Australian Government

Australian Transport Safety Bureau

ATSB TRANSPORT SAFETY REPORT
Aviation Occurrence Investigation
AO-2009-044
Final

Air system event
74 km NE of Perth Airport
Western Australia
16 July 2009
VH-TAM
Beechcraft King Air C90

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Abstract

On 16 July 2009 the pilot of a Beechcraft King Air C90 aircraft, registered VH-TAM, departed Perth Airport on a flight to Wiluna, Western Australia with one passenger on board.

Sometime after becoming established at flight level (FL) 210, the pilot became affected by hypoxia, which resulted in him becoming fixated on the ‘distance-to-run’ figures on the aircraft’s Global Positioning System equipment display and incorrectly interpreting those figures as the aircraft’s ‘groundspeed’. That confusion resulted in the pilot interpreting the lower-than-expected figures as a significant headwind and in him descending the aircraft to escape the winds. Once established at FL150 for a significant period of time, he realised that that he had been affected by hypoxia. The pilot descended further before landing at his destination.

The investigation identified problems with the aircraft’s left landing gear squat switch that prevented the aircraft from pressurising in flight. In addition, the cabin altitude warning system was non-operational due to the incorrect connection of the switch wiring during previous maintenance.

Following this occurrence, the aircraft manufacturer changed the aircraft type’s maintenance manuals and documentation and the Civil Aviation Safety Authority (CASA) issued a letter to owners and operators of Australian-registered pressurised aircraft that proposed mandating the fitment of aural cabin pressure warning systems in those aircraft. As a result of that industry consultation, CASA determined that a uniquely Australian installation requirement could not be justified.

Notwithstanding, as a result of the ongoing risk of serious incidents and fatal accidents in which the occupants of single-pilot, turbine-powered, pressurised aircraft have been affected by, or have succumbed to unrecognised hypoxia in an unpressurised cabin, the Australian Transport Safety Bureau has issued a safety advisory notice. That notice encourages all operators of such aircraft to consider the installation of an aural cabin altitude pressure warning system that operates separately to their aircraft’s visual warning system.

THE AUSTRALIAN TRANSPORT SAFETY BUREAU

The Australian Transport Safety Bureau (ATSB) is an independent Commonwealth Government statutory agency. The Bureau is governed by a Commission and is entirely separate from transport regulators, policy makers and service providers. The ATSB's function is to improve safety and public confidence in the aviation, marine and rail modes of transport through excellence in: independent investigation of transport accidents and other safety occurrences; safety data recording, analysis and research; fostering safety awareness, knowledge and action.

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 identify and reduce safety-related risk. ATSB investigations determine and communicate the safety factors related to the transport safety matter being investigated. The terms the ATSB uses to refer to key safety and risk concepts are set out in the next section: Terminology Used in this Report.

It is not a function of the ATSB to apportion blame or determine liability. At the same time, 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 initiate proactive safety action that addresses safety issues. Nevertheless, the ATSB may use its power to make a formal safety recommendation either during or at the end of an investigation, depending on the level of risk associated with a safety issue and the extent of corrective action undertaken by the relevant organisation.

When safety recommendations are issued, they focus on clearly describing the safety issue of concern, rather than providing instructions or opinions on a preferred method of corrective action. As with equivalent overseas organisations, the ATSB has no power to enforce the implementation of its recommendations. It is a matter for the body to which an ATSB recommendation is directed to assess the costs and benefits of any particular means of addressing a safety issue.

When the ATSB issues a safety recommendation to a person, organisation or agency, they must provide a written response within 90 days. That response must indicate whether they accept the recommendation, any reasons for not accepting part or all of the recommendation, and details of any proposed safety action to give effect to the recommendation.

The ATSB can also issue safety advisory notices suggesting that an organisation or an industry sector consider a safety issue and take action where it believes it appropriate. There is no requirement for a formal response to an advisory notice, although the ATSB will publish any response it receives.

TERMINOLOGY USED IN THIS REPORT

Occurrence: accident or incident.

Safety factor: an event or condition that increases safety risk. In other words, it is something that, if it occurred in the future, would increase the likelihood of an occurrence, and/or the severity of the adverse consequences associated with an occurrence. Safety factors include the occurrence events (e.g. engine failure, signal passed at danger, grounding), individual actions (e.g. errors and violations), local conditions, current risk controls and organisational influences.

Contributing safety factor: a safety factor that, had it not occurred or existed at the time of an occurrence, then either: (a) the occurrence would probably not have occurred; or (b) the adverse consequences associated with the occurrence would probably not have occurred or have been as serious, or (c) another contributing safety factor would probably not have occurred or existed.

Other safety factor: a safety factor identified during an occurrence investigation which did not meet the definition of contributing safety factor but was still considered to be important to communicate in an investigation report in the interests of improved transport safety.

Other key finding: any finding, other than that associated with safety factors, considered important to include in an investigation report. Such findings may resolve ambiguity or controversy, describe possible scenarios or safety factors when firm safety factor findings were not able to be made, or note events or conditions which 'saved the day' or played an important role in reducing the risk associated with an occurrence.

