Australian Government
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ATSB TRANSPORT SAFETY INVESTIGATION REPORT
Aviation Occurrence Report – 200506380
Final

Smoke event – 89 km south-east Mackay, Qld
9 Dec 2005
VH-EEQ
Fairchild Industries Inc SA227-AC

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Smoke event – 89 km south-east Mackay, Qld – 9 Dec 2005 – VH-EEQ, Fairchild Industries Inc SA227-AC

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Abstract

At approximately 0530 Eastern Standard Time hours on 9 December 2005, a Fairchild Industries Inc SA227-AC Metroliner, registered VH-EEQ was being operated on a scheduled cargo flight from Rockhampton to Mackay, Qld with a crew of two pilots on board. The crew reported that, during the cruise at flight level (FL) 140, an oily smell was detected emanating from the right nozzle cockpit air vent. Shortly after, and at a position 85 NM north-north-west of Rockhampton, the crew noticed smoke in the cockpit.

Although the crew reported completing the relevant checklist actions, the smoke re-entered the cockpit on two more occasions and the crew diverted to land back at Rockhampton. The third instance of smoke being detected in the cockpit followed shortly after the right engine oil temperature 'approached the top of the green arc' and, in the belief that to do so would prevent more smoke from entering the cockpit, the crew shut down the right engine.

A local engineering examination of the aircraft found that the air cycle machine had failed, releasing lubricating oil mist and smoke into the aircraft's airconditioning ducts. In addition, that examination revealed that the indicated increased right engine oil temperature was as a result of an indicating system malfunction.

As a result of this incident, a number of safety actions were carried out, or proposed to be carried out, including:

- by the operator, to:
  - amend its operations manual to remove non-type specific instructions that conflict with approved flight manual (AFM) procedures
  - advise its pilots of the Civil Aviation Safety Authority's (CASA) expectations in regard to the application of the word 'recommended' in AFM Emergency Procedures
  - advise its Training Captains to include CASA's expectations for the application of the word 'recommended' in AFM Emergency Procedures in all endorsement training
  - by CASA, which published its interpretation of the term 'recommended' in relation to the required conduct by pilots of aircraft manufacturer's emergency checklist procedures.

THE AUSTRALIAN TRANSPORT SAFETY BUREAU

The Australian Transport Safety Bureau (ATSB) is an operationally independent multi-modal Bureau within the Australian Government Department of Transport and Regional Services. 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

At approximately 0530 Eastern Standard Time[1] hours on 9 December 2005, a Fairchild Industries Inc SA227-AC Metroliner (Metroliner), registered VH-EEQ was being operated on a scheduled cargo flight from Rockhampton to Mackay, Qld with a crew of two pilots on board. The crew reported that, during the cruise at flight level (FL) 140, an oily smell was detected emanating from the right nozzle cockpit air vent. Shortly after, and at a position 85 NM north-north-west of Rockhampton, the crew noticed smoke in the cockpit.

The crew advised that the right engine bleed air switch was selected to OFF in an effort to stop the smoke entering the cockpit, and that a descent was initiated to 10,000 ft above mean sea level (AMSL). In addition, the 'cabin [was] dumped[2] to remove [the] smoke from the cockpit'. The crew did not immediately, or subsequently, don their oxygen masks as required by the aircraft's Quick Reference Handbook (QRH) or the company's operations manual in response to the smoke in the cockpit.

The crew reported that the smoke cleared, and that the 'smoke in aircraft checklist [was then] called for and completed'. On activation of the fresh air fan as part of that checklist, smoke re-entered the cockpit. The crew turned the fresh air fan and left engine bleed air switch OFF and, at a reported 48 NM from Mackay, declared a PAN[3] to air traffic control (ATC) before carrying out a diversion the about 105 NM back to Rockhampton.

The crew stated that, about 5 minutes later, the right engine oil temperature 'approached the top of the green arc' and, shortly after, smoke re-entered the cockpit a third time. In the belief that to do so would prevent more smoke from entering the cockpit, the crew shut down the right engine and continued the return flight to Rockhampton with one engine inoperative. The crew advised ATC of that action and requested the Rockhampton fire services to be placed on standby for their arrival.

The aircraft landed at Rockhampton at 0607.

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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 Emergency deactivation of the cabin pressurisation system.

