NO. 94-013

FAIRCHILD SA-227-AC METROLINER III

ZK-NSW

28 NM NORTH-EAST OF PALMERSTON NORTH

30 MAY 1994

ABSTRACT

On the morning of 30 May 1994 a Fairchild Metroliner, ZK-NSW, while cruising at 17,000 feet, suffered a rapid de-pressurisation following the failure of the First Officer's cockpit side acrylic window. ZK-NSW subsequently diverted to Palmerston North Aerodrome and landed safely. The safety issues discussed are the adequacy of the inspection procedures for the detection of cracks in the acrylic window panels.

TRANSPORT ACCIDENT INVESTIGATION COMMISSION

AIRCRAFT ACCIDENT REPORT NO 94-013

Aircraft Type, Serial Number and Registration:	Fairchild SA-227-AC, Metroliner III, AC-508, ZK-NSW
Number and Type of Engines:	Two Garrett TPE-331-11U
Year of Manufacture:	1983
Date and Time:	30 May 1994, 0843 hours*
Location:	28 NM North-East of Palmerston North Latitude: 40°06'S Longitude: 176°11'E
Type of Flight:	Scheduled Air Transport
Persons on Board:	Crew: 2 Passengers: 9
Injuries:	Crew: 1 Minor Passengers: Nil
Nature of Damage:	Substantial
Pilot in Command's Licence:	Airline Transport Pilot Licence (Aeroplane)
Pilot in Command's Age:	50
Pilot in Command's Total Flying Experience:	14,534 hours 2,246 hours on type
Information Sources:	Transport Accident Investigation Commission field investigation
Investigator in Charge:	Mr K A Mathews

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

1. NARRATIVE

1.1 At 0814 hours on 30 May 1994, ZK-NSW departed Wellington International Airport as flight NZ 8546, on a scheduled flight to Gisborne. The flight was planned to route overhead Napier, and on board were a crew of two pilots and nine passengers. Earlier that morning ZK-NSW had been positioned at Wellington from Nelson.

1.2 The Captain was the handling pilot and a normal take-off was achieved. Following initial radar vectoring, the aircraft intercepted the 018° radial and proceeded to climb uneventfully to 17,000 feet, its assigned cruising altitude.

1.3 ZK-NSW was established in the cruise in VMC on top of an overcast cloud layer some 7,000 feet lower. The pilots noted that the aircraft's ground speed was 50 to 60 knots faster than expected due to a strong south-westerly flow. The normal checks, including a "trend" check, were completed. No abnormalities were evident and the aircraft was performing as expected.

1.4 Several minutes later there was a "loud bang" as the First Officer's acrylic cockpit side window shattered outwards without warning. This was followed immediately by loud wind blast and engine noises, and a mist formed briefly in the cockpit and rear of the cabin. The glareshield became dislodged and was pushed against the First Officer's neck and chest. His head-set was torn from his head and was sucked out the window along with his oxygen mask, hand-held microphone, charts, and various paper items.

1.5 The Captain, unable to communicate by interphone with the First Officer, determined that the aircraft was still controllable but had lost pressurisation. He declared an emergency by transmitting a distress message to Ohakea Control and initiated a rapid descent. He turned the aircraft left off track during the descent, followed by a right turn towards Palmerston North Aerodrome which he determined to be the most suitable aerodrome for an emergency landing.

1.6 Because of the wind blast and engine noises through the broken window the Captain had difficulty receiving communication by radio from Air Traffic Control, but from intermittent messages received he knew that they were aware of the emergency situation and his intentions.

1.7 The Captain descended ZK-NSW rapidly to 11,100 feet where he levelled the aircraft in order to remain in VMC on top of the overcast cloud layer. He was able to take stock of the situation at this point and assess the First Officer's injuries which were found to be minor. Despite the noise and the Captain's difficulty of communicating with the First Officer, the First Officer was able to assist the Captain and reassure the passengers.

1.8 The Captain slowed the aircraft to 140 knots which reduced the noise to a level enabling him to communicate more effectively by radio with Air Traffic Control. He was able to update them on the situation and he downgraded the emergency from distress to urgency and continued towards Palmerston North Aerodrome.