Safety issue: a safety factor that (a) can reasonably be regarded as having the potential to adversely affect the safety of future operations, and (b) is a characteristic of an organisation or a system, rather than a characteristic of a specific individual, or characteristic of an operational environment at a specific point in time.

Risk level: The ATSB's assessment of the risk level associated with a safety issue is noted in the Findings section of the investigation report. It reflects the risk level as it existed at the time of the occurrence. That risk level may subsequently have been reduced as a result of safety actions taken by individuals or organisations during the course of an investigation.

Safety issues are broadly classified in terms of their level of risk as follows:

- **Critical** safety issue: associated with an intolerable level of risk and generally leading to the immediate issue of a safety recommendation unless corrective safety action has already been taken.
- **Significant** safety issue: associated with a risk level regarded as acceptable only if it is kept as low as reasonably practicable. The ATSB may issue a safety recommendation or a safety advisory notice if it assesses that further safety action may be practicable.
- **Minor** safety issue: associated with a broadly acceptable level of risk, although the ATSB may sometimes issue a safety advisory notice.

Safety action: the steps taken or proposed to be taken by a person, organisation or agency in response to a safety issue.

FACTUAL INFORMATION

History of the flight

On 16 July 2009, at about 1030 Western Standard Time[1], a Beechcraft King Air C90 aircraft (King Air C90), registered VH-TAM (TAM), departed Perth Airport on a 1 hour 52 minute flight to Wiluna, Western Australia. On board the aircraft for the flight under the instrument flight rules (IFR) were the pilot and one passenger.

The weather for the departure and climb to the planned cruise altitude of flight level (FL) 210[2] indicated instrument meteorological conditions, with moderate turbulence, rain and cloud.

The pilot reported that as the aircraft climbed through 6,000 ft above mean sea level (AMSL), he completed the Climb checklist items, which included a visual check of the aircraft's pressurisation system. That check was intended to confirm the normal operation of the system.

Approaching 10,000 ft, the pilot completed the Transition checks, which included a further check of the aircraft's cabin pressurisation. The pilot reported seeing about 300 ft/min on the cabin rate-of-climb indicator during those checks; however, he did not recall checking the adjacent dual cabin altimeter[3]. The pilot indicated that during the Transition checks he was 'pretty busy', as the aircraft was encountering rough weather with moderate turbulence and he was also having difficulties with the aircraft's autopilot at that time.

The pilot recalled that the climb to cruise altitude was 'fairly slow', with initially about 1,000 ft/min rate of climb at transition[4], slowing to about 500 ft/min by the time the aircraft reached FL 210. Recorded air traffic control (ATC) information showed that the aircraft reached FL 210 about 18 minutes into the flight.[5]

The pilot reported that the autopilot difficulties continued once at FL 210, with the system taking several minutes to engage the altitude hold function. He also indicated that, on checking the dual altimeter as part of his normal procedure upon reaching cruise altitude, he noted a reading on the outer scale (measuring cabin altitude) of 20,000 ft. He recalled feeling some concern at this, but at the time being unable to reason what to do to alleviate that concern. The pilot then completed the laid down Cruise checks.

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1 The 24-hour clock is used in this report to describe the local time of day, Western Standard Time (WST), as particular events occurred. Western Standard Time was Coordinated Universal Time (UTC) +8 hours.

2 A level of surface of constant atmospheric pressure that is related to a datum of 1013.25 HPa and is expressed in hundreds of feet. FL 210 approximates 21,000 ft.

3 A combined pressure gauge, with individual pointers operating from the same pivot point to indicate cabin altitude (what height above sea level the pressure in the cabin equates to) and cabin differential pressure (the difference between the pressures inside and outside the aircraft).

4 The altitude at or below which aircraft control is referenced to the altitude above sea level (in Australia, 10,000 ft).

5 An occurrence timeline is provided at Appendix A.

The pilot was given an amended route clearance by ATC and re-programmed the aircraft's Global Positioning System (GPS) equipment to reflect the amended route. The pilot reported that he subsequently became fixated on the distance-to-run figures on the GPS display, incorrectly interpreting those figures as the aircraft's groundspeed[6,7]. That confusion resulted in the pilot interpreting the lower-than-expected figures to mean that the aircraft was being subjected to an unexpected 100 kt headwind that significantly reduced its progress. Consequently, the pilot contacted ATC requesting a descent to FL 190 in an attempt to improve his groundspeed. That request was granted and about 11 minutes into the flight, the pilot descended to the lower flight level.

At 11:07, about 10 minutes after becoming established at FL 190, the pilot queried ATC about the perceived 'strong headwinds'. ATC indicated that no-one else had reported those winds but that they would 'advise'.

The 'headwind' remained and, shortly after, the pilot requested a further descent to FL 140. That request was granted by ATC and, at 11:17 the pilot began to descend. ATC indicated that their information showed that the winds in the area were from 290º[8]. The pilot then indicated to ATC that he was descending to FL 150 and ATC amended the descent clearance to reflect the pilot's revised descent altitude. The pilot established the aircraft at FL 150 about 58 minutes into the flight, and continued toward Wiluna. The pilot clearly recalled seeing 15,000 ft on the outer scale of the dual altimeter several times, but noted that he was still unable to understand the reason for that reading.