3 A radio transmission indicating uncertainty or alert.

Aircraft examination

A local engineering examination of the aircraft found that the air cycle machine (ACM) had failed, releasing lubricating oil mist and smoke into the aircraft's airconditioning ducts. The turbine engine lubricating oil used in the ACM contained the anti-wear agent tricresyl phosphate[4], a compound known to have neurotoxic properties[5], the symptoms of which can include: headache, nausea and disorientation.

In addition, the local engineering examination revealed that the indicated increased right engine oil temperature was as a result of an indicating system malfunction.

The ACM unit was changed, the right engine oil temperature indicating system malfunction was rectified and the aircraft was returned to service.

Operational information

Information from the crew

At interview, the crew indicated that they did not don their oxygen masks as required by the 'Smoke in Aircraft' checklist as they believed that donning the masks was primarily a defence against a depressurisation event.

The crew stated that, as the aircraft's altitude and the amount of smoke in the cockpit from the right nozzle cockpit air vent were not excessive, they could avoid the 'Smoke in Aircraft' checklist's oxygen mask requirement. The crew felt that that decision was supported by the speed with which the smoke was able to be initially cleared, and that the aircraft was descended to 10,000 ft.

Finally, the crew indicated that:

- the aircraft's oxygen masks were 'clumsy and time-consuming to put on'
- because the aircraft was not fitted with an autopilot, the donning of the crew's oxygen masks required the transfer of pilot flying (PF) duties between the pilots, in order for each pilot to independently don their mask
- wearing the oxygen masks had the potential to adversely affect intra crew communication during an important decision-making time.

During interview, the pilot in command indicated that he had definitely carried out the 'Smoke in Aircraft' checklist actions, including the donning of oxygen masks during his line training on type. However, the pilot in command could not recall having subsequently ever been required to use the masks during his proficiency checks on type with the company.

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4 A chemical identified by the National Industrial Chemicals Notification and Assessment Scheme (NICNAS) as toxic.

5 Air Safety and Cabin Air Quality BAe 146 Aircraft – Report by the Senate Rural and Regional Affairs and Transport References Committee Page 38.

The copilot recalled a similar exposure to the use of the aircraft's oxygen masks during his time with the operator.

Information from the operator

The introduction to the Emergencies section of the Metroliner aircraft's flight manual[6] stated that:

> Section 3 of this manual covers emergencies that might occur during ground or flight operation and the recommended procedures for correcting the situations.

An operator representative related the company's belief that the use of the word 'recommended' by the aircraft manufacturer meant that the conduct of Section 3 emergency checklist procedures was at the discretion of affected crews. On that basis, the operator felt that the action by the crew to not don their oxygen masks was justified.

The representative also reported that opinion had been sought from the company's pilots as to their understanding of the intent of the word 'recommended', and its affect on the conduct by crews of bold-faced (or memory) emergency checklist actions. Pilots' opinion was reported to have been evenly split on the mandatory or otherwise nature of those actions.

The operator felt that that interpretation of the term 'recommended' as it applied to emergency checklist actions probably also existed in other companies, and requested a precise interpretation in the interests of flight safety. The operator indicated that, if that interpretation was that the term 'recommended' actually mandated compliance with emergency checklist actions, then the industry should be widely-informed to ensure consistency of application.

Civil Aviation Safety Authority interpretation

The investigation sought an interpretation of the intent and application of the term 'recommended' in aircraft manufacturers' flight manuals from the Civil Aviation Safety Authority (CASA). In its response, CASA indicated that:

> CASA considers that the emergency procedures specified in an aircraft manufacturer's flight manual/pilot operating handbook are an instruction, procedure or limitation concerning the operation of the aircraft. While a manual may characterise such procedures as recommended or not mandatory, CASA considers the effect of regulation 138(1) of the Civil Aviation Regulations 1988 is to require compliance with such procedures. Further, with respect to aircraft operated in commercial operations, an operator's operations manual may also mandate compliance or describe emergency procedures that operating crew are to comply with, pursuant to regulation 215(2).

The operator was subsequently informed by the investigation of the interpretation provided by CASA. At the time of drafting this report, there was no evidence that the operator had advised its pilots of that interpretation.

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6 Revised May 11/1999.

CASA promulgated its interpretation of the intent and application of the term 'recommended' in manufacturers' emergency checklists in the Readback column of the September-October 2006 edition of its magazine *Flight Safety Australia*.

Company emergency procedures

The company's pilots were required to comply with the standard operating procedures (SOPs) that were promulgated in the company's operations manual when operating Metroliner aircraft. Those SOPs were intended to supplement the content of the aircraft's approved flight manual (AFM), which was required to be carried on board each flight. If any conflict was identified by company personnel between the SOPs and an aircraft's AFM, the operations manual required that the flight manual took priority over the SOP.

Section 3.1 of the operations manual stipulated the emergency and abnormal procedures that were to be carried out by company personnel in response to those situations. That included the requirement that flight crews were to refer to the relevant Emergency and Abnormal Checklist procedures promulgated in Part B2 of the operations manual. In addition, pilots were required to use the aircraft's checklist 'at all times for normal and emergency checks' as follows:

> a. All emergency procedures checklists are contained in the Quick Reference Handbook [QRH]. Phase 1 checks **(BOLD TYPE)** shall be memorised.
>
> b. For Phase 2 checks, all checks shall be completed as per the QRH. The PF shall complete the appropriate check by reference to the QRH.

Section 3.1 to Part B3 of the operations manual discussed the continuation of flight after an in-flight emergency or abnormal procedure. That included that the continuation of flight to an aerodrome that might not have been the nearest suitable location at the time of the emergency or abnormality was 'at the discretion of the PIC [pilot in command] after consideration of all relevant factors'.

Smoke in the Cockpit/cabin

The emergency procedures in response to smoke in the cockpit/cabin were promulgated in the QRH and Annex 5 to Part B2 and Part B3 of the operations manual. Those procedures are discussed in the following paragraphs.

Quick Reference Handbook

The QRH is carried on the flight deck of the aircraft as part of the AFM suite of documents. The actions for a Smoke in Cockpit emergency were listed as follows[7]:

1.	**Crew Oxy masks……..DON**
2.	**Pax Oxy control……....ON**
3.	**Pax oxy masks……..DON**

7 Bold-faced items enclosed in a shaded box in the operations manual in order to highlight the requirement for their commitment to memory.

4. Smoke or fire from an electrical source

    a) From essential BUS

        i) Bus Tie Switch…….OFF

        ii) Bus Transfer Switches……..OPPOSITE BUS

    b) From Non Essential BUS

        i) Bus Tie Switch…….OFF

* Refer applicable bus failure checklist for further considerations. AFM Abnormal Procedures.

5. If smoke is from bleed source

    a) Bleed air switch…….ONE OFF AT A TIME

    If unsuccessful

    b) Bleed Air Switches (both)…….OFF

It is unlikely that both bleed air systems should malfunction simultaneously. However, if they should, closing both bleed air valves would prevent more smoke from entering the cockpit and cabin. But the outflow valve would then close in order to retain the cabin diff and the existing smoke would be trapped until depressurisation procedures are begun.

6. SMOKE in REAR of the aircraft

    a) Manual PRESS…….FULL DECREASE

    b) Press Diff Zero…….ACTIVATE CABIN DUMP

7. Smoke in the cockpit……..CABIN DUMP

8. Emergency Descent…….AS REQUIRED

9. Airspeed……...175 KIAS MAXIMUM

10. Landing Gear……DOWN

11. Fresh Air Fan……ON

* If the failure occurs in the pneumatic or electrical system of the bleed air control valve, the engine may have to be shut down to stop the flow of bleed air.

* If an engine must be shut down to prevent bleed air from entering the cockpit and cabin, the landing gear should be retracted to ensure adequate single engine performance.

Operations manual

In response to smoke in the cabin, Annex 5 to Part B2 of the operations manual required Metroliner flight crews to carry out the following actions:

1. Oxygen valve……..ON

2. Passenger and Crew Oxygen Masks...DON

3. Cabin Dump Switch……....DUMP

4. Emergency Descent……..AS REQUIRED
5. Airspeed……...176 KIAS MAXIMUM
6. Landing Gear……...…EXTEND
7. Fresh Air Fan……...…ON

> Extend landing gear to allow cabin air dumped into the nose baggage area and wheel well to go overboard.

Part B3 of the operations manual was aircraft type non-specific in its consideration of the pilot actions in response to emergency and abnormal procedures. In response to the detection of smoke in the cabin of company aircraft, that part mandated that:

> Pilots should immediately don oxygen masks, increase the rate of cabin airflow (by increasing cabin altitude) to aid in the dissipation of smoke.
>
> Should the smoke continue, an emergency descent should be initiated along with use of the appropriate checklist.

Flight crew use of supplemental oxygen

Part A8-8 of the operations manual stipulated the aircraft type non-specific requirements affecting the use of supplemental oxygen by flight crews. Those requirements included that 'all pilots use supplemental oxygen at all times during which the cabin altitude exceeds 10,000 feet'.

Flight crew incapacitation

The risks associated with, and management of, flight crew incapacitation were highlighted in section 3.2 to Part B3 and section 4.1.3 of the operations manual. The discussion included a review of the common symptoms displayed by an incapacitated pilot, a review of the potential hazards to continued safe flight as a result of an incapacitated pilot(s) interference, and the management of 'subtle incapacitation'.

The risks associated with flight crew incapacitation as a result of any delay by flight crew in donning oxygen masks in response to smoke and fumes in the cockpit/cabin was highlighted in the ATSB investigation report BO/200205307 (available at www.atsb.gov.au). That included the potential degradation of flight crew decision-making, and of the ongoing safe management of flight.

ANALYSIS

The action by the crew to not don their oxygen masks in response to the smoke entering the cockpit was contrary to the requirements of the aircraft's Quick Reference Handbook (QRH) component of the approved flight manual (AFM) suite of documents, and to the requirements of the company operations manual. Similarly, the action to not don their oxygen masks once the crew had 'dumped' the cabin pressure while above 10,000 ft did not accord with the operations manual requirements affecting the use of supplemental oxygen.

The decision by the crew to not don their oxygen masks did not appear to have been as a direct result of any interpretation by the crew that the term 'recommended' in the Emergencies section of the AFM might have allowed for crews' discretion in complying with that requirement. Rather, that decision by the crew appeared to have been a considered, conscious decision with the intent of expediting the resolution of the emergency and, in the crew's belief, minimising the risks associated with having donned the oxygen masks.

The extent to which the company's and other pilots' interpretation of the discretionary nature of the term 'recommended' in the Emergencies section of the AFM might have influenced the crew's decision to not don their oxygen masks could not be quantified.

Despite the crew's various actions in response to the three instances of smoke being detected in the cockpit, the crew could not have been confident that they had successfully identified the source and nature of the smoke. In any event, a subsequent engineering examination of the aircraft found that the source of the smoke was lubricating oil mist and smoke from the aircraft's air cycle machine. That oil contained an anti-wear agent that is known to have neurotoxic properties.

In that case, the crew's decisions to not immediately don their oxygen masks, and to return the about 105 NM to Rockhampton rather than the remaining 48 NM to Mackay increased the crew's potential exposure to the hazards associated with smoke in the cockpit. Despite their probable knowledge of the risk treatments outlined in the operations manual, the crew could not assure themselves that they had not each been subtly incapacitated by the lubricating oil mist and smoke.

FINDINGS

Contributing safety factors

- The aircraft's air cycle machine failed, releasing turbine oil mist and smoke into the cockpit.
- The crew did not don their oxygen masks in accordance with the emergency procedures specified in the aircraft manufacturer's flight manual.

Other safety factor

- The flight crew's decision to return the about 105 NM to Rockhampton, rather than the remaining 48 NM to Mackay, increased the crew's potential exposure to the hazards associated with smoke in the cockpit, including the risk of subtle incapacitation.

Other key finding

- There was an inconsistent interpretation amongst company pilots of the term 'recommended' in the emergency procedures sections of aircraft manufacturers' flight manual/pilot operating handbooks.

SAFETY ACTION

Operator

As a result of this incident, the operator:

- amended part B3 of the company's operations manual to remove non-type specific instructions that conflict with approved flight manual (AFM) procedures
- distributed a memo to all company pilots advising them of the Civil Aviation Safety Authority's (CASA) expectations in regard to the application of the word 'recommended' in AFM Emergency Procedures
- distributed a memo to all Training Captains advising them to include CASA's expectations for the application of the word 'recommended' in AFM Emergency Procedures in all endorsement training.

Civil Aviation Safety Authority

In response to a reader's enquiry concerning the effect of 'recommended' emergency checklist procedures in aircraft manufacturers' flight manuals, CASA published its interpretation of that term in the Readback section of the September-October 2006 issue of the authority's *Flight Safety Australia* magazine.