

**Report 07-002, Dornier 228-202, ZK-VIR, partial incapacitation of flight crew,
en route Westport to Christchurch, 30 March 2007**

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Report 07-002

Dornier 228-202

ZK-VIR

**partial incapacitation of flight crew
en route Westport to Christchurch**

30 March 2007

Abstract

On Friday 30 March 2007, Dornier 228-202 ZK-VIR was on a positioning flight from Westport to Christchurch, when the 2-pilot crew became light-headed and felt faint. Concerned about their safety, the crew was able to descend the aircraft and make a safe landing at Christchurch. They subsequently made a full recovery.

No cause for the effects felt by the crew could be identified. The aircraft eventually entered revenue service and no further incidents were reported.

The safety issues identified were the failure of the cockpit voice recorder to function as designed and the lack of portable oxygen for sustained flights at moderate altitudes. Because of the actions by the operator, no safety recommendations were required.



Dornier 228-202 ZK-VIR

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Abbreviations

ATC	Air Traffic Control
ATSB	Australian Transport Safety Bureau
°C	degrees Celsius
CAA	Civil Aviation Authority of New Zealand
CO	carbon monoxide
CO ₂	carbon dioxide
CVR	cockpit voice recorder
FDR	flight data recorder
IFR	instrument flight rules
kg	kilograms
ppm	parts per million
UTC	coordinated universal time

Data Summary

Aircraft registration:	ZK-VIR
Type and serial number:	Dornier 228-202, 8100
Number and type of engines:	2 Garrett – Allied Signal TPE331-5-525D turbo-prop
Year of manufacture:	1986
Operator:	Air West Coast
Date and time:	30 March 2007, about 1910 ¹
Location:	about 100 km north of Christchurch latitude: 42° 40' south longitude: 172° 10' east
Type of flight:	ferry
Persons on board:	crew: 2 passengers: nil
Injuries:	crew: nil passengers: nil
Nature of damage:	nil
Captain's licence:	Air Transport Pilot Licence (Aeroplane)
Captain's age:	39
Captain's total flying experience:	12 300 hours (210 hours on type)
Investigator-in-charge:	I R M ^c Clelland

Acknowledgement

The Commission acknowledges the assistance of the Australian Transport Safety Bureau (ATSB) during the investigation.

¹ Times in this report are New Zealand Standard Time (UTC + 12 hours) and are expressed in the 24-hour mode.