1.9 Clearance was received from Ohakea Control for further descent and for the VOR approach to runway 25 at Palmerston North. ZK-NSW was cleared to land by Palmerston North Tower and landed safely at 0906 hours.

1.10 Prior to the landing the Police were advised of the situation by Palmerston North Control Tower, and deployed personnel to the aerodrome to provide a victim support role to the passengers. The First Officer was taken to Palmerston North Hospital where he received treatment for minor cuts, abrasions and bruising.

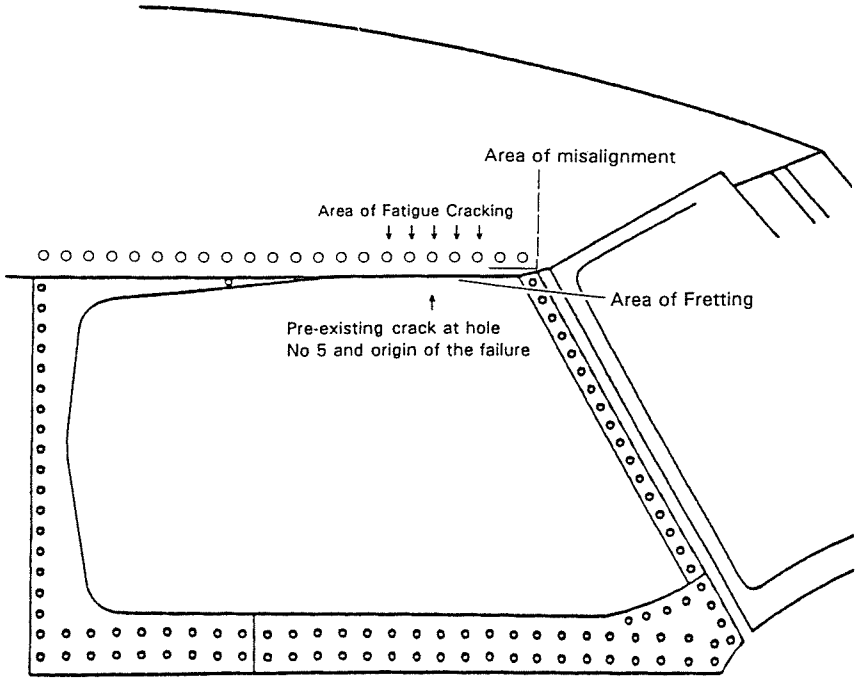
1.11 Although the Captain had downgraded the emergency from distress to urgency, the emergency services were maintained at full readiness due to the reported injuries to the First Officer.

1.12 Subsequent inspection of the aircraft revealed that the First Officer's acrylic side window panel had failed and separated from the aircraft under normal pressurisation loading. The window had separated from the aircraft except for its entire outer edging which remained attached to the aircraft by its retaining screws.

1.13 Further inspection showed that a piece, or pieces, of the acrylic side window panel, and some items from the cockpit, had passed through the right propeller and damaged three of its four blades. One blade had a piece (measuring approximately 18 mm by 12 mm) missing from its tip at the leading edge. Another blade received some gouging and nicking adjacent to its tip, and tearing around its electric de-icing boot. The third blade received tearing around its electric de-icing boot and a piece of acrylic was found embedded in the boot. The fuselage and four passenger windows adjacent to the right engine and rearwards of the First Officer's window, had been "peppered" with fragments from the acrylic window as they were thrown from the propeller. An examination of the engine showed no evidence of injestion of debris.

1.14 At the time of the failure the airframe of ZK-NSW had accumulated 10,703 flying hours and 17,168 pressurisation cycles.[1] The acrylic window panel, part number 26-21383-006, was the original fitted to the aircraft at manufacture and had not been removed or replaced.

1.15 The outer edge of the acrylic side panel which remained in the aircraft was removed and sent to Industrial Research Ltd for analysis. Examination showed that a pre-existing crack at the fifth fastener hole on the top edge of the panel, numbered rearwards from the front edge, had existed from the time of the installation of the panel. The crack was 6 mm in length, and extended from the outside face in to a depth of 3 mm. The panel was 6.35 mm thick. The original window sealant which was green in colour could be seen adhering to the remaining face of the crack. Further examination revealed that the last failure originated at that crack, and the crack had propagated outwards from the fastener hole to a critical length of about 15 cm, from hole number three to midway between hole number eight and hole number nine, before failure occurred. (See diagram).



1 A cycle is the result of pressurising and de-pressurising the cabin once.

1.16 Examination also showed that a series of small fatigue cracks, up to 6 mm in length, had developed at holes 3, 4, 5, 6 and 7. These cracks had propagated slowly during the life of the panel to about 6 mm, and then rapidly within about 100 cycles to the combined critical length of 15 cm. It is most likely that the cracks originating at hole number five propagated and ran over the top of fatigue arcs found at holes 3, 4, 6 and 7. Additionally, there was evidence of heavy fretting between the fuselage and the acrylic panel adjacent to fastener holes 3, 4 and 5. (See diagram).

1.17 An AD (Airworthiness Directive) issued by the US FAA in 1988 was in force for all US registered Fairchild Metroliner III SA-227-AC series aircraft. This AD was issued following several in-flight failures of the cockpit and cabin windows which had resulted in injuries to crew members and passengers. An equivalent NZ CAA AD, AD DCA/SA226/17, issued in March 1989 called for all New Zealand registered Metroliners to be inspected in accordance with the requirements of the FAA AD. This directive called for the mandatory inspection of the cockpit acrylic side window panels and the passenger cabin windows for cracking, as detailed in a Fairchild Aircraft Corporation Service Bulletin issued in September 1984. The directive required the inspection to be carried out within 50 hours time-in-service (TIS) after the effective date of the AD, unless already accomplished within the last 2,500 hours TIS, and thereafter at intervals not exceeding 2,500 hours TIS or 12 calendar months, whichever occurred first.

1.18 These ADs were revised by the US FAA and the NZ CAA (AD DCA/SA226/17A) in 1993 which reduced the flight time requirement from 2,500 hours to 1,000 hours. Several further acrylic window failures that occurred within the inspection intervals called for in the original AD's prompted this action.

1.19 ZK-NSW had been inspected correctly in accordance with the requirements of the AD's and its last inspection had been carried out on 5 April 1994 and 232 hours prior to the failure of the window. The inspection was carried out by a licensed Aircraft Maintenance Engineer who was familiar with the requirements of the AD and the inspection procedures. He had carried out a number of these inspections in the past. During the last inspection he detected no cracks although subsequent investigation revealed that a number were present at the time of the inspection.

1.20 The Service Bulletin to which the AD referred prescribed the procedure to be used when inspecting the window panels for cracks in the vicinity of the retaining holes, and called for the use of a 45° acrylic reflecting prism. The Service Bulletin did not require the removal of the panels and called for the inspection to be carried out from the outside of the window. Any cracks would appear as a frosty or reflective irregular surface. If any were found then their extent would determine whether the panel required immediate replacement, or whether the aircraft could be flown unpressurised with certain restrictions imposed until replacement could be effected.

1.21 Investigation showed that a total of nine similar in-flight failures had occurred in Metroliner 226 and 227 series aircraft throughout the world. In each case the failure had initiated in the top forward area of the panel. The two most recent in-flight failures occurred in Australia in October 1993 and in the United States in March 1994. The aircraft had flown 180 hours and 126 hours respectively since inspection of their windows using the procedures detailed in the Service Bulletin, and no cracks were detected. The Metroliner aircraft would reach their maximum cabin pressure differential of 7 psi at 16,800 feet and all the failures had occurred at 17,000 feet or greater. The average number of cycles until failure was around 19,000.

1.22 The failure to detect any cracks during earlier inspections of the Metroliner aircraft indicated that the inspection procedures called for in the Fairchild Service Bulletin were inadequate.