The pilot stated that, about 1 hour and 27 minutes after departure, or about 29 minutes after establishing the aircraft at FL 150, the aircraft was about 80 miles (148 km) from Wiluna. Only then did he finally realise that the aircraft was not pressurised, and that he was affected by hypoxia. The pilot immediately conducted a descent to below 10,000 ft, contacting ATC and indicating that he had left FL 150 on descent for Wiluna.

The pilot indicated that he did not fit his oxygen mask during the occurrence.

Personnel information

The pilot was appropriately qualified for the flight. He held a Commercial Pilot Licence Aeroplane with a Command Multi-engine Instrument Rating.

The pilot was employed by the operator and had a total of 3,140 hours flight experience, of which 2,619 hours were as pilot in command. He had a total of 470 hours flight experience in turboprop aircraft, of which 80 hours were on the King Air C90 aircraft type.

The pilot's most recent check flight was carried out in a Beechcraft 1900D aircraft in July 2009. He had a valid Class 1 Medical Certificate with the limitations that glasses were to be worn while exercising the privileges of the licence.

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6 The aircraft's Garmin 530 GPS display was configured to read 'groundspeed' in the lower left of the screen and 'distance-to-run' in the upper right corner.

7 Aircraft speed relative to the ground, expressed in kts.

8 The aircraft was tracking about 034º. A wind direction of 290º would have resulted in a slight tailwind affecting the aircraft.

Aircraft information

The twin turboprop, Beechcraft King Air C90 aircraft, serial number LJ-919 was manufactured in the United States in 1980 and placed onto the Australian Civil Aircraft Register on 6 December 2006. The aircraft had accrued a total of about 7,420 airframe hours at the time of the occurrence.

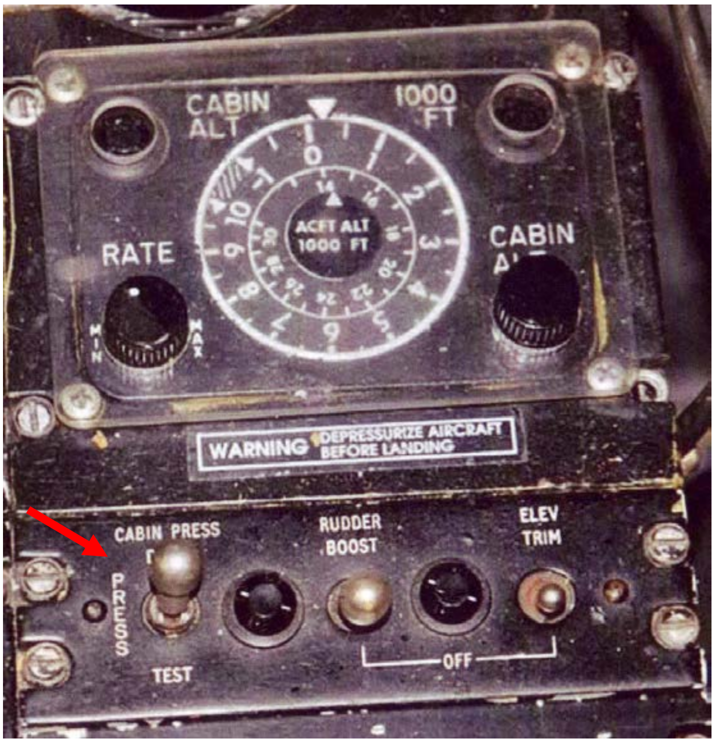
Aircraft pressurisation system

Description and operation

The aircraft's pressurisation system used high pressure bleed air from the engines to pressurise the cockpit and cabin areas for high-altitude flight. The bleed air passed through flow control valves that were mounted on the firewall for each engine, wing mounted heat exchangers, valves and system plumbing before entering the fuselage.

The pilot could regulate the level of pressurisation inside the aircraft's cabin by setting the cabin pressurisation controller (pressurisation controller) that was located on the aircraft's instrument pedestal (Figure 1).

Figure 1: Typical King Air C90 cabin pressurisation controller with adjacent three-position cabin pressure control switch indicated by arrow



