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Rapid Ice Buildup Triggers Stall and In-flight Breakup

While being flown in an area of severe icing conditions in New Zealand, the Convair 580 freighter stalled and entered a spiral dive from which the flight crew was not able to recover. The aircraft broke up and struck water nearly vertically and at a high rate of speed.

FSF Editorial Staff

At 2126 local time Oct. 3, 2003, a Convair 580 struck water about 10 kilometers (five nautical miles) north of Paraparaumu, New Zealand, during a cargo flight from Christchurch to Palmerston North. The aircraft was destroyed, and the two pilots were killed.

The New Zealand Transport Accident Investigation Commission (TAIC) said, in its final report on the accident, that "the aircraft probably became heavily iced up while descending through an area of severe icing and stalled after flying level for a short time. The crew was unable to recover from the ensuing spiral dive, and the aircraft broke up as it descended."

The aircraft was one of four Convair 580s operated by Air Freight New Zealand. It was built in 1952 and converted from a Convair 340 to a Convair 580 in 1966; the conversion primarily consisted of replacing the aircraft's radial piston engines with turboprop engines. The aircraft was converted from a passenger transport to a freighter by its previous operator, Kelowna Flightcraft, a Canadian company that held the type certificate for the Convair 580. The aircraft was imported into New Zealand from Canada in 1995. At the time of the accident, the aircraft had accumulated 66,660 flight hours and 98,774 cycles (takeoffs and landings).

"In January 1998, a repair to remove corrosion from the left-wing upper-spar-cap wing-attachment area was considered necessary by the operator," the report said. "A repair was proposed to, and subsequently approved by the [New Zealand] Civil Aviation Authority (CAA), [which] also directed that the area be inspected every 500 [flight] hours or every 12 months, whichever came first. The area was recorded as last inspected on 21 August 2003 at 66,608.3 aircraft hours.

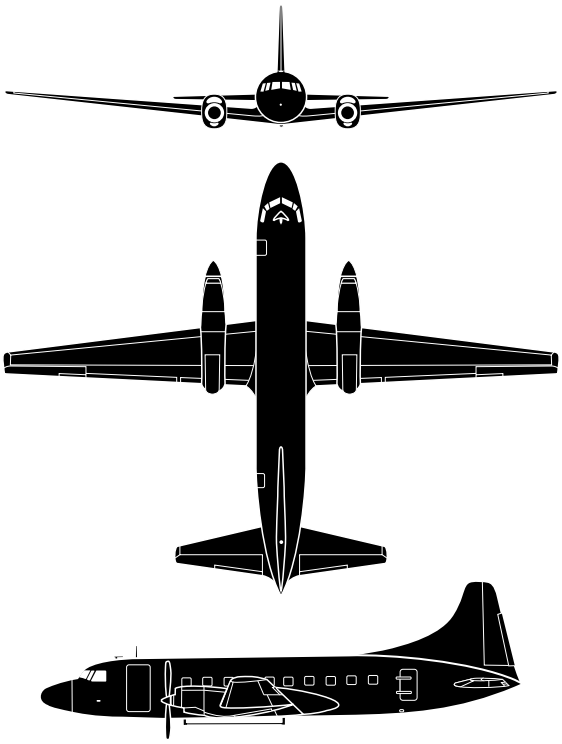
"A review of aircraft maintenance documents identified no outstanding additional maintenance requirements on [the aircraft]."

The aircraft had electric anti-ice systems for the propellers, windshield and pitot tubes, and engine-bleed-air anti-ice systems for the leading edges of the wings, horizontal stabilizer and vertical stabilizer.

The flight manual said, "The aircraft anti-icing system is not approved for use as a deicing system. Turn the anti-icing system on when icing conditions are anticipated or first encountered."

The company told investigators that its pilots selected the anti-icing systems "at the slightest indication of icing conditions."

"The Convair 580 was not fitted with electronic ice-detection equipment; but, according to the operator and other company pilots, the anti-icing systems were very effective in preventing and removing ice from the aircraft," the report said.



Consolidated Vultee Corp. Convair 580

The Convair 580 is a turboprop conversion of the piston-engine-powered Convair 340 and 440. The conversion included replacement of the 1,800-horsepower (1,343-kilowatt) 18-cylinder Pratt & Whitney R-2800 radial engines with 3,750-shaft-horsepower (2,798-kilowatt) Allison 501-D13 turboprop engines and enlargement of the empennage surfaces. Optional modifications included increased fuel capacity.

