"A review of the maintenance documents showed that all significant defects had been rectified or deferred as appropriate," the report said. "No outstanding airworthiness directives were found."

On the morning of the accident, the company's chief pilot conducted four flights in the aircraft between Invercargill and Ryans Creek; another company pilot conducted a fifth flight. This pilot then was given an IFR check ride in the aircraft by the chief pilot. The accident pilot, who was scheduled to complete the day's scheduled flights to Stewart Island, accompanied them as an observer.

"Before departure, he refueled the aircraft with 141 liters [224 pounds] of [aviation-grade gasoline], so that the fuel gauges indicated just under 300 pounds in each wing tank," the report said. "The check flight, of 47 minutes, was completed without incident. After this flight, the pilots noted that the fuel gauges indicated 190 pounds in each side." Each wing tank has a maximum usable fuel capacity of 618 pounds.

The accident pilot, 51, had a commercial pilot license and 14,564 flight hours, including 27 hours in type. A former agricultural pilot, he had joined Southern Air in August 1986.

"He had flown some 5,200 hours with the company, principally on the Stewart Island service [in Islanders], with an estimated number of crossings of Foveaux Strait in excess of 10,000," the report said. "Most of these flights had been in daytime VFR [conditions], with some 15 hours as night IFR."

He was a company check pilot and training pilot for VFR operations in single-engine aircraft and multi-engine aircraft.

He completed Cessna 402 type-conversion training in May 1998 and then flew the aircraft primarily between Invercargill and Dunedin. Five days before the accident, he failed an instrument competency check administered by the chief pilot in ZK-VAC.

"The deficient items related to instrument procedures and use of the autopilot," the report said. "His basic aircraft handling and procedures were reported as satisfactory. His previous 180-day instrument check, in January 1998 and on [an] Islander aircraft, had been satisfactory."

On the day of the accident, a deep low-pressure area was northeast of New Zealand's North Island, and a weakening ridge of high pressure extended across South Island.

"While North Island had rain and strong easterly winds, a light southwesterly flow over southern South Island gave mostly fine, cool weather, with some clouds and a few showers on Stewart Island and the South Coast," said the report.

At 1600, Invercargill Airport reported 40 kilometers (25 statute miles) visibility, a few clouds at 2,000 feet and scattered clouds

at 3,000 feet. Surface temperature was 9 degrees Celsius (C; 48 degrees Fahrenheit [F]), and the dew point was 4 degrees C (39 degrees F).

"Flying conditions between Invercargill and Stewart Island were reported as clear, with occasional showers in the area," the report said. "Light turbulence near Stewart Island was mentioned."

The pilot conducted one scheduled flight between Invercargill and Ryans Creek that began at 1500 local time. At 1600, he flew from Invercargill to Ryans Creek with four passengers.

"The turnaround at Ryans Creek took about 10 minutes, with nine passengers being boarded for the return flight," the report said. "The pilot did a walk-around of the aircraft and closed the cabin entrance door after boarding. He started the engines before giving the passengers a routine safety briefing, which covered the use of seat belts, the location of life jackets and emergency exits, and the safety-information cards."

The aircraft departed about 1630. The pilot leveled the aircraft at 1,000 feet and radioed Invercargill Tower that the aircraft was en route from Ryans Creek. The flight to Invercargill typically took 12 minutes.

"The flight initially proceeded normally, in clear weather conditions but with one or two showers in sight and some mild turbulence," the report said. "At about midstrait, some five or six minutes after departure, the aircraft yawed and banked to the right, turning off course some 20 [degrees] or 30 degrees. At the same time, the right engine appeared to slow down and lose power."

The passengers saw the pilot move the engine-control levers, the fuel-selector knobs and some switches. They said that the right engine appeared to regain power, and the pilot turned back on course.

"A short but undetermined time later, both engines appeared to lose power," the report said. "The pilot again moved the engine-control levers and the fuel-selector knobs several times. The passengers also reported hearing a beeping warning tone for a few seconds."

At 1643, the pilot declared an emergency with Invercargill Tower and reported the aircraft's position. He then told his passengers: "We have an engine failure. I am ditching the aircraft. Put your life jackets on."

The surviving passengers said that they found their life jackets in the seat pockets in front of them.