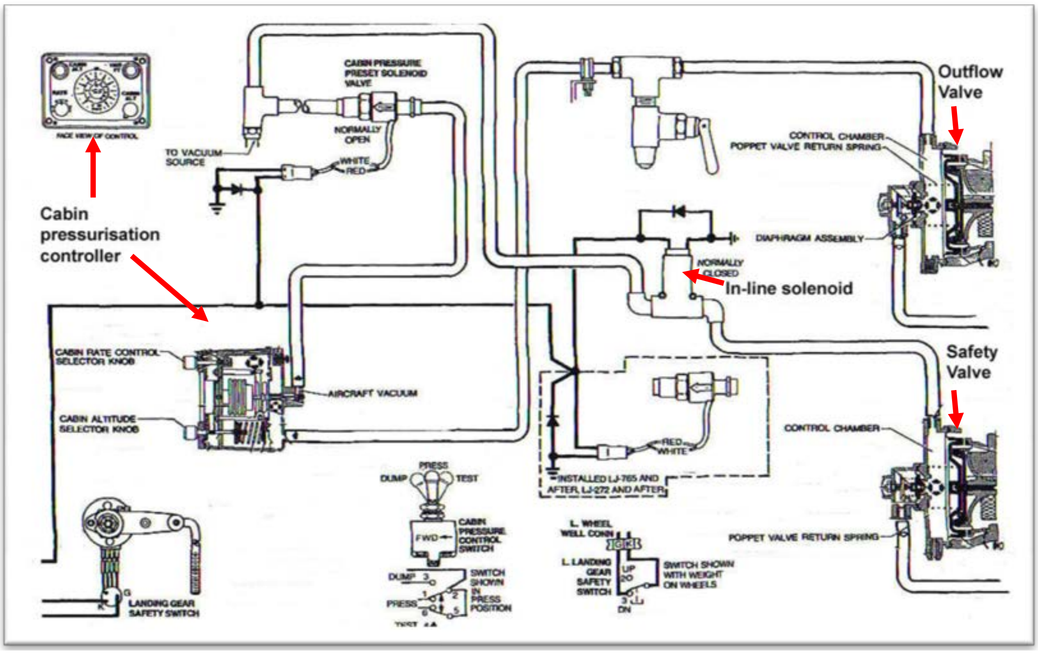
The pressurisation controller incorporated a cabin altitude selector knob that allowed the pilot to select the desired cabin pressure altitude on the controller dial. A cabin rate control selector knob regulated the speed at which the cabin pressure increased or decreased. For normal operation, the cabin rate control selector knob was set at about the 12 o'clock position.

A three-position cabin pressure control switch marked DUMP/PRESS/TEST (dump/pressurise/test) was located adjacent to the pressurisation controller (Figure 1). During normal system operation, the switch was left in the central 'pressurise' position.

The pilot monitored the operation of the cabin pressurisation system using the dual altimeter and the rate-of-climb indicator that were located on the lower right centre section of the instrument panel.

The pressurisation controller operated in conjunction with the cabin outflow valve (outflow valve) that was mounted in the cabin's rear pressure bulkhead (Figure 2). That valve automatically metered the outflow of cabin air during pressurised operation in response to vacuum control forces from the pressurisation controller that acted on the valve's control chamber. The outflow valve also contained positive and negative pressure relief valves.

Figure 2: Beechcraft C90 pressurisation system schematic diagram (simplified)



A safety valve was positioned adjacent to the outflow valve. The safety valve contained a positive pressure relief valve that activated at a higher pressure than the outflow valve in case the latter failed. The safety valve had a vacuum line attached to its control chamber, which incorporated an in-line solenoid valve that was normally closed. When electrically activated by either the selection of the dump/pressurise/test switch to the DUMP position, or by the closing of the contacts in the left landing gear safety switch, the in-line solenoid valve allowed vacuum to the control chamber, pneumatically opening the valve.

The left landing gear safety switch was positioned on the left landing gear strut and was activated by compression of the strut when the aircraft was on the ground. The safety switch normally prevented the aircraft from pressurising while on the ground, or remaining pressurised following landing.

Pressurisation ground test for flight

It was normal procedure for the pilot to test the operation of the pressurisation system on the ground prior to flight. That test entailed the pilot rotating the pressurisation controller's cabin altitude selector knob to a setting of about 1,000 ft below field elevation as shown on the cabin altitude indicator dial.

The pilot then selected and held the dump/pressurise/test switch in the momentary 'TEST' position[9]. That action interrupted the power to the left landing gear safety switch electrical circuit, temporarily overriding that switch and causing the safety valve to close under spring pressure. It also allowed the aircraft's vacuum source to act on the pressurisation controller through the cabin pressure preset solenoid valve to control the outflow valve.

The aircraft manufacturer's documentation indicated that, during test, the cabin rate-of-climb indicator should indicate a descent within 45 seconds of the pilot selecting TEST, and that the aircraft should begin to pressurise. In combination, each indicated that the system was operational. The pilot then released the switch, allowing it to spring-return to the central PRESS position.

Cabin altitude warning system

The aircraft's cabin altitude warning consisted of a back-lit amber annunciator[10], which was located in the approximate centre of the glareshield-mounted annunciator panel. The words 'ALTITUDE WARN' were printed on the light's glass face (Figure 3).

Figure 3: Annunciator panel with ALTITUDE WARN annunciator indicated

The ALTITUDE WARN annunciator was electrically connected to a cabin altitude warning pressure switch that was located in the cockpit, forward of the instrument panel. That pressure switch contained a barometric capsule that expanded and contracted consistent with the cabin's changing internal air pressure. The expansion of the capsule as a result of decreasing cabin air pressure to a preset limit activated internal electrical contacts and illuminated the ALTITUDE WARN annunciator.

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9 A momentary switch is one that is spring-loaded away from the selected position. The switch must be held there by finger pressure to allow system operation.

