Australian Government
Australian Transport Safety Bureau

ATSB TRANSPORT SAFETY INVESTIGATION REPORT

Aviation Occurrence Report – 200603438

Final

Smoke Event
Maroochydore, Qld
15 June 2006
VH-SEF
Fairchild Industries SA227-AC

Australian Government

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M7 Aerospace LP, for Figure 1

Abstract

On 15 June 2006 at approximately 1630 Eastern Standard Time, during a scheduled flight from Hervey Bay, Qld, to Brisbane, Qld, the crew of the Fairchild Industries SA227-AC (Metro III) aircraft, registered VH-SEF, noticed that the cabin temperature was colder than desired. After adjustment to the auto and manual cabin temperature controls, the cabin temperature increased to a higher than expected range and could not be reduced. Shortly after, smoke was seen coming from the right side cockpit air vents. The crew isolated the right bleed air system and diverted the aircraft to Maroochydore, Qld.

After examination of the aircraft's air-conditioning system, the right hot air mixing valve was replaced and the aircraft returned to service without further problem.

During the incident, the crew found that fitment of their emergency oxygen masks was ineffective, requiring them to hold the masks in place with one hand, and that the passenger address system was also ineffective in alerting the passengers to the emergency.

Only one minor injury in the form of sore ears was reported as a result of the incident.

As a result of this incident the Australian Civil Aviation Safety Authority issued an Airworthiness Bulletin to address maintenance aspects of flight crew oxygen masks.

THE AUSTRALIAN TRANSPORT SAFETY BUREAU

The Australian Transport Safety Bureau (ATSB) is an operationally independent multi-modal Bureau within the Australian Government Department of Infrastructure, Transport, Regional Development and Local Government. ATSB investigations are independent of regulatory, operator or other external bodies.

The ATSB is responsible for investigating accidents and other transport safety matters involving civil aviation, marine and rail operations in Australia that fall within Commonwealth jurisdiction, as well as participating in overseas investigations involving Australian registered aircraft and ships. A primary concern is the safety of commercial transport, with particular regard to fare-paying passenger operations.

The ATSB performs its functions in accordance with the provisions of the Transport Safety Investigation Act 2003 and Regulations and, where applicable, relevant international agreements.

Purpose of safety investigations

The object of a safety investigation is to enhance safety. To reduce safety-related risk, ATSB investigations determine and communicate the safety factors related to the transport safety matter being investigated.

It is not the object of an investigation to determine blame or liability. However, an investigation report must include factual material of sufficient weight to support the analysis and findings. At all times the ATSB endeavours to balance the use of material that could imply adverse comment with the need to properly explain what happened, and why, in a fair and unbiased manner.

Developing safety action

Central to the ATSB's investigation of transport safety matters is the early identification of safety issues in the transport environment. The ATSB prefers to encourage the relevant organisation(s) to proactively initiate safety action rather than release formal recommendations. However, depending on the level of risk associated with a safety issue and the extent of corrective action undertaken by the relevant organisation, a recommendation may be issued either during or at the end of an investigation.

The ATSB has decided that when safety recommendations are issued, they will focus on clearly describing the safety issue of concern, rather than providing instructions or opinions on the method of corrective action. As with equivalent overseas organisations, the ATSB has no power to implement its recommendations. It is a matter for the body to which an ATSB recommendation is directed (for example the relevant regulator in consultation with industry) to assess the costs and benefits of any particular means of addressing a safety issue.

About ATSB investigation reports: How investigation reports are organised and definitions of terms used in ATSB reports, such as safety factor, contributing safety factor and safety issue, are provided on the ATSB web site www.atsb.gov.au.

FACTUAL INFORMATION

History of the flight

On 15 June 2006 at approximately 1630 EST[1], during cruise at flight level (FL) 160 on a scheduled passenger flight from Hervey Bay to Brisbane, Qld, the crew of the Fairchild Industries SA227-AC (Metro III) aircraft, registered VH-SEF, noticed that the cockpit temperature was colder than desired. The aircraft was carrying two flight crew and nine passengers at the time.