"One man, traveling with his three children, got out of his seat to help them don their life jackets and returned to his seat just before the aircraft ditched on the sea surface," said the report.

The report said that the aircraft was ditched 2.5 nautical miles (4.6 kilometers) west of Bluff, which is on the southern coast, approximately 12 nautical miles (22 kilometers) south of Invercargill.

"The sea state during the search was reported as a swell or chop of one meter [three feet]," the report said. "The surface wind was southwest at 15 knots [28 kilometers per hour]."

The aircraft stopped abruptly after striking the water, and some passengers sustained minor bruises when they struck the seats in front of them. The aircraft then floated in a level attitude for three minutes or four minutes.

"All the passengers were able to evacuate the aircraft, either through the emergency exit window on the right side of the cabin or the main door on the left," the report said. "The pilot got out through the crew door on the left side of the cockpit.

"The occupants initially stood on the wings or cabin roof, while the aircraft was floating. The pilot and three passengers had not donned life jackets, so the pilot re-entered the cabin to look for them. He did not find any and had to get out again, as - he aircraft started to sink."

ccording to the report, there was some confusion regarding he position report that the pilot had provided when he declared n emergency. The Invercargill Tower controller had asked he pilot to "report distance."

he pilot said, "Heading for The Bluff, we've got 13 DME distance-measuring equipment]." The report said that the word thirteen" was indistinct and that the controller told police and hristchurch Air Traffic Control Center that the pilot had eported 30 miles from Invercargill Airport, which has a very-h igh-frequency omnidirectional range with DME.

It was unfortunate that the pilot, in reporting his distance from nvercargill, used the word 'thirteen' rather than 'one three,' ut he was acting under considerable stress at the time," the eport said. "The indistinct word 'thirteen,' with some radio istortion and background noise, was heard and initially elayed as 'thirty.' The standard aviation pronunciation of such umbers by separate digits is specifically intended to prevent uch ambiguities."

he aircraft's probable position was resolved after the ontroller notified Southern Air of the emergency.

The company chief pilot responded by telephoning the ontroller back straight away, and they determined that the eported location was at 13 DME, on a bearing of 165 degrees] magnetic from Invercargill Airport, as noted by he controller on the tower VDF (very-high-frequency irection finder) during the 'mayday' radio call," said the eport.

The chief pilot and an observer flew a Cessna 172 to the area at 1704 and began to search for the downed aircraft and its occupants. The search was joined a few minutes later by three more aircraft.

"The observers in search aircraft reported great difficulty spotting people, life jackets or debris in the prevailing sea state and light," the report said. "This was the major impediment to an earlier rescue, and any other delays had little or no effect on the rescue as a result."

At 1742, an aircraft crew saw wreckage or debris on the water and relayed their global positioning system position to the crews of boats that had begun searching at 1656 for the downed aircraft.

Among the debris were the hatches for the nose locker and avionics bay, and an inflated life jacket, which later was identified as having been worn by the missing passenger.

At 1800, an aircraft crew saw the survivors and dropped smoke flares. The survivors then were rescued by the crew of a coast guard vessel and the crews of two other boats.

"Seven of the occupants had been recovered by 1803 hours, and two more by 1810 hours," the report said. "The search continued in darkness with floodlights until 2200 hours and on subsequent days along the coastline, but one passenger, a 7-year-old boy, was not found."

The water temperature in Foveaux Strait was 9 degrees C. The survivors were treated for hypothermia in a hospital and were released after one day to three days of treatment.

"All five survivors wore life jackets, while the four nonsurvivors did not," the report said. "The missing 7-year-old boy had worn a life jacket, but this was found floating without him during the search. How he became separated from it was not known."

The company's flight operations manual (FOM) required 14 life jackets aboard the aircraft. Investigators did not determine why the pilot and three passengers were not able to find life jackets.

"Expert medical opinion was that swimming and efforts to stay afloat would have become impossible for immersed swimmers without life jackets in approximately 15 minutes, given the sea state and temperature of 9 degrees C," the report said. "Survival for longer than this period would have required the use of a life jacket. Without life jackets, and with the quite-light clothing worn by most passengers, hypothermia would have presented an increasing risk to survival after approximately 40 minutes (see Figure 1)."