10 Caution annunciators are amber and are for faults that require the immediate attention of, but not necessarily the immediate reaction of the pilot. The annunciator remains on until the fault is rectified.

That indicated to the pilot that the internal cabin air pressure had decreased to the equivalent of 10,500 ft altitude.[11]

The ALTITUDE WARN caution annunciator was required to be tested during a pilot’s pre-flight checks via an instrument panel mounted press-to-test facility. That test confirmed the operation of the annunciator light bulb. The pilot reported that the aircraft’s ALTITUDE WARN caution annunciator tested satisfactorily prior to the flight.

There was no other warning system in the aircraft, such as an aural alarm, to indicate to the pilot that the cabin was not pressurised appropriately for flight.

Cabin altitude switch wiring diagram

The wiring diagram for the cabin altitude switch installation[12] detailed the connections for the cabin altitude warning pressure switch in the occurrence aircraft.

The pressure switch had three electric terminal posts on the body of the switch. Those terminal posts were marked:

- NC - normally closed
- NO - normally open
- C[13] - common.

The wiring diagram for the C90 aircraft type did not include the connection nomenclature as indicated on the switch to facilitate correct wiring connection.

Crew oxygen system

The aircraft’s oxygen system provided dry breathing oxygen to the crew and passengers in an emergency, or as operationally required. The oxygen for the system was stored in a steel pressure vessel that was positioned behind the aircraft cabin’s rear pressure bulkhead.

The crew masks were positioned on quick release hangers that were located in the cockpit behind and outboard of the pilot’s head. In order for the masks to supply oxygen to the crew and allow for radio communications during normal or emergency operations, the crew’s masks had to be connected into the dedicated oxygen and microphone connections that were positioned in the left and right cockpit sidewalls.

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11 The cabin altitude warning annunciator preset limit in TAM equated to a cabin altitude of 10,500 ft ±500 ft. It was designed to extinguish again at an increasing internal cabin pressure equivalent to an altitude of 9,000 ft.

12 The King Air 90 Electrical Diagram Manual (P/N 90-590024-11 Reissue E May 1, 2010).

13 The ‘C’ terminal provided the electrical earth for the Cabin Altitude Warning, allowing for the illumination of the ALTITUDE WARN caution annunciator.

Maintenance manual requirements

Cabin altitude warning pressure switch maintenance

The aircraft manufacturer's maintenance manual (MM) detailed the maintenance procedures for the aircraft. Chapter 21-30-00 of that manual detailed the procedures affecting the removal, installation and testing of the cabin altitude warning pressure switch. Three methods for confirming the serviceability of the cabin altitude warning system were listed as follows:

- Method 1 entailed the off-aircraft test of a pressure switch in a vacuum chamber and was to be used to verify the operation of a pressure switch if that testing had not been previously accomplished. Method 1 required the connection of the test wires to the NO and C terminal posts (see earlier discussion titled *Cabin altitude switch wiring diagram*) and referred maintenance personnel to the CABIN ALTITUDE WARNING PRESSURE SWITCH INSTALLATION procedure if the switch was to be fitted to an aircraft.
- Method 2 required the aircraft to be test flown unpressurised and that the operation of the pressure switch was verified during that flight by reference to a switch operation data table in the MM. Method 2 was to be used in the case of the test of a new switch if a vacuum chamber was not available (that is, Method 1 was not possible).
- Method 3 required the pressure switch to be tested in a vacuum chamber while still attached to the aircraft's wiring. The operation of the pressure switch was verified by reference to a switch operation data table in the MM.

A separate test of the aircraft's wiring was also stipulated to ensure annunciator operation. While the connection of the wires to the switch was detailed in the MM, there was no mention of the correct terminals to which the wiring was attached.

Beechcraft C90 Special Inspection 52

Beechcraft C90 Special Inspection 52[14] (SI 52) required a 12-monthly test of the aircraft's cabin altitude warning system in accordance with MM Chapter 21-30-00. A note at the commencement of the cabin altitude warning pressure switch test procedure in that chapter indicated that, if the procedure was being performed solely to check the operation of the switch due to the requirements of an SI, then Methods 2 or 3 must be performed.

There was no evidence of SI 52 being carried out on the aircraft since its being placed on the Australian aircraft register in late 2006. The maintenance control subcontractor indicated that the requirement for the periodic completion of SI 52 had inadvertently been omitted when setting up the aircraft's maintenance database.

Previous maintenance

There was no evidence of any prior maintenance of the left landing gear safety switch. However, post-occurrence maintenance on the switch found that it was a

[14] Beechcraft King Air 90 Series Maintenance Manual, paragraph 5-21-05, page 206.

different paint colour to the surrounding components, possibly indicating that it may have been replaced at some time in the past.

The aircraft's cabin altitude warning pressure switch was last replaced during scheduled maintenance on 12 December 2007. The maintenance personnel who carried out that work indicated that the original switch was removed and tested as a result of information in the maintenance work package, in the form of Civil Aviation Safety Authority (CASA) airworthiness bulletin (AWB) AWB 21-1[15]. The switch failed that test and was replaced with a superseded part number item.[16] The maintenance personnel indicated that the new switch was not tested prior to fitment as its supporting documentation indicated that it was serviceable.