The Allison Division of General Motors Corp. was the prime contractor for the conversion program, which was begun in 1958; the modifications were performed by Pacific Airmotive Corp. About 175 conversions were performed before the program was terminated in 1969.

The Convair 580 accommodates three crewmembers or four crewmembers and up to 44 passengers in the 340 model conversion or up to 52 passengers in the 440 model conversion.

Standard maximum takeoff weight is 54,600 pounds (24,767 kilograms). Optional maximum takeoff weight is 58,140 pounds (26,372 kilograms). Maximum landing weight is 52,000 pounds (23,587 kilograms).

Rate of climb at 5,000 feet is 2,050 feet per minute. Cruising speed at 20,000 feet is 297 knots. Single-engine ceiling is 14,500 feet. Maximum range with fuel reserves is 2,490 nautical miles (4,611 kilometers).♦

Sources: *Jane's All the World's Aircraft* and *The Encyclopedia of Civil Aircraft*.

Pilots seated in the cockpit can see the leading edges of the wings but not the leading edges of the horizontal stabilizer or vertical stabilizer.

"Pilots reported that, with the hot engine bleed air having to travel further to heat the leading edges on the tailplane, the tailplane anti-icing temperature reading on the gauges took longer to rise than [the temperature readings] for the main wings," the report said. "Therefore, any ice formed on the tailplane took longer to dislodge, compared to that on the main wings."

The flight crew was conducting the first leg of two scheduled flights between Christchurch [on South Island] and Palmerston North [on North Island].

The captain, 58, had an airline transport pilot license, several type ratings and 16,928 flight hours, including 3,286 flight hours in type.

"The captain joined the operator in November 1995 and obtained his command in August 1998," the report said. "At the time of the accident, he held the position of operations manager and also performed the duties of line instructor. He was based in Christchurch and mainly flew the Christchurch–Palmerston North–Christchurch route twice nightly, two or three nights a week."

The copilot, 50, had a commercial pilot license, several type ratings and 20,148 flight hours, including 194 flight hours in type.

"The copilot joined the operator in April 2003 and completed his type rating on the Convair 580 on 11 May 2003," the report said. "He was approved for line operations on 28 August 2003, having completed his instrument rating renewal, six-month competency check, route check and biennial flight review.

"The copilot was normally based in Auckland but had moved to Christchurch for about 10 days to provide temporary cover for another pilot who had taken leave. He had flown the Christchurch–Palmerston North–Christchurch route on the previous Monday and Wednesday nights [i.e., Sept. 29, 2003, and Oct. 1, 2003]."

The pilots arrived at the Christchurch airport about 1915 and checked loading details, weather conditions along the route and notices for the flight.

"The cargo manifest indicated that most of the cargo consisted of small parcels, including courier packs and the like," the report said. "No dangerous or combustible cargo was recorded as being carried on the flight to Palmerston North."

Investigators determined that the aircraft was within weight-and-balance limits. The cargo was in 11 cargons (almost fully enclosed aluminum pallets with canvas access panels) that were loaded and fastened on rails on the aircraft's floor.

"The load occupied the total cargo floor space of the aircraft," the report said. "A cargo net was fitted forward of the cargons to stop any freight [from] entering the forward area of the aircraft."

The aircraft had fuel for three hours of flying, which was sufficient to fly from Christchurch to Palmerston North, complete an instrument approach and return to Christchurch.

Weather conditions over North Island were affected by an occluded front preceded by a very strong and moist northerly flow. A briefing package prepared for the flight crew included the 1800 aviation routine weather report (METAR) for Palmerston North, which included surface winds from 320 degrees to 030 degrees at six knots, 15 kilometers (nine statute miles) visibility with showers in the vicinity of the airport, scattered clouds at 4,000 feet and a broken ceiling at 9,000 feet. The 1800 METAR for Wellington, which is on the southern tip of North Island, included surface winds from 350 degrees at 27 knots, gusting to 41 knots, visibility of 4,000 meters (2.5 statute miles), and a broken ceiling at 1,500 feet.

The crew's briefing package included significant meteorological reports (SIGMETs) of forecasts of isolated severe icing between 9,000 feet (the freezing level) and 21,000 feet, and occasional severe turbulence below 18,000 feet.