Figure 1 shows the time for body-core temperature to decrease below 34 degrees C (93 degrees F), which is the body-core temperature associated with moderate hypothermia.

Five days after the accident, a Royal New Zealand Navy vessel located the aircraft on the seabed, resting inverted at a depth of 115 feet (35 meters). Significant postaccident damage was caused by strong tidal currents, and both engines and propellers separated from the aircraft when it was hoisted out of the water.

"The wreckage, as recovered, was essentially complete, however," the report said. "Apart from the [AFM], a fire extinguisher and the crash axe, no loose items — such as luggage, life jackets or passenger-briefing cards — were found in the cabin or nose lockers.

"The aircraft, as recovered, was configured with the landing gear and flaps retracted. Both propellers were feathered."

Both fuel selectors were positioned to the left tank, which shows that the pilot was cross-feeding fuel from the left tank to the right engine before the double engine failure occurred.

Investigators found no evidence of malfunction or failure of any components of the engines or propellers.

"The propellers were fully feathered and showed no evidence of rotation at ditching," the report said. "The engines showed a normal amount of wear, consistent with their hours [in service]. No fuel staining was evident around any fuel component."

The wing fuel tanks and engine fuel sumps were crushed by water pressure. The fuel tanks were punctured when their metal skins were pressed against the fuel-quantity-sensing units.

"The aircraft fuel tanks and associated plumbing and fuel components contained seawater, with only traces of fuel found at the crossfeed drain lines," the report said. "A normal small quantity of clean trapped fuel was found in each [engine fuel-manifold] valve.

"The crushing damage to the fuel-quantity-sensing units and seawater damage to the other components precluded testing the fuel-gauge system and the digital fuel-flow and fuel-totalizer system."

The cause of the double engine failure could not be established conclusively.

"There was no evidence of a mechanical malfunction of any component which could have led to the double engine failure," the report said. "While it could not be conclusively established, fuel exhaustion may have caused the double engine failure."

The company's Islanders had calibrated dipsticks for use in visual monitoring of fuel quantity. Because of the length of the Cessna 402C's wing tanks and the aircraft's wing dihedral, however, fuel quantity could not be monitored visually if the tanks were less than about half full.

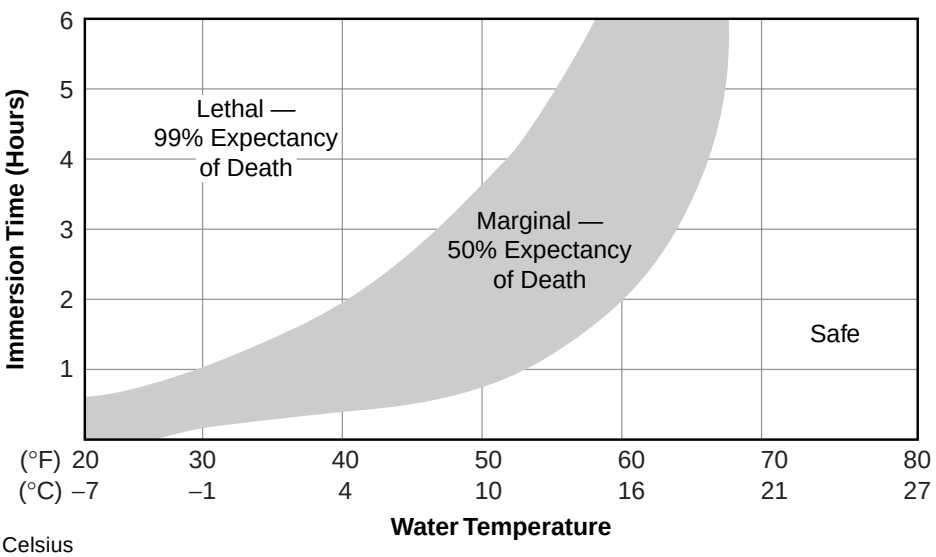



**Figure 1**

"The company had conducted tests to measure fuel consumption and establish fuel-gauge function, but had not developed any strategy with ZK-VAC to take the place of the routine dipstick fuel measurement used on the Islander, relying on the fuel-gauge indications to monitor the fuel quantity," said the report.