1.23 During installation of a replacement acrylic window in ZK-NSW it was discovered that the sections of the fuselage to which the window was to be fastened did not align to provide uniform

support to the acrylic panel. The upper forward window side post frame did not align with the fuselage inner window frame at the top of the window, leaving a mismatch of some 6 mm. Further investigation revealed that the mismatch was a design error. When the panel was fastened into position by the retaining screws the misalignment caused a bending stress to be set up in the panel's top forward corner and the panel broke. The panel, as supplied, was shaped to conform with the contour of the aircraft's fuselage. The maintenance manual did not include any warnings regarding pre-stressing of window panels during fitment. To rectify the misalignment Fairchild advised that a tapered spacer should be made and used as a packer. Alternatively PRC 1422 sealant could be used and allowed to harden before the retaining screws were tightened.

1.24 Investigation showed that this misalignment had existed when ZK-NSW was first manufactured and when its acrylic panel was installed. The window panel was therefore pre-stressed in the area of the subsequent failure, from installation. It is probable that this pre-stressing, in conjunction with the normal pressurisation cycles, eventually caused the pre-existing crack to propagate and the fatigue cracks to form at holes 3, 4, 6 and 7.

1.25 Both pilots of ZK-NSW were appropriately licensed and authorised to carry out the flight. On 28 May 1994 the Captain had completed a Civil Aviation Regulation 76 check which had included a check of the actions to be taken in the event of a rapid depressurisation.

1.26 An aftercast of the weather conditions prevailing at the time showed that a strong south-westerly airstream flowed over New Zealand with a number of bands of cloud that were moving quickly north-east in the airstream. The cloud tops were generally less than 10,000 feet, and the 17,000 foot wind was 250° true at 75 knots. The temperature was minus 18°C.

The 0900 hours METAR for Palmerston North Aerodrome included:

Wind:	300°m at 19 knots gusting to 32 knots
Visibility:	30 km
Cloud:	1 octa at 1700 feet, 5 octas at 2400 feet and 7 octas at 3200 feet
Temperature:	+14°c
QNH:	1011 hPa

The Palmerston North Aerodrome 0915 hours ATIS included:

Wind:	280°m at 15 to 20 knots
Visibility:	20 km reducing to 10 km in passing showers
Cloud:	7 octas at 1600 feet
Temperature:	+14°C
QNH:	1010 hPa

2. FINDINGS

2.1 ZK-NSW had a valid Certificate of Airworthiness and Maintenance release.

2.2 ZK-NSW had been maintained correctly.

2.3 The crew were appropriately qualified and licensed to conduct the flight.

2.4 The failure of the First Officer's acrylic side window caused a rapid loss of cabin pressurisation.

2.5 The crew handled the emergency appropriately.

2.6 Previous inspections of the window panel failed to detect existing cracks.

2.7 The inspection procedures called for in the Fairchild Service Bulletin for the detection of cracks in the acrylic window panels were inadequate.

2.8 The failure of the side window panel resulted from stress fatigue caused by the combination of an airframe design fault causing stress to be set up in the top forward corner of the window panel, plus the normal pressurisation cycles of the aircraft. A pre-existing crack, the rapid propagation of the cracks within the inspection cycles, and the inadequacy of the inspection procedures were contributing factors.

3. SAFETY ACTIONS

3.1 On 31 May 1994 the Civil Aviation Authority issued a Defect Alert Notice to all New Zealand operators of the Fairchild Metroliner SA-227-AC series aircraft, as follows:

"FAIRCHILD METRO COCKPIT SIDE WINDOW

The CAA in association with the Transport Accident Investigation Commission is investigating an accident involving a Fairchild SA227-AC Metro aircraft where the right cockpit side window separated during cruise at 17,000 feet. This resulted in a sudden decompression and injuries to the co-pilot.

Initial investigation indicates the failure was a result of a pre-existing defect originating from a fastener hole. This defect appears to have occurred during installation of the window at manufacture and resulted in a fatigue fracture of approximately 150 mm until complete failure.