The aircraft departed from Christchurch on schedule at 2032. The captain was the pilot flying. At 2108 — soon after the aircraft crossed over Cook Strait [which divides the two main islands] at Flight Level (FL) 210 (approximately 21,000 feet) — the copilot requested clearance from Wellington Control to fly directly to the Paraparaumu nondirectional beacon (NDB). [Paraparaumu is about 80 kilometers (43 nautical miles) southwest of Palmerston North.]

"The change in routing was common industry practice and offered a shorter distance and flight time with no safety penalty," the report said.

The Wellington controller approved the request and told the crew to descend to FL 130. At 2122, the controller told the crew to descend to 11,000 feet.

Recorded air traffic services (ATS) radar data showed that the aircraft was flown over the Paraparaumu NDB at 2125. The aircraft was descending through 14,800 feet at about 1,500 feet per minute; groundspeed was between 247 knots and 251 knots.

The Wellington controller told the crew to establish radio communication with Ohakea Control.

The copilot told Ohakea Control that they were conducting a descent to 11,000 feet. The Ohakea controller told the crew to continue the descent to 7,000 feet. The controller also issued route instructions and an altimeter setting for Palmerston North. The copilot read back the route instructions but not the altimeter setting.

During this time, the descent was stopped and the aircraft was flown level at 14,400 feet for about 14 seconds. Indicated airspeed decreased to about 200 knots. Data recorded by the flight data recorder (FDR) indicated that moderate turbulence had been encountered during the descent.

"The captain may have wished to slow the aircraft to reduce the effects of that turbulence," the report said. "The content and demeanor of the copilot's transmission to Ohakea Control indicated nothing untoward with either the aircraft or the conditions being encountered as the aircraft [was] leveled."

The Ohakea controller observed on his radar screen a loss of data from the aircraft's transponder. The report said that a buildup of ice on the transponder antenna likely obstructed transmission of data to ATS.

"The controller wasn't initially concerned at the loss of transponder information as the copilot responded correctly to his instructions, the controller observed a good primary radar return with the aircraft's track continuing as expected and, although not common, a temporary loss of transponder signal did occur on occasion," the report said.

The Ohakea controller again issued the altimeter setting but received no response from the copilot. The controller observed the aircraft's primary radar target begin a left turn; the aircraft's target then disappeared from the controller's radar screen.

The report said that an ice-induced tail stall likely caused the aircraft to enter a nose-down pitch attitude of about 70 degrees and descend rapidly in a spiral dive. The aircraft was descending through 9,000 feet at about 345 knots when the cockpit voice recorder (CVR) recorded a terrain awareness and warning system (TAWS) warning — "bank angle, bank angle" — indicating that the aircraft was banked more than 50 degrees.

The last data recorded by the FDR five seconds later showed that the aircraft was descending through 6,800 feet at 392 knots with a vertical acceleration of 3.21 g (i.e., 3.21 times standard gravitational acceleration). The report said that the aircraft's never-exceed speed (V_{NE}) was about 313 knots at that altitude and maximum load limit was 2.94 g.

"That the FDR stopped recording at 6,800 feet suggests that this was about the time [when the] wings, and possibly the engines also, started to separate and electrical power was affected," the report said.

The aircraft was in a near-vertical descent when it struck the water at about 400 knots.

After making several unanswered radio transmissions to the crew, the Ohakea controller telephoned police, and a search was begun. Search efforts were hindered by adverse weather conditions, adverse sea conditions and the absence of accurate data on the possible accident site.

"Within an hour of the aircraft disappearing from the radar, some debris, later identified as coming from [the accident aircraft], was found washed ashore along Paraparaumu Beach," the report said. "Later in the evening, an aerial search by a Royal New Zealand Air Force helicopter using night vision devices and a sea search by local coast guard vessels located further debris offshore.

"After an extensive underwater search lasting nearly a week, aircraft wreckage identified as being from [the accident aircraft] was located [under 35 meters (115 feet) of water]. … Police divers recovered the bodies of the two pilots on 11 October and 15 October. … About 15 percent of the freight was recovered, with the rest being either lost or destroyed."

Investigators found no sign of a pre-impact explosion or fire. Examination of the engines and propellers indicated that they were operating normally on impact.

"Although there was no evidence to support the possibility of a mechanical failure or other catastrophic event contributing to the accident, given the level of destruction [of the aircraft] and that some sections of the aircraft were not recovered, these possibilities cannot be fully ruled out," the report said.

Post-mortem examinations of the pilots indicated that they sustained extreme trauma injuries.