Factual Information

1.1 History of the flight

- 1.1.1 On Friday 30 March 2007, Dornier 228-202 ZK-VIR was being used for route familiarisation and crew training by the operator, Air West Coast, prior to the aircraft's introduction to service. The flights were also an opportunity to promote the operator's newly acquired aircraft by giving free carriage to passengers while flying their existing routes. The aircraft had arrived in Wellington the previous day, with the crew staying overnight in a local motel (see Figure 1).
- 1.1.2 On Friday morning, a check captain and co-pilot flew a local certification flight in ZK-VIR to check the aircraft Global Positioning System that would be used for instrument approaches. No passengers were carried. A Civil Aviation Authority (CAA) inspector accompanied the crew to validate the results. The flight took about an hour and was completed without incident. After landing back at Wellington, the 2 pilots were joined by a third pilot, who was undergoing training to become a captain on the aircraft. The third pilot (the pilot) was to be the flying pilot for the afternoon flights.
- 1.1.3 The 3 pilots had lunch together and prepared the aircraft for the flights to Westport and Greymouth. The plan was to offload the co-pilot and the last of the passengers at Greymouth before the check captain and the pilot flew the aircraft to Christchurch in preparation for further flights the following day.
- 1.1.4 At about 1630, ZK-VIR departed Wellington under an instrument flight rules (IFR) plan, with the 3 pilots and 10 passengers on board. The pilot was flying the aircraft from the left seat, with the check captain in the right seat performing the co-pilot duties. After landing at Westport, the crew received reports of deteriorating weather conditions at Greymouth and Hokitika, so they elected to offload the remaining passengers and the co-pilot, and fly directly to Christchurch. The passengers and the co-pilot continued to their destination by road transport.
- 1.1.5 At about 1850, ZK-VIR departed Westport, under an IFR plan and about 5 minutes before the end of daylight. The crew reported that with no passengers and a light fuel load they climbed the aircraft steeply to about 8000 feet before increasing speed and climbing to a final cruise altitude of 10 000 feet. The crew later commented that the cockpit heating control for the air conditioning system was selected ON for the climb and remained in the automatic mode, as it had been for the Wellington – Westport leg.
- 1.1.6 At about 1908, the pilot started to feel unusual and began to develop a dizzy sensation. He commented to the check captain that he “didn't feel very well” and thought he may “faint or pass out”. The check captain took control of the aircraft but said that within 4 or 5 seconds he too started displaying similar symptoms, including his peripheral vision starting to blur and a feeling of being light-headed. The check captain turned off the air conditioning bleed air supplying the heating, selected external ram air and instructed the pilot to open the storm window² on the left side of the aircraft. The aircraft was not fitted with portable oxygen or side air vents.
- 1.1.7 The pilot opened the window and, cupping his hands, was able to direct fresh air into the cockpit and onto his face. He reported that within 10 seconds he was able to sit back and start analysing the situation. At the same time, the check captain leaned across and breathed in some of the fresh cold air. He also noticed an almost immediate improvement in his condition.
- 1.1.8 The check captain passed control of the aircraft back to the pilot, who by this stage considered himself to be improving to “a lot closer to 100%, [but] not quite”. At 1911, the check captain transmitted a “pan pan” urgency call³ to Christchurch Air Traffic Control (ATC), advising of

² A small, hinged window inset into the larger fixed side window.

³ Urgency is a condition concerning the safety of an aircraft or person on board but which does not require immediate assistance.

the situation, including his belief that there was some form of air contamination. He requested descent to the minimum allowable radar terrain altitude for that area. ATC cleared ZK-VIR to descend initially to 9000 feet and the pilot promptly started the descent.

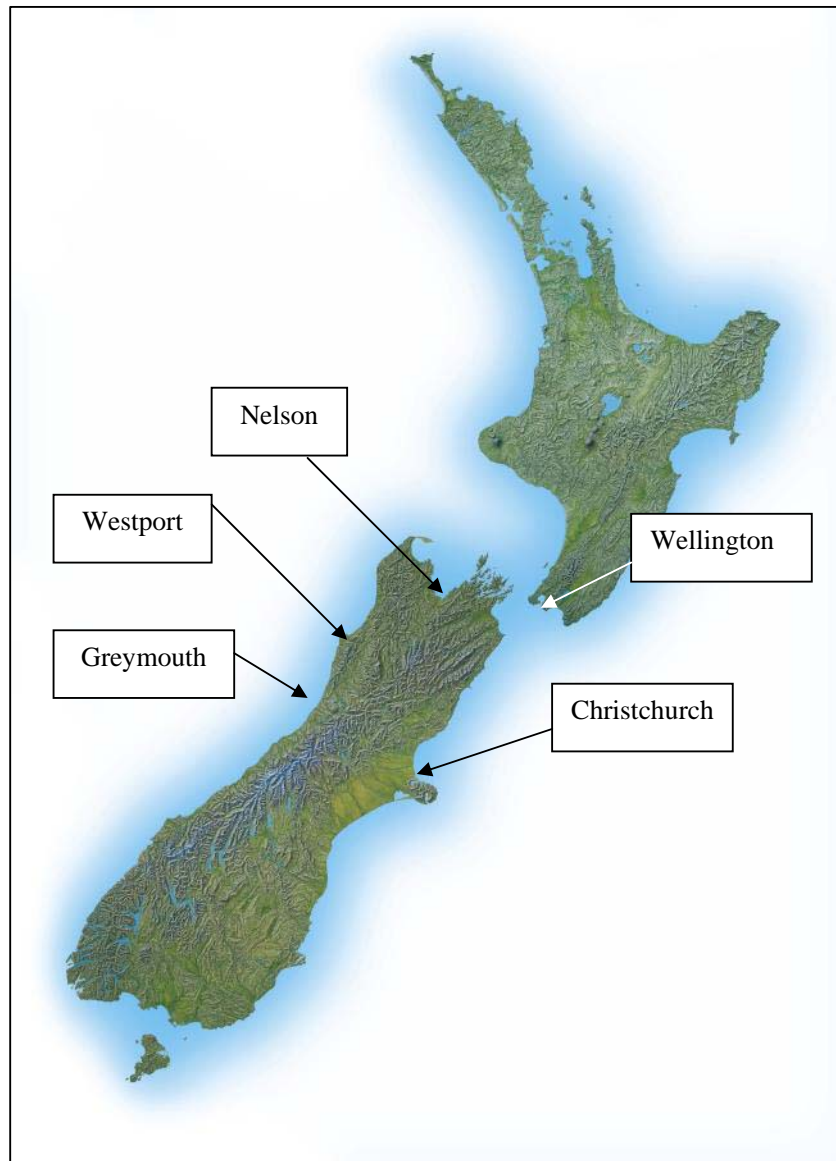


Figure 1
Location map

- 1.1.9 The crew considered that continuing to Christchurch was preferable as they were about midway between the 2 locations and the terrain allowed an earlier descent. Further, the weather at Christchurch was suitable for a visual approach and the aerodrome offered the choice of 2 longer, lighted runways with full ATC and rescue fire service support. By comparison, the facilities at Westport were limited.
- 1.1.10 The crew reported that at 9000 feet they were able to remain above the cloud layer and the moonlight continued to give a clear horizon. The check captain requested ATC maintain a continuous dialogue with them to help ensure they remained alert and responsive.
- 1.1.11 As ZK-VIR descended, the crew recalled that they checked around the cockpit to see if they “could find anything wrong”, or out of place. They also checked the cabin for any fumes, but smelled nothing unusual and everything seemed normal.

- 1.1.12 The pilot, unbeknown to the check captain, removed his left hand from the storm window because of the cold. The pilot reported that within a few seconds of this action the check captain said that he was again becoming light-headed and his vision was blurring. The check captain alerted the pilot to again start directing fresh air into the cockpit and noted an immediate improvement in his condition. The pilot continued to fly with his right hand, keeping his left hand at the storm window, which required the check captain to manage the power levers and radio.
- 1.1.13 As the aircraft was descended through about 6500 feet, the crew became visual with the aerodrome and joined straight-in for runway 11. At about this time, ATC asked the crew if any assistance was required once on the ground. The check captain replied that no assistance was required, and that their primary aim was to land safely.
- 1.1.14 At 1934, ZK-VIR was landed safely and taxied to the apron, where it was shut down and secured by the crew. The pilots agreed that despite feeling better, it would be prudent to have a medical examination and so proceeded to the Accident and Emergency Department of Christchurch Hospital. Blood samples were taken at about 2045 and the pilots put on oxygen. Displaying no ill effects, the pilots were released after about an hour.

1.2 Aircraft information

- 1.2.1 ZK-VIR was a Dornier Luftfahrt GmbH Do 228-202, serial number 8100, high wing, twin-engined turbo prop aircraft constructed in Germany⁴ in October 1989. The aircraft was powered by 2 Garrett AiResearch TPE331-5-252D turbine engines driving Hartzell HC-B4TN-5ML propellers. A synthetic-based oil was used for engine lubrication. The aircraft had retractable landing gear and was fitted with 2 crew and 19 passenger seats. The aircraft was capable of being flown single pilot, but CAA Rules directed that an aircraft with 15 or more passenger seats be crewed by 2 pilots when flown under instrument flight rules⁵.
- 1.2.2 The maximum normal operating altitude for the Dornier 228-202 was 15 000 feet above mean sea level. It was not equipped with a pressurisation system or supplementary oxygen⁶. ZK-VIR had a recorded basic weight of 3739 kg in the 19-passenger seat configuration and a maximum take-off weight of 6200 kg.
- 1.2.3 After manufacture the aircraft was exported to North America, where it was flown by several operators. In 1998 the aircraft was returned to Germany, where it was held in open air storage until it was purchased by the New Zealand operator in early 2006.
- 1.2.4 The operator, assisted by the previous owner, spent several months bringing the aircraft back to an airworthy condition. Part of the work included installing an air conditioning system removed from another Dornier 228. The operator reported that the aircraft was given a test flight before commencing the delivery flight to New Zealand. The operator also commented that during the delivery the aircraft flew at altitudes of up to 19 000 feet with the engines and air conditioning heating system being given a thorough workout⁷. No problems or technical faults en route were reported.
- 1.2.5 On arrival in New Zealand, the CAA inspected the aircraft to ensure it conformed to its type specifications. It was subsequently issued with a Type Acceptance Certificate on 31 August 2006 and registered as ZK-VIR.
- 1.2.6 The CAA directed that ZK-VIR be given a full engineering examination before a Certificate of Airworthiness would be issued. The examination included a structural inspection and the

⁴ West Germany at the time of manufacture.

⁵ Civil Aviation Rules Part 125.511.

⁶ Civil Aviation Rules Part 91.209 require supplemental oxygen for unpressurised flight above 13 000 feet, or above 10 000 feet for more than 30 minutes.

⁷ The occupants were on supplemental oxygen during this time.

completion of an Annual/100 Hour inspection, Annual Review of Airworthiness and a 4800 Flight Hours and 48 Months check. These checks made up a complete maintenance cycle for the aircraft.

- 1.2.7 The concentrated examination, combined with other rectification work, provided a starting reference for the ongoing scheduled maintenance of the aircraft. ZK-VIR was subsequently issued with a Certificate of Airworthiness on 3 February 2007, which was non-terminating provided the aircraft was maintained and operated in accordance with the prescribed manual and operating limitations. At this time the aircraft had accumulated 18 855.6 hours.
- 1.2.8 At the time of the incident, ZK-VIR had accumulated 18 905.45 hours and had 50 hours to run to the next scheduled servicing. There were no outstanding technical defects that would have affected the safe conduct of the flight.

Aircraft air conditioning

- 1.2.9 ZK-VIR was fitted with an air conditioning system to help manage the cockpit and cabin environments during flight. Hot bleed air was taken from the second stage compressor of either or both engines and passed through a check valve before feeding through a pressure regulator and shut-off valve. Hot air for aircraft anti-icing was ducted off before it reached the pressure regulator and shut-off valve.
- 1.2.10 After the shut-off valve, air was then divided into 2 routes, with one part going directly to a temperature mixing chamber. The other part of the air was directed through a heat exchanger and cold air unit containing a cooling turbine. At the mixing chamber the 2 airflows were mixed to establish cabin outlet temperatures between 18° and 28° Celsius (C) as selected by the pilots.
- 1.2.11 From the mixing chamber the air was directed through a water separator and 2 distribution lines to outlets in the cabin and cockpit. Should the temperature after the water separator exceed a preset value, a caution light would light up to alert the pilots.
- 1.2.12 A ram air system was available should the air conditioning system fail. After bypassing the temperature mixing chamber, the external ram air would travel by the same lines and outlets as the aircraft's air conditioning system to enter the cabin or cockpit.

Flight recorders

- 1.2.13 ZK-VIR was fitted with a flight data recorder (FDR) and cockpit voice recorder (CVR). The FDR, a Fairchild 8130-3, was not downloaded, as none of the 15 parameters recorded were useful to the investigation and the relevant information was available from other sources.
- 1.2.14 The CVR, a Sundstrand⁸ AV-557D, was removed from the aircraft and passed to the Australian Transport Safety Bureau (ATSB) for downloading and analysis. The ATSB advised that the CVR was designed to record 4 channels of information for a minimum duration of 30 minutes.
- 1.2.15 Four channels of sound were recovered from the CVR. One channel contained flight crew conversation, one channel contained some low-level crew speech and a signal which may have been related to a digital time signal, and the other 2 channels contained a chime sound. The recovered audio was identified as not being from the incident flight on 30 March, but an earlier flight, possibly the Wellington – Westport leg, with the recording ceasing as the aircraft passed Nelson.
- 1.2.16 The duration of the recording was timed at 26 minutes and 17 seconds, being shorter than the minimum 30 minutes described in the recorder's specifications and required by Civil Aviation Rules Part 125, Appendix B.3.