The crew toggled the temperature mode selector switch to AUTO and rotated the temperature control dial to a warmer setting to obtain a more comfortable cabin temperature. Within a short time, warm air was felt from the outlets in the cockpit. Both crew noticed that the temperature rise had occurred faster than normal and was reaching a higher than expected range. The copilot, who was the pilot flying at the time, then turned the temperature control dial to the left 'full cold' position, to stop the temperature increase. The cabin temperature remained the same.

With the inability to decrease the temperature in AUTO mode, the copilot turned the mode selector from AUTO to COLD (manually closing the hot air mixing valves). After a brief time, the cabin temperature had not changed, so the pilot in command (PIC) elected to review the quick reference handbook (QRH). At that moment, the copilot noticed what he believed to be smoke coming from the right side cockpit vents and advised the PIC, who confirmed he could see the same.

On sighting the smoke, the crew commenced the appropriate non-normal checklist, donning their oxygen masks and established on-mask communications. Both crew found that the single straps on the oxygen masks were not sufficient to hold the masks in place and provide an adequate seal against their faces. As a result, the crew were required to hold the masks in place with one hand.

Control of the aircraft was given to the PIC, who called for passenger oxygen to be turned on. The PIC then contacted air traffic control (ATC) making a PAN[2] call. An emergency announcement, including the need to don oxygen masks, was given to the passengers through the cabin speakers. The passengers, however, did not react to the announcement.

As cabin pressurisation had not yet been turned off, and as the smoke in the cockpit had not increased, the copilot felt it was safe to leave the cockpit, to advise and assist the passengers. While he was in the cabin, some passengers commented on the high temperature experienced.

After all passengers had donned their oxygen masks and the copilot was seated back in the cockpit with his mask on, the aircraft's right bleed air switch was turned off, stopping further smoke ingress.

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1 The 24-hour clock is used in this report to describe the local time of day, Eastern Standard Time (EST), as particular events occurred. Eastern Standard Time was Coordinated Universal Time (UTC) +10 hours.

2 PAN – Radio code indicating uncertainty or alert, general broadcast to widest area but not yet at level of Mayday, *the Cambridge Aerospace Dictionary.*

While the copilot was assisting the passengers, the PIC again contacted ATC advising them of the smoke in the cockpit. ATC asked if the crew intended diverting to Maroochydore, to which he said they would. The PIC opted not to initiate an emergency descent at that time as the problem appeared to be isolated by the closing of the right bleed air valve. With both crew seated in the cockpit, the crew commenced the descent. At approximately FL110, the aircraft pressurisation was turned off, at which point the smoke cleared rapidly from the cockpit.

Passing over Maroochydore at 6,000 ft above ground level, the crew descended the aircraft for runway 18 (the descent rate became higher than normal just prior to landing). After taxiing to the bay, shut down checks were completed and passengers were allowed to disembark. The crew asked the passengers about injuries, to which only one female passenger advised she had sore ears, but that she had been a little congested prior to the flight.

Passenger communications

The aircraft passenger address (PA) system consisted of eight ceiling speakers for communication. These were positioned so that passengers were not more than one seat row away from a speaker. The pilot and copilot audio panels contained the capability for adjusting the audio output (volume) of these cabin speakers.

The crew commented that they did not believe the emergency brief to don oxygen masks had been heard by the passengers and that it was generally known throughout the company that communication with the passenger cabin was poor on the aircraft when the engines were operating. As a matter of routine, the PIC would conduct his pre-departure passenger briefs prior to starting the aircraft's engines.

Maintenance records showed that both the pilot and copilot audio panels were replaced three months prior to the incident. No further maintenance was recorded for the audio system until six days after the incident when the PA system was tested and adjusted.

Aircraft examination

An inspection of the right bleed air system, between the engine and areas of the right side of the cabin was conducted. No evidence of component damage or obvious signs of heat damage to underfloor ducting in the inspected areas was found. The right hot air mixing valve was suspected to have malfunctioned, failing in the full hot position. The valve was replaced and an engine ground run was carried out. A flight test was then conducted with no defects reported.

The right hot air mixing valve was sent to the Australian Transport Safety Bureau where it was examined. The valve was then tested at an approved overhaul facility. The valve was subjected to the manufacturer's test procedures and was found to meet the serviceability requirement with all tolerances and functions found to be within limits.

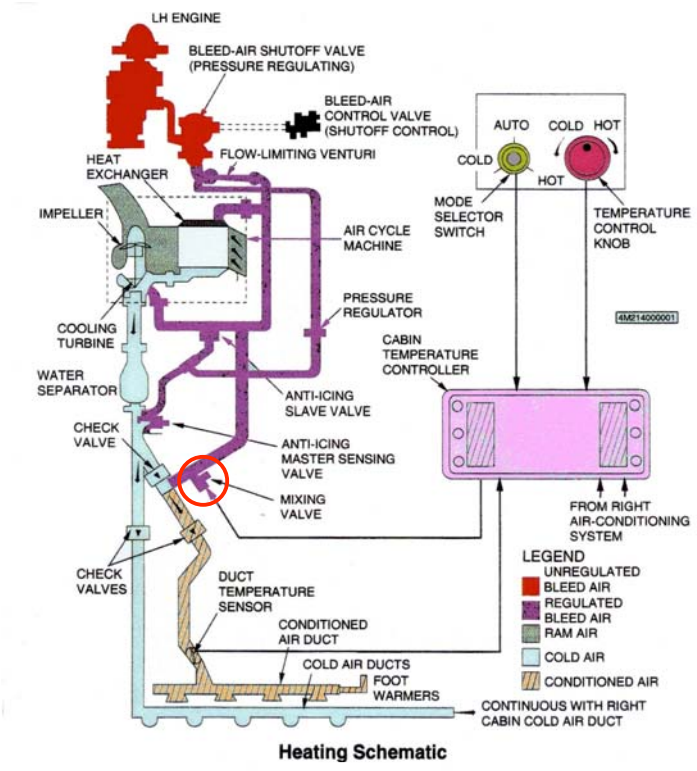
As a result of the right hot air valve test, further operational checks of the cabin temperature mode selector were carried out. No faults were found during those checks.

Aircraft temperature control system

The aircraft's two engines supplied independent bleed air to facilitate aircraft pressurisation and cabin heating and cooling. Each engine's bleed air was ducted to an Air Cycle Machine (ACM) for cooling and a hot air mixing valve. The correct ratio of hot and cold air was then mixed to provide the required cabin temperature and dispersed through outlets within the cabin and cockpit. A separate cold air duct ran directly from the left engine's ACM to the right engine's ACM. That provided cold air only through certain outlets in the cabin.

Control of the temperature was achieved through an electronic cabin temperature controller, which could be operated in AUTO or MANUAL modes through the mode select switch and temperature control knob. With the mode selector switch in AUTO, the controller modulated the hot air mixing valve of each engine between full open and full closed until the desired temperature setting (set on the control knob) was reached. With the mode selector switch set to the cold or hot positions, the cabin temperature controller modulated the hot air mixing valves to the full closed or full open position respectively (Figure 1).

Figure 1: Fairchild Industries SA227 Series Heating Schematic (left engine shown)



Heating Schematic

Aircraft oxygen masks

The aircraft was fitted with passenger and crew oxygen masks. The passenger oxygen masks were the clear 'medical' type that contained a re-breather bag. These masks were located under each passenger seat and required connection into the

emergency oxygen line receptacle located in the ceiling. These masks were of a constant flow design.

Crew oxygen masks were ‘on demand’ flow type, providing oxygen flow only when required through the ‘breathing in’ of the user. A positive seal against the user’s face was essential to ensure correct oxygen flow. These masks were of a natural rubber, oral-nasal face piece with a single (elastic) strap head harness design. To facilitate ‘quick donning’, the head harness contained an adjustable plastic strip that held the elastic strap open when the mask was primed (Figure 2).