The defect had not been detected during earlier inspections, per Airworthiness Directive DCA/SA226/17, 230 hours previously. An attempt is being made to establish the crack propagation rate, but in the meantime operators of Fairchild Metro aircraft are strongly recommended to perform a detailed inspection of cockpit side windows in accordance with the AD as soon as possible, preferably before further flight.

Investigation is continuing and further action may be taken. Please report any defects found to the CAA."

3.2 Following discussions with the Civil Aviation Authority, Fairchild Aircraft Incorporated and the operator, the following further actions were decided:

That the CAA would: (1) issue a revised AD, AD DCA/SA226/17B, as per paragraph 3.3; (2) liaise with the US FAA on the recommendations following the conclusion of the investigation.

That the Fairchild Aircraft company would: (1) explore alternative inspection methods, such as ultrasonic testing; (2) amend their maintenance manual procedures to improve the inspection and fitment of cockpit side windows and include specific warnings on fitment and pre-stressing of the window panel; (3) as a long term solution, look at redesigning the cockpit side windows to prevent recurrence. Fairchild did advise however that current production models of the Metroliner aircraft were being produced with double side cockpit pressure windows installed.

That the operator would: (1) institute an immediate inspection programme for all Fairchild Metroliner aircraft cockpit side windows; (2) carry out an immediate assessment of aircraft with a similar or longer service life to ZK-NSW; (3) restrict Metroliner aircraft cabin pressurisation to a maximum of 5 psi for those aircraft with similar or greater flight cycles to ZK-NSW; (4) immediately begin a maintenance programme to remove all Metroliner aircraft cockpit side windows for inspection. All windows that exceeded 10,000 flight cycles would be replaced, and windows with lower flight cycles would be inspected and replaced or refitted as appropriate.

3.3 The Civil Aviation Authority issued an Airworthiness Directive, DCA/SA226/17B, effective 5 August 1994, to all New Zealand operators of the Fairchild Metroliner series aircraft, as follows:

"AIRWORTHINESS DIRECTIVE

DCA/SA 226/17B Cockpit and Cabin Windows—Inspection

Applicability: All model SA266-T, SA266-T(B), and SA226-TC also all model SA227-TT, SA227-AC and SA227-AT.

Requirement: To prevent possible failure of cockpit and cabin windows, accomplish the following:

1. Visually inspect:-
   (a) All cabin windows per Fairchild SB 226-56-002 revised 29 May 1992, or 227-56-002 revised 1 April 1993, as applicable.
   (b) All cockpit windows per Fairchild SB 226-56-003 revised 2 November 1989, or 227-56-003 revised 2 November 1989, as applicable. Pay particular attention to the upper forward corner fastener holes.

   Windows with cracks which exceed 4.3" in combined total length, must be renewed before further flight.

   Windows with cracks which do not exceed 4.3" in combined total length may continue in service subject to:-
   (i) Cracked window is re-inspected for crack growth at intervals not exceeding 30 calendar days.
   (ii) Operating limitation placard affixed to instrument panel as near as possible to pressurisation controls in clear view of pilot, which states in letters at least 0.10" high.

   'AIRCRAFT MUST BE OPERATED UNPRESSURISED'
2. Remove cockpit side windows.
   (a) Inspect windows for burrs, cracks, fretting or any other damage using a 10 times magnifying glass. If any damage is found, replace window before further flight.
   (b) Inspect fastener hole plastic bushes for any evidence of damage and replace bushes as necessary. Smooth window exterior edges.
   (c) Install window without pre-stress per Fairchild MM, and allow sealant to set before tightening screws.

Compliance: 1.

(a) Inspect cabin windows at intervals not exceeding 1000 hours TIS or every 12 calendar months, whichever occurs first.

(b) Inspect cockpit windows at intervals not exceeding 1000 flight cycles or every 12 calendar months, whichever occurs first.

For cockpit windows with greater than 10,000 flight cycles that have not been removed and inspected per part 2 of this requirement, inspect at either:-

Intervals not exceeding 100 flight cycles, or at intervals not exceeding 200 flight cycles if maximum cabin pressure differential is limited to 5 psi.

2. Remove cockpit side windows at 10,000 flight cycles or within next 1600 flight cycles, whichever is the later, unless already accomplished.

Effective Date: DCA/SA266/17A 24 December 1993

DCA/SA226/17B 5 August 1994"

3.4 In view of the above actions taken, the Transport Accident Investigation Commission has no recommendations to make.

12 October 1994

M F Dunphy
Chief Commissioner

ABBREVIATIONS COMMONLY USED IN TAIC REPORTS

AD	Airworthiness Directive
ADF	Automatic direction-finding equipment
agl	Above ground level
AI	Attitude indicator
AIC	Aeronautical Information Circular
AIP	Aeronatical Information Publication
amsl	Above mean sea level
ASI	Airspeed indicator
ATA	Actual time of arrival
ATC	Air Traffic Control
ATD	Actual time of departure
ATIS	Automatic terminal information service
ATPL (A or H)	Airline Transport Pilot Licence (Aeroplane or Helicopter)
AUW	All-up weight
C	Celsius
CAA	Civil Aviation Authority
CASO	Civil Aviation Safety Order
CFI	Chief Flying Instructor
cm	Centimetres
CPL (A or H)	Commercial Pilot Licence (Aeroplane or Helicopter)
DME	Distance measuring equipment
E	East
ELT	Emergency location transmitter
ERC	En route chart
ETA	Estimated time of arrival
ETD	Estimated time of departure
F	Fahrenheit
FAA	Federal Aviation Administration (United States)
FL	Flight level
g	Acceleration due to gravity
GPS	Global Positioning System
HF	High frequency
hPa	Hectopascals
IAS	Indicated airspeed
IGE	In ground effect
IFR	Instrument Flight Rules
ILS	Instrument landing system
IMC	Instrument meteorological conditions
ins Hg	Inches of mercury
kHz	Kilohertz
KIAS	Knots indicated airspeed
km	Kilometres
kt	Knot(s)

LF	Low frequency
LLZ	Localiser
M	Mach number (e.g. M1.2)
M	Magnetic
MAANZ	Microlight Aircraft Association of New Zealand
MAP	Manifold absolute pressure (measured in inches of mercury)
MAUW	Maximum all-up weight
METAR	Aviation routine weather report (in aeronautical meteorological code)
MF	Medium frequency
MHz	Megahertz
mm	Millimetres
mph	Miles per hour
N	North
NDB	Non-directional radio beacon
NOTAM	Notice to Airmen
nm	Nautical mile
NZ	New Zealand
NZAACA	New Zealand Amateur Aircraft Constructors Association
NZGA	New Zealand Gliding Association
NZHGPA	New Zealand Hang Gliding and Paragliding Association
NZMS	New Zealand Mapping Service map series number
NZDT	New Zealand daylight time (UTC + 13 hours)
NZST	New Zealand standard time (UTC + 12 hours)
NTSB	National Transportation Safety Board (United States)
octa	Eighths of sky cloud cover (eg: 5 octas = 5/8 of cloud cover)
OGE	Out of ground effect
PAR	Precision approach radar
PIC	Pilot in command
PPL (A or H)	Private Pilot Licence (Aeroplane or Helicopter)
psi	Pounds per square inch
QFE	An altimeter subscale setting to obtain height above aerodrome
QNH	An altimeter subscale setting to obtain elevation above mean sea level
RNZAC	Royal New Zealand Aero Club
RNZAF	Royal New Zealand Air Force
rpm	Revolutions per minute
RTF	Radio telephone or radio telephony
S	South
SAR	Search and Rescue
SSR	Secondary surveillance radar
T	True
TACAN	Tactical Air Navigation aid
TAF	Terminal aerodrome forecast
TAS	True airspeed
TIS	Time-in-service
UHF	Ultra high frequency

US	United States
UTC	Coordinated Universal Time
VASIS	Visual approach slope indicator system
VFG	Visual Flight Guide
VFR	Visual flight rules
VHF	Very high frequency
VMC	Visual meteorological conditions
VOR	VHF omnidirectional radio range
VORTAC	VOR and TACAN combined
VTC	Visual terminal chart
W	West