⁸ Now Honeywell.

- 1.2.17 The ATSB investigation determined that the low amplitude of the recovered audio indicated that the signals supplied to the CVR may not have been correctly adjusted. Further, the shorter than specified recording duration may be due to an incorrect tape transport speed or a tape being fitted that was shorter than specified by the CVR unit manufacturer. The simultaneous ceasing of recording across the 4 channels suggested that the CVR suffered a loss of power supply from either the aircraft power supply or internal power converter.

1.3 Personnel information

- 1.3.1 The check captain held an Airline Transport Pilot Licence (Aeroplane), and a class 1 medical certificate valid until 30 May 2007. He had flown about 12 300 hours, including 210 hours on the Dornier 228 type aircraft.
- 1.3.2 The check captain had qualified on the Dornier 228 type aircraft some 15 years previously. He was a current airline flight examiner and held category B and D instructor ratings. He held ratings on Airbus A320, Boeing 767, de Havilland Canada Dash 8, Fokker F27 and Dornier 228 aircraft types.
- 1.3.3 The check captain had been flying part-time with the operator since November 2006. He had recently taken leave from his regular employer to assist the operator in training pilots for operations on the Dornier 228.
- 1.3.4 The check captain had flown 158 hours in the last 90 days, including 55 hours on the Dornier 228. He reported that he was in good health, had no known allergies and was well rested at the start of flying duties on the day of the incident.
- 1.3.5 The pilot was aged 26. He held a Commercial Pilot Licence (Aeroplane), and a class 1 medical certificate valid until 26 October 2007. He had joined the operator in July 2006 and had initially qualified on the operator's Piper PA-31 Chieftain aircraft.
- 1.3.6 The pilot had flown 160 hours in the last 90 days, and had flown 2960 hours in total. He had accrued 48 hours on the Dornier 228 aircraft, all in the last 90 days.
- 1.3.7 The pilot reported that he was in good health, had no known allergies and was well rested at the start of flying duties on the day of the incident.
- 1.3.8 The 2 pilots, along with the co-pilot who left the aircraft at Westport, had eaten together during the day, with none reporting any ill effects from the food or drink. Neither the check captain nor the pilot had anything to eat at Westport. The pilot reported that he may have had a drink from his personal drink bottle, but this was all.
- 1.3.9 Both pilots were tested for carbon monoxide (CO) poisoning using the blood samples taken after the event. The carboxyhaemoglobin levels were 1.8% for the check captain and 1.6% for the pilot. The normal range for a non-smoker was zero to 1.5%, and zero to 9.0% for a smoker. Both pilots were non-smokers.

1.4 Tests and research information

- 1.4.1 Following the incident, ZK-VIR was quarantined until the arrival of the Commission and a licensed engineer. An initial examination of the engines, associated bleed-air systems and aircraft air conditioning identified no unusual smells and nothing that might have caused contamination of the flight deck air. A second engineer, familiar with the type of engines installed on the aircraft, completed another examination and found nothing untoward.
- 1.4.2 An engine ground run was performed and a CO tester used to sample air at various positions around the cockpit and cabin, including demister and ventilation outlets. Firstly, the left engine was run and tests carried out with engine bleed-air selected, air conditioning set to ON and the auto selector set to full heat. The tests were then repeated on the right engine. The heating system was confirmed as operating but there was no evidence of any CO.

- 1.4.3 The inlet and outlet tubes for the cold air unit of the air conditioning system were examined for the presence of oil or other contaminants. While the inside of some of the tubing displayed a shiny appearance, chemical analysis of the surface material identified no hazardous substances. The shiny appearance may have resulted from exposure to minute amounts of foreign matter, for example engine washing fluid or exhaust gases, over the previous 10 years.
- 1.4.4 The hose joining the outlet tube to the mixing chamber downstream of the cold air unit was examined. The tube contained an expansion bulge to allow for movement between the fixed units and would have acted like a collection chamber for any oil flowing from the cold air unit. There was no evidence of any oil.
- 1.4.5 The inside surface of the mixing chamber appeared to be coated with a slight oil film but this could not be rubbed off. The outlet pipe from the mixing chamber was clear. The air conditioning shut-off regulator valve showed evidence of occasional sticking. The valve was removed, cleaned and checked before being refitted to the aircraft.
- 1.4.6 The air conditioning system was reassembled and additional testing equipment installed for a second ground run. The equipment enabled recording of CO, carbon dioxide (CO₂), temperature, relative humidity and oxygen levels. On completion of the ground run, including taxiing the aircraft to face at different headings to the wind, the results were downloaded for analysis by a consulting laboratory. The results were unremarkable and identified nothing unusual.
- 1.4.7 A test flight was then flown, using the same equipment and repeating as closely as possible the flight profile flown on the incident flight. Charcoal sorbent tubes were also used to test for the presence of any solvents or other organic material. Portable oxygen was carried on board as a precaution but was not required.
- 1.4.8 The test results were again unremarkable and identified no foreign matter that could have affected the performance of the crew. No CO was detected during the flight. The CO₂ levels peaked at 2000 parts per million (ppm) on occasions. This level was well below the workplace exposure standard limit of 5000 ppm for an 8-hour time-weighted average, and well below the 30 000 ppm for short-term exposure⁹.
- 1.4.9 The oxygen level during the ground test was constant at 20.9%, showing nothing replaced the oxygen inside the aircraft¹⁰. During the flight, the oxygen level fluctuated around 20-22%. This was considered to be an instrument response to changes in altitude. A brief drop in oxygen percentage to 16% was recorded but this corresponded to the air conditioning being set to ON after take-off and the percentage quickly returned to normal levels.
- 1.4.10 Investigation of the cleaning compounds used by the operator to clean the aircraft indicated nothing that would produce any toxic or odourless fumes that might cause incapacitation.
- 1.4.11 Enquiries with the aircraft manufacturer and overseas government aviation regulation, transport safety and investigation organisations identified no other similar cases of crew incapacitation or toxic cockpit environment on a Dornier 228 aircraft.
- 1.4.12 At the time of writing this report, the aircraft had flown over 500 hours since the incident, including through 2 winters, with no reported problems, unexplained fumes or cases of ill health.

⁹ Standards set by the Department of Labour.

¹⁰ The normal percentage of oxygen in the air was considered to be 20.9463%.

2 Analysis

- 2.1 The incident flight was the latest in a series of flights to give pilots type and route experience before the operator introduced the aircraft into service. The opportunity was also being taken to promote the new aircraft on its intended routes. The carriage of passengers on such flights was permissible, provided there was no revenue being derived or certain emergency procedures being practised. The passengers were made aware of the intentions of the flights and agreed by the conditions.
- 2.2 The crew undoubtedly suffered some form of incapacitation. The timing and similarity of the symptoms, the crew's individual recollection of matching events and the check captain's symptoms returning after the pilot removed his hand from the window suggested that there was likely to have been some form of contamination of the air inside the aircraft. The symptoms displayed by the 2 pilots, and the fact that the third pilot suffered no similar ill effects, would exclude food poisoning as a cause.
- 2.3 The symptoms reported by the crew, including light-headedness, vision impairment and no associated smell, have on occasions in the past been associated with CO poisoning. The subsequent toxicology tests that showed slightly elevated levels of CO in the blood also suggested some degree of CO poisoning, but the levels recorded would not by themselves be expected to affect a person to the degree reported. However, with a half-life for CO of about 8 hours, the time lapse between the onset of the symptoms and when the pilots had blood samples taken, nearly 2 hours later, and the fact that the crew had been breathing fresh air for most of this time, meant that the actual CO levels could have been about 1% higher. A moderately higher level, especially if associated with a rapid rise in CO levels, combined with the effects of a high cabin altitude, 10 000 feet, could have been sufficient to have affected the pilots to a minor extent.
- 2.4 CO is odourless, colourless and non-irritating, and is primarily produced by incomplete combustion of any carbonaceous fossil fuel. The aircraft heating and air conditioning system was, therefore, a focus of the investigation. The bleed air used for cabin heating was taken from the second stage engine compressor, well before the injection of fuel and combustion, and would not itself produce CO.
- 2.5 Cleaning products were eliminated as a possible source of the contamination as they were not capable of producing any toxic by-product. According to a technical specialist for the lubricant manufacturer, the oil used for engine lubrication, while a synthetic product, could produce toxic fumes, including CO, when heated to sufficiently high temperatures. However, the fumes are accompanied by a strong acrid smell.
- 2.6 The air conditioning had accrued over 100 hours' use since installation, including being subjected to high demands during the delivery flight when the aircraft was flown at high altitudes and low temperatures. Post-incident examination of the plumbing identified no leaks or residue that may have caused the contamination.
- 2.7 The weather was not a factor. However, a point of difference from the earlier flight from Wellington to Westport was the time of day, and therefore the temperature would have been colder. This would have placed greater demand on the temperature controller to provide the same cabin temperature. Therefore, the possibility that engine oil had slowly pooled in the air conditioning system and was heated to the point of giving off fumes cannot be eliminated. However, there was no smell, and subsequent ground runs and a test flight were unable to replicate the contamination. Further, the aircraft later flew 430 hours, including through 2 winters, without incident.
- 2.8 The action of completely turning off the air conditioning system and selecting external ram air was appropriate considering the crew did not know the source of the contamination. The directing of fresh air in through the storm window would have also helped them overcome any further impairment. The crew also prudently monitored their performance and ensured that ATC continued frequent communication as the aircraft approached Christchurch.

- 2.9 While portable oxygen was not required to be carried, the pilots would most likely have handled the situation with greater ease if they had been able to quickly access such a supply. Further, the availability of supplementary oxygen for extended flights above 10 000 feet has potential future benefits should it be needed for any passenger ailment.
- 2.10 The failure of the CVR to record the last 30 minutes of the incident flight was of concern, because a valuable resource was lost to the investigation. The CVR test function was not able to detect the type of fault that led to the failure, most probably because of some internal failure. To check that a tape-based recorder was functioning correctly required the recorder and then the tape to be removed for analysis, which is a time-consuming and expensive exercise. However, modern, readily available, digital recorders offer greater reliability and easier download options.

3 Findings

Findings are listed in order of development and not in order of priority.

- 3.1 The pilots were qualified on the aircraft type, with the pilot undergoing upgrade training to captain.
- 3.2 The reason the pilots became partially incapacitated could not be determined, but was most likely from some form of air contamination, because the symptoms disappeared when fresh air was introduced into the cockpit.
- 3.3 Although post-incident testing of the pilots identified only slightly elevated levels of CO in their blood, it was considered, in the absence of any other explanation for air contamination, that the crew could have suffered a degree of CO poisoning, possibly from engine oil being heated, but this could not be proved.
- 3.4 Since there has been no repeat of the incident in over 430 hours of flying after the event, it is regarded as an isolated occurrence.
- 3.5 If the CVR had functioned as designed and required, it may have provided useful information to assist the investigation.
- 3.6 If portable oxygen had been available, it could have assisted the crew's ability to handle the situation.

4 Safety Actions

- 4.1 In September 2007, the operator replaced the CVR with a more modern, digital recorder before the aircraft entered revenue service in October 2007.
- 4.2 The operator also reported that an oxygen system was installed on board ZK-VIR that could be directly accessed by the pilots or, if required, administered to a passenger.

Approved on 18 December 2008 for publication

Hon W P Jeffries
Chief Commissioner



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