Figure 2. Crew oxygen mask.

Strap in relaxed position (not Primed)

Strap in quick donning position (Primed)

Both crew members found that the elastic strap fitted to their masks was not tight enough to provide an adequate positive seal of the mask against their face, resulting in the need to physically hold the mask against their face to obtain effective oxygen flow.

A random check of these types of masks, fitted to another operator's aircraft also found that the elastic straps had been stretched to a point where the mask was no longer held tight on the user's head.

A review of the operations manual from multiple operators showed that the depth of check to be carried out on oxygen masks during the pre-flight checks varied considerably from a visual check of the pressure gauge only, to checking mask condition and flow through the mask at the first flight of the day. These checks however, were not consistent throughout all operators. Even where an operations manual stated 'Connect mask, adjust strap, check normal and 100% flow…' the operator agreed that it was often the practice of the crews to only check flow.

A review of the oxygen mask manufacturer's recommended maintenance practices indicated that the masks should be thoroughly inspected annually and, while the face piece assembly was an 'on condition'[3] item, replacement should not exceed five years. That document did not provide specific details on strap assembly examination or replacement requirements.

Maintenance records showed that the pilot's oxygen mask had been fitted to the aircraft approximately two weeks prior to the incident, having completed repair and testing at an overhaul facility. During that short period of time, the strap was able to reach a condition of ineffectiveness and unserviceability.

Aircraft history

The aircraft had spent a considerable amount of time (more than four months) out of service during the previous nine months, due to non related on-going maintenance problems. That included the period 1 April 2006 to 6 June 2006, when the aircraft was not flown. The aircraft had accumulated 11.2 operating hours over the 9 days prior to the incident.

Approximately 3 months and 244 operating hours after the incident, the aircraft was sold to another operator. During that delivery flight, it was observed that the passenger cabin was unusually noisy and very cold in the rear section. The flight crew found the cockpit was also cold, so adjusted the temperature control to high. Passing through the cabin from the back to the cockpit, one of the ferrying crew noticed that very hot air could be felt in an isolated region of the cabin's mid section.

Examination of the entire cabin underfloor area found that both the left and right underfloor ducting around the mid cabin region had deteriorated with significant tears and holes evident. Floor track trim strips adjacent to that area had also been warped by the concentration of heat distributed there. Following rectification of those defects, uniform cabin and cockpit temperature control was achieved and a reduction in ambient cabin noise was noticed.

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3 On condition - A primary maintenance process having repetitive inspections or test to determine the condition ... with regard serviceability. *Aviation Recommended Maintenance Interval Manual, AVOX Systems Inc.*

ANALYSIS

Cabin temperature

The cabin temperature control system was reported to operate normally after the aircraft's right hot air mixing valve was replaced. Independent testing of the right hot air mixing valve however, did not find any deficiencies that would suggest it had failed, nor did testing of the temperature control system reveal any component anomalies to explain the inability to control the temperature within the aircraft.

It was possible that the intermittent operation of the hot air mixing valve may have occurred due to poor electrical continuity or a sticking motor, resulting from the aircraft being out of service for a considerable time prior to the incident. It is also possible that the infrequent use of the various selected positions of the mode selector switch and temperature control dial, led to the build up of FOD[4] creating poor continuity within those components. Subsequent cycling could have led to the removal of the FOD and resumption of normal operation. As the switch was not disassembled, details of internal FOD levels could not be determined.

Significant tears and holes in the underfloor ducting were found 3 months after the incident, although no such defects were reported during the inspection of the right ducting immediately following the incident. The distortion to the floor track trim strips indicated that the presence of high temperature within that region of the cabin had been ongoing for some time, indicating that the subsequently observed damage may have been present to a lesser degree and not identified during the post-incident inspection.

Crew oxygen masks

The effectiveness of the straps on each of the crew's oxygen masks to provide sufficient contact of the mask face piece to its user was inadequate. As a result, the crew had to physically hold the masks in place to ensure sufficient oxygen flow was obtained, hindering their ability to control the aircraft.

The design of the mask required that the strap be placed in a 'quick donning' stretched position for the duration of flight, accelerating the wear of its elastic fibres. The pilot in command's (PIC's) mask had been fitted to the aircraft for only two weeks after being overhauled. The elastic tension in the strap however, was still found to be insufficient to hold the mask firmly against the PIC's face.

Although the manufacturer of the oxygen mask clearly defined the overhaul period for the mask face piece, clear indication of the maintenance requirements for the strap were not defined. The level of detail required for the pre-flight check of these masks varied considerably from operator to operator.

4 FOD - Foreign object damage [or debris], *The Cambridge Aerospace Dictionary.*

Passenger cabin communications

Although the aircraft was installed with cabin ceiling speakers for cockpit to cabin communications, those speakers failed to alert passengers of the emergency when used. As a result, the co-pilot was required to leave the cockpit during the incident to ensure the safety of the passengers. Maintenance records showed that both crew audio panels had only been fitted to the aircraft for 3 months. Although no defects had been recorded during that time, shortly after the incident, the passenger address (PA) system was checked and adjustments carried out indicating that the PA system had not been operating satisfactorily.

As a result of the inability of the passengers to hear the emergency announcement, the copilot had to leave the cockpit during the incident to ensure passengers were prepared for the loss of pressurisation, with their masks donned. Although that action, together with the decision of the PIC to refrain from depressurising the aircraft until all passengers were fully prepared, demonstrated a strong focus on passenger safety, it was not consistent with the non-normal checklist procedures, noting that throughout this period, the PIC was also required to hold his oxygen mask in place with one hand.

SAFETY ACTION

Civil Aviation Safety Authority

As a result of this investigation, on 26 July 2007, the Civil Aviation Safety Authority (CASA) issued Airworthiness Bulletin (AWB) 35-002, Quick-Donning Oxygen Mask Maintenance. The AWB recommended that oxygen mask head harnesses should be inspected at an appropriate interval to ensure correct functioning. The AWB also recommended that maintenance schedules be corrected to include oxygen masks and any other aircraft equipment not currently covered by the schedule. A copy of the AWB is at Appendix A.

APPENDIX A

Australian Government
Civil Aviation Safety Authority

AIRWORTHINESS BULLETIN

Quick-Donning Oxygen Mask Maintenance

AWB 35-002 **Issue** : 1
Date : 26 July 2007

1. Applicability

All Australian registered aircraft fitted with quick-donning oxygen masks.

2. Purpose

This Bulletin is to clarify the maintenance requirements of quick-donning oxygen masks fitted to aircraft.

3. Background

A recent investigation by the Australian Transport Safety Bureau (ATSB) identified that some quick-donning oxygen masks head harness assemblies were faulty.

The mask and head assembly in normal ready for use configuration is shown in Figure 1.

Figure 1 - Ready for Use

The fault identified by the ATSB is the elastic of the assembly was stretched to such an extent that, when released for use, did not contract to hold the mask assembly in place. Figure 2 shows the stretched band on the assembly.

Figure 2 - Stretched Band

The manufacturers of this type of equipment generally recommend that a yearly user inspection be performed and a time between overhaul of five years.

4. Recommendation

Oxygen head harness assemblies should be inspected to ensure correct functioning and repaired if required. A check of any relevant maintenance schedule should be undertaken and if these items are not included in the maintenance schedule then the maintenance schedule must be corrected to include them and any other aircraft equipment not covered by the schedule (Refer to CAR (1998) 42 - *Defective or inappropriate maintenance schedule*).

Note: AWB 02-023 provides information on CAR 41(2) maintenance of aircraft components.

5. Enquiries

Enquiries with regard to the content of this Airworthiness Bulletins should be made via the direct link e-mail address:

AirworthinessBulletin@casa.gov.au

Or in writing, to:

Manufacturing, Certification and
New Technologies Office,
GPO Box 2005, Canberra, ACT, 2601