Effective use of the aircraft's fuel-totalizer system to monitor fuel quantity would have required the pilots to keep a written record of fuel consumption. Such a record could have been kept as part of the "trip record" required by the company's operations specifications and FOM. Company pilots for many years, however, had not maintained trip records for the Stewart Island service.

"The company had numbered 'flight record' forms for this purpose which were kept in the office, where ground staff entered standard times for each sector, with a cumulative hours total for maintenance-record purposes," the report said. "The 'uplifted fuel' and 'total fuel' columns were not used."

Cumulative analysis of fuel usage on the day of the accident indicated that the aircraft's fuel-gauge readings might have been erroneous. For example, the analysis showed that each tank contained 159 pounds of fuel when the fuel gauges showed 190 pounds of fuel per tank after the check ride was completed and before the accident pilot made his first flight to Stewart Island.

"This cumulative analysis … of the fuel status of the aircraft suggests that sufficient fuel to complete the accident flight was present, albeit below company and [AFM] minimums for takeoff [120 pounds of fuel in each tank]," the report said. "The analysis does depend on the reported fuel quantity before the first flight, based on the gauge readings at the time."

The aircraft was not equipped with a low-fuel warning system. The system, offered by the manufacturer as an option on the Cessna 402C, illuminates a "fuel low" light when fuel quantity in either tank decreases below 60 pounds. Some company pilots, including the chief pilot, believed that the accident aircraft had the system.

"This belief may have arisen from the description of such a system being located in the 'airplane and systems' section of the [AFM], rather than the 'supplements' section," the report said. "The belief was not supported by the actual annunciator panel, which had no 'fuel low' warning captions visible. It was not known whether the pilot of ZK-VAC shared this belief, but he probably did.

"A result of this belief may have been that pilots had an unfounded expectation that the system would compensate to some extent for their inability to dip the fuel tanks, by providing an independent warning of a low-fuel state before it became critically low.

"The absence of clear information in the [AFM] about whether or not the low-fuel warning system was installed in ZK-VAC was undesirable and may have contributed to the erroneous belief."

After the accident, Southern Air made several changes, including the following:

- "Completely redesigning the fuel sheet to include all required data;
- "Daily flight records are now carried on all operations, with fuel uplifts recorded;
- "The pilot on all overwater flights now wears a pouch-type life jacket;
- "Flares and smoke canisters are carried on all flights;
- "Life rafts are carried on all single-engine overwater flights; [and,]
- "The company has established its own [search-and-rescue] plan in cooperation with other operators in the area."

Based on the investigation's findings, TAIC recommended that the New Zealand director of civil aviation "require individual [AFMs] to list those optional equipment items of operational significance which are installed in the aircraft."

On April 29, 1999, the director of civil aviation responded as follows:

> "This recommendation seems to be a general response to a specific problem that existed because of the design features of the aircraft involved, i.e., reliance on the fuel contents indicating system, including optional low-level warning lights that were not actually fitted, when dipping of tanks was not a practical capability.
>
> "The recommendation, while it may go some way to preventing a further occurrence of this kind, will nevertheless bring with it a number of other considerations which, on balance, may show that it is not cost beneficial and imposes a significant workload to bring up to date the large number of existing [AFMs]. There is also likely to be a degree of difficulty in defining both *optional* and *operational significance*, as used in the recommendation.
>
> "It should also be born in mind that the responsibility for ensuring that a pilot undergoing a type conversion is competent rests with the (industry) instructor giving that endorsement training. That training is not limited to flight time, but should also include extensive discussion, briefing and training on the aircraft and all its fitted systems. The endorsement is not complete until the instructor has ensured that the endorsee is fully familiar with all systems and operating parameters of the aircraft.
>
> "Notwithstanding these comments, the [Civil Aviation Authority] is prepared to adopt this recommendation in principle as a petition for rule making and submit it to the rule-making process. The action will be initiated within a month, but no time frame can be given for its completion."♦

[Editorial note: This article, except where specifically noted, is based entirely on New Zealand Transport Accident Investigation Commission *Aviation Occurrence Report 98-008: Cessna 402C ZK-VAC, Double Engine Failure and Ditching, 19 August 1998, Foveaux Strait*. The 19-page report contains one illustration.]



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