"The examinations also identified numerous fractures of the forearms and lower legs, suggesting [that] the pilots were conscious and operating the controls of the aircraft at the time of impact," the report said. "No toxicology tests were completed due to the nature of the injuries. There was no evidence of pilot fatigue or other medical or personal factors that might have contributed to the accident."

On the day of the accident, Meteorological Service of New Zealand (MetService) received several pilot reports, including a report of moderate-to-severe turbulence and a report of severe icing in the area of the accident. Both reports were based on encounters with the weather conditions about one hour and 45 minutes before the accident occurred. MetService received the pilot report of severe icing after the accident occurred.

"[During the investigation,] MetService expressed concern at a general lack of reports being made by pilots immediately after encounters with hazardous meteorological conditions," the report said. "The CAA AIP [*Aeronautical Information Publication*] informed pilots that: 'When hazardous conditions are encountered which, in the opinion of the pilot are, or may become severe enough to warrant a SIGMET, an AIREP (air report) should be made to the nearest ATS unit immediately.'"

The report said that this wording might cause pilots to believe that a hazardous weather condition should be reported to ATS only if the condition is not already the subject of a SIGMET.

"This was clearly not the intention," the report said. "Rather, pilots should make an AIREP regardless of the SIGMET status to help reinforce everyone's general appreciation of the current weather conditions."

MetService told investigators that it typically receives an AIREP within 15 minutes of its transmission to ATS and that an AIREP of severe icing would prompt the issuance of a new SIGMET that severe icing had been forecast and had been observed.

"The presence of severe icing, while forecastable with some accuracy, can only be confirmed when actually encountered," the report said. "Reports of actual icing encounters, as well as other weather phenomena, can therefore also play a significant role in helping to alert pilots to potentially hazardous conditions and allow them to take appropriate avoiding action."

Divers retrieved the aircraft's CVR and FDR seven days after the accident. The recorded data were processed by the Australian Transport Safety Bureau. Although the CVR was in good condition, it had recorded only radio transmissions and some background cockpit sounds; no intercom communications between the pilots were recorded.

"The lack of any pilot intercom or cockpit recordings on the CVR limited the investigation and may have prevented an early and exact determination of the causes of the accident," the report said.

The aircraft's maintenance schedule required that the CVR be checked every 125 flight hours. A maintenance check of the CVR had been performed 36 flight hours before the accident occurred.

The report described the required CVR maintenance check procedures as follows: "The check called for a headset to be plugged into the CVR monitor in the cockpit overhead panel. A VHF [very-high-frequency] radio transmission was then made on the captain's audio selector, which should be heard through the CVR monitor [headset]. The exercise was then to be repeated for the copilot's audio selector. To test the area microphone, a short phrase was to be spoken about one meter [three feet] from the microphone, which should also be heard through the CVR monitor headset."

The failure of the maintenance check to detect the CVR's recording faults indicated that the procedure might be inadequate and should be reviewed, the report said.

New Zealand Civil Aviation Regulations (CARs) are similar to U.S. Federal Aviation Regulations (FARs) in requiring FDRs to record various parameters; the number of parameters is based primarily on the date of manufacture of the aircraft in which the FDR is installed.

The FDR in the accident aircraft was required by the CARs to record six parameters (time, altitude, airspeed, vertical

acceleration, heading and the time at which a radio transmission is made or received). The report said that FDRs in Convair 580s registered in Canada are required to record 11 parameters — the six parameters previously discussed plus pitch attitude, roll attitude, longitudinal acceleration, control-column position or pitch-control-surface position, and engine thrust.

"Had the next level of FDR been installed [in the accident aircraft], a more efficient and effective investigation would have possibly been achieved," the report said. "The availability of aircraft attitude, longitudinal [acceleration] and control-column information could have greatly assisted the analysis of the aircraft's flight path as it approached and entered the spiral dive."

The report said that two weather-related accidents and a Ministerial Inquiry in 1998 prompted CAA to commission an independent report on icing hazards in New Zealand. The independent report, *New Zealand Aircraft Icing Hazards*, recommended that:

- "An icing education program for pilots be developed;
- "Pilot licensing syllabuses be amended to include greater reference to icing;
- "All company operations manuals be reviewed with regard to their icing [information] content;
- "Improvements to icing forecasting be investigated; [and,]
- "Certification requirements for IFR [instrument flight rules] and night-freight operations be reviewed."

In response to the recommendations, CAA in 2000 made available on its Internet site [www.caa.govt.nz] the *Aircraft Icing Handbook*; published articles on icing in its bimonthly safety magazine, *Vector*; published a video presentation on icing; revised the licensing syllabuses for private pilots, commercial pilots and air transport pilots to include greater emphasis on icing; and required review of the operations manuals for CARs Part 135 (*Operations — Helicopters and Small Aeroplanes*) operators.

"In the case of Part 121 [*Air Operations — Large Aeroplanes*] operators and Part 125 [*Air Operations — Medium Aeroplanes*] operators, a specific review was not seen as necessary as this was already routinely dealt with as a key certification requirement and was well entrenched in the airline environment," the report said.

CAA and MetService discussed icing-forecast improvements.

"The CAA subsequently determined that MetService was continually striving to improve forecasting via technological advancements, and no further prompting was required," the report said.

CAA reviewed the certification requirements for IFR operations and night-freight operations, and found them to be adequate; nevertheless, CAA found that revisions to pilot-training requirements were necessary to address aircraft ice-protection equipment and its capabilities.

"This action had not been completed at the time of this accident," the report said.

Based on the findings of the accident investigation, TAIC in August 2004 made the following recommendations to CAA:

- "Use this report to re-emphasize to pilots and operators the hazards of icing, in particular tailplane icing and freezing rain."

  CAA accepted the recommendation and said that an article emphasizing the hazards of airframe icing would be published in the December 2004 issue of *Vector*.

- "Educate pilots on the benefits of transmitting AIREPs and amend the AIP to better reflect the objectives of the AIREP."

  CAA accepted the recommendation and said that the AIP would be revised "to advise pilots to make air reports on weather that they encounter which is severe enough to warrant a SIGMET regardless of whether a SIGMET has been previously issued." CAA said that an article on the topic would be published in the February 2005 issue of *Vector*.

- "Ensure that, in addition to the current installation and operating requirements, all CVRs and FDRs are periodically interrogated to ratify the content and quality of the information recorded."

  CAA did not accept the recommendation and said that "the current rule is adequate." Nevertheless, CAA said that it would "review Convair CVR and FDR modification, installation and maintenance instructions in conjunction with the design-data holder to ensure that instructions for continued airworthiness meet rule requirements."

- "Complete the recommendations of the independent report, *New Zealand Aircraft Icing Hazards*; in particular:

  – "Ensure [that] all IFR operators provide adequate written guidance for operations in adverse or hazardous weather conditions;

  – "Audit air operators to ensure that they have clear and unambiguous procedures for avoiding not only turbulence and thunderstorms, but also severe icing conditions; and,

– "Ensure [that] pilot training requirements for inadvertent flight into hazardous meteorological conditions are adequately defined for commercial operations under [CARs] Parts 121, 125 and 135."

CAA accepted the recommendation and said that it would "amend the airline audit procedures checklist to ensure that operators' manuals provide adequate written guidance for operations in adverse or hazardous weather conditions." CAA said that it also would "ensure that an advisory circular is written for all IFR and night freight operators [to] specify what the training specifications are for hazardous meteorological conditions."

- "Draft an amendment to the [CARs] upgrading the standard of recorders carried on board New Zealand registered aircraft to a minimum of an 11-parameter-capable FDR and a [technical standard order] TSO-C123a-compliant CVR without reducing any higher standard already contained in [CARs]."

  CAA did not accept the recommendation and said that it would continue to follow FAA [U.S. Federal Aviation Administration] standards for FDRs and CVRs.

TAIC made the following recommendations to the managing director of Air Freight New Zealand:

- "As a matter of urgency, inspect [the company's] fleet of Convair 580 aircraft to ensure [that] the [CVRs] are correctly installed and are functioning as required."

  The managing director said that the company's CVRs comply with CAA requirements and that the company decided to replace the metallic-tape-type CVRs in its Convair fleet with more modern solid-state CVRs.

- "Review and update company manuals and procedures to ensure [that] they are correct and provide the best available guidance for pilots to detect, avoid and escape from adverse or hazardous conditions."

  The managing director said that the company's policy and procedures manuals comply with CAA requirements and "reflect standard industry practice." The managing director said that the company conducted an internal review of its policies and procedures and would "liaise with the New Zealand CAA to ensure that 'best practice' principles are applied and/or developed."♦

[FSF editorial note: This article, except where specifically noted, is based on New Zealand Transport Accident Investigation Commission Aviation Occurrence Report 03-006, *Convair 580, ZK-KFU, Loss of Control and In-flight Break-up, Kapiti Coast, 3 October 2003*. The 49-page report contains illustrations.]

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