The wiring to the replacement switch was reported to have been 'shorted' together to test the operation of the ALTITUDE WARN caution annunciator before being connected to the same terminal posts on the new switch as on the original switch. No further testing of the assembled system was carried out.

Post-occurrence maintenance

Pressurisation system

Following the occurrence, the aircraft was returned to Perth where it was found that the left landing gear safety switch was incorrectly adjusted. Maintenance personnel described that the adjustment was found to be on a 'hair-line' setting with the effect that the switch sometimes worked correctly, and at other times did not. A number of the aircraft's other pressurisation and associated engine bleed air components were found to not be achieving optimal performance at the time of the occurrence.

The pilot indicated that the aircraft's pressurisation system had worked normally on a previous flight on 2 July 2009.

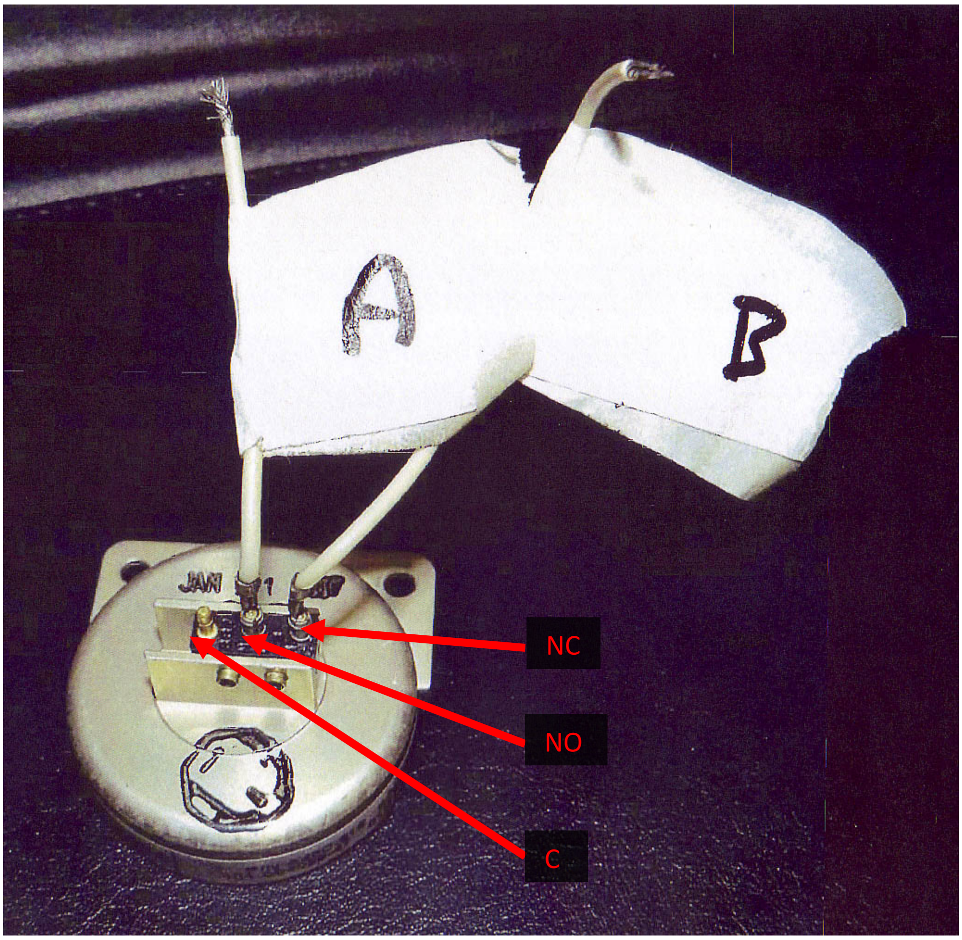
Cabin altitude warning system

During the post-occurrence maintenance checks it was also discovered that the aircraft's cabin altitude warning system was not operational. A detailed examination of that system found that the aircraft's cabin altitude warning system wiring was attached to the NO and NC terminals (Figure 4), rather than the NO and C terminals as stipulated in the MM.

15 AWB 21-1 Issue 1, 30 August 2002, *Cabin Altitude Alert Pressure Switch Maintenance Requirements*.

16 The original switch, part number 101-384028-3 was superseded by switch part number 101-384028-47. The '-47' switch was not mentioned in the Switch Operation Data information in the MM.

Figure 4: As-found cabin altitude warning pressure switch wiring in TAM



Organisational and management information

Operational and aircraft maintenance arrangements for the flight

The operator reported using the aircraft for charter operations on an opportunity-based, hourly-rate hire basis. The aircraft owner maintained the aircraft in accordance with the operator’s CASA-approved system of maintenance. This was the only aircraft in the operator’s fleet that was maintained in this way.

The aircraft owner subcontracted the maintenance control for the aircraft to a third party provider. That third party placed the aircraft into their computer-based maintenance control system, and routinely supplied the owner with a ‘due-list’ of scheduled maintenance.

On receipt of the due-list, the aircraft owner sought quotes for the maintenance from a number of maintenance providers before allocating the work. Unscheduled maintenance during the day-to-day operation of the aircraft was flagged to the owner and the maintenance control subcontractor by the operator. The owner would then arrange for the maintenance to be carried out.

Operator’s oxygen system procedures

Part B of the operator’s Operations Manual comprised the *King Air C90 Operating Manual* (operating manual).[17] That operating manual included the description and operation of the aircraft’s oxygen system, flight profile and flight planning information, and the abbreviated checklist procedures for the aircraft. Paragraph B3.2.2 of the operating manual under the title *Crew Oxygen* stated in part that ‘the microphone and oxygen tube are to be plugged in at all times.’

The pilot reported that, in the occurrence aircraft, the pilot’s oxygen mask was often stored disconnected from the oxygen outlet during flight. The reason for that non-compliance with the operating manual was reported to be a combination of the positioning of the oxygen sidewall outlet and the design of the mask’s hose connector. The pilot indicated that the hose connector was a straight fitting rather than angled fitting, which meant that when connected to the outlet, it would partially obstruct the crew’s normal movements.

Abbreviated checklist procedures

The abbreviated checklist procedures for the aircraft detailed the various operational checks to be carried out by a pilot and the times at which they were to be accomplished. The checklist procedures required a visual check of the available indications of the operation of the aircraft’s pressurisation system a number of times during a flight.

Initially the cabin pressurisation system was ‘set’[18] by the pilot during the taxi check prior to flight. It was then checked during the climb checks soon after takeoff and again during the transition climb checks. There was no requirement for the pressurisation system to be checked again until the descent for landing.

Single-pilot operations

A CASA regulation impact statement relating to Autopilot Requirements for IFR flight commented on the level of difficulty associated with single-pilot operations under the IFR as follows:[19]

> Single pilot operation of an aeroplane under the IFR is widely accepted as being demanding and imposing a high workload on the pilot. This high workload environment can contribute to serious errors in fuel, calculation, assessment of weather, accuracy of navigation, adherence to Air Traffic Control clearance requirements, the application of checklists and judgement under stress.

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17 Operations Manual Part B3 Beechcraft C90, Initial Issue I November 2006.

18 Normally prior to flight a pilot would set an altitude on the cabin pressurisation controller dial of 1,000 ft above planned cruise altitude. For descent the pilot would set an altitude of about 500 ft above landing airport height.

19 RIS 9804, Autopilot Requirements, Amendment to Civil Aviation Order (CAO) 20.18, issued July 1998.

Additional information

Hypoxia

Many different factors can cause oxygen deficiency in the body that may result in hypoxia. That can include certain respiratory and cardiovascular conditions, the administration of a number of pharmaceutical drugs, the effects of toxic substances and breathing air at a reduced barometric pressure.

The unintentional breathing of air at low barometric pressure is a hazard in aviation that causes *hypoxic hypoxia*, which is also called *hypobaric hypoxia* or *altitude hypoxia*. This can occur at altitudes in excess of 10,000 ft when flying a non-pressurised aircraft without supplemental oxygen, as a result of a decompression during flight, or due to a pressurisation or oxygen system malfunction.

Hypoxic hypoxia is a result of inadequate oxygen being available to the lungs, which in turn decreases the amount of oxygen available to the arterial blood and so to the body tissues. It can be prevented by pressurising the aircraft cabin (typically to pressure altitudes of 10,000 ft or below), or by the aircraft occupants breathing supplemental oxygen.

The clinical features of hypoxic hypoxia include the following:

- Impairment of cognitive skills such as judgment, decision-making, memory, self regulation, and self-awareness.
- Impaired psychomotor coordination and reaction times.
- Restriction of visual field, reduced colour discrimination, reduced auditory acuity and cyanosis (skin turning blue).
- Loss of consciousness, finally resulting in death.

Some of the subjective symptoms of hypoxic hypoxia include euphoria, light headedness, dizziness and feelings of warmth. Hence, hypoxic hypoxia can also create a false sense of well being, at the same time as it is degrading the subject's mental and physical performance, which can compound the problem. In most cases, the initial signs of hypoxia are subtle and the pilot has limited time to recognise the signs, make decisions, and carry out the actions to rectify the situation.

Depending on the degree of exposure to the hypoxic environment, higher mental functions such as thinking and concentration can be impaired before any degradation of physical abilities becomes apparent. For example, a hypoxic pilot may be quite capable of pressing the transmit button but may be unable to form the words to speak.

In 2004, a revised United States Federal Aviation Administration (FAA) Pilot Safety Brochure stated in part that:[20]

> The brain is the first part of the body to reflect a diminished oxygen supply, and the evidence of that is usually a loss of judgement.

[20] Federal Aviation Administration (FAA), Medical facts for Pilots, Publication AM-400-90/2, Revised May 2004, Pilot Safety Brochure, titled *Hypoxia, The Higher You Fly...The Less Air In The Sky.*

Vision is also particularly sensitive to hypoxia. Moderate and severe hypoxia causes a restriction of the visual field, with loss of peripheral vision. There may also be a subjective darkening of the visual field.

Auditory acuity or hearing sensitivity is also reduced by moderate and severe hypoxia. However, some hearing is usually retained even after other senses such as vision are lost.

Time of useful consciousness

The term 'time of useful consciousness' (TUC) describes the amount of time available to an individual who is breathing air at a given altitude before the ability to perform 'deliberate and purposeful acts' at that altitude is lost. As the altitude increases above 10,000 ft, the symptoms of hypoxia increase in severity, and the TUC rapidly decreases.

Table 1 shows the TUC for a person in an aircraft at an undefined 'standard ascent rate' and after a rapid decompression. The TUC associated with a rapid aircraft decompression is less than if the decompression was more gradual.

There is significant variability between individuals that may alter the TUC. Reasons such as age, fitness, whether the person was a smoker, physical activity, temperature, rate of ascent, altitude attained and duration at altitude can all affect one's TUC and therefore the values provide guidance only.

Table 1: TUC at various altitudes[21]

Altitude (Feet)	Standard Unpressurised Ascent Rate (minutes and seconds)	After Rapid Decompression (minutes and seconds)
18,000	20 to 30 minutes	10 to 15 minutes
22,000	10 minutes	5 minutes
25,000	3 to 5 minutes	1.5 to 3.5 minutes
28,000	2.5 to 3 minutes	1.25 to 1.5 minutes
30,000	1 to 2 minutes	30 to 60 seconds
35,000	30 to 60 seconds	15 to 30 seconds
40,000	15 to 20 seconds	7 to 10 seconds
43,000	9 to 12 seconds	5 seconds
50,000	9 to 12 seconds	5 seconds

[21] FAA Advisory Circular AC No: 61-107A, titled *Operations of aircraft at altitudes above 25,000 feet MSL and/or MACH numbers (M_{mo}) greater than .75*. 2 January 2003, page 11 paragraph f, Table 1-1.

Aircraft warning systems

A warning system should, if installed, present information to flight crews in a form that crews can readily understand, and in sufficient time to facilitate effective judgement and decision making. When designed correctly, warning signals can improve operator performance and reduce accidents.

As previously indicated, human vision is particularly sensitive to the effects of hypoxia whereas, even after other senses such as vision are significantly degraded, some hearing is usually retained. Hence, warning systems in complex domains such as aviation and medicine can be made more effective by supplementing the system's visual indications with aural warnings.

It is therefore widely regarded that, in a depressurisation event, an auditory warning is more effective than a visual warning in effecting a response.[20] Auditory warnings have an immediacy that may not be apparent with visual warnings and allow events both in and outside the operator's field of view to be monitored. Reaction times to visual signals are shortened when accompanied by an auditory warning signal.

Previous pressurisation-related research, investigations and safety action

ATSB research and analysis report B2006/0142

In June 2006, the ATSB released a research and analysis report titled *Depressurisation Accidents and Incidents Involving Australian Civil Aircraft 1 January 1975 to 31 March 2006*. That report found that, of 517 pressurisation failure events (two accidents, eight serious incidents and 507 incidents), only one pressurisation event was fatal.

In general, the results of the study showed that there is a high chance of surviving a pressurisation system failure, provided that the failure is recognised and the corresponding emergency procedures are carried out expeditiously. Flight crews should maintain a high level of vigilance with respect to the potential hazards of cabin pressurisation system failure.

Investigations

The (then) Bureau of Air Safety Investigation (BASI)[22] and ATSB have undertaken a number of pressurisation failure-related investigations, all of which are available for download at www.atsb.gov.au. Of those, ATSB occurrence 199902928, involving a Beech Super King Air 200, registered VH-OYA, and occurrence 200105188, involving a similar aircraft, registered VH-SWP, illustrated how pilots, when occupied with other tasks, can miss visual warnings.

In addition, ATSB investigation 200003771, which involved a Beech Super King Air 200 aircraft, registered VH-SKC, concluded that, while there were several possible reasons for the pilot and seven passengers becoming incapacitated during the flight, the incapacitation was probably a result of hypobaric hypoxia due to the aircraft being fully or partially unpressurised. The aircraft continued flying for 5 hours before impacting the ground, fatally injuring all on board.

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22 BASI was the predecessor of the ATSB.

Safety action

The ATSB investigation report 199902928 contained a number of safety recommendations in respect of the installation of cabin pressurisation warning systems. In particular safety recommendation R20000288, which was issued on 17 December 2000 stated that:

> The ATSB has concerns regarding the ineffectiveness of visual cabin altitude warning systems that are not accompanied by an aural warning. In this incident [that involving Beech Super King Air 200, registered VH-OYA] the inclusion of an audible warning, as strongly recommended in CAO [Civil Aviation Order] 108.26, may have assisted the pilot to recognise a depressurisation.
>
> The ATSB therefore recommends that CASA mandate the fitment of aural warnings to operate in conjunction with the cabin altitude alert warning systems on all Beechcraft Super King Air and other applicable aircraft.

After initially accepting that recommendation, and taking a number of steps to mandate the installation of aural cabin altitude alert warning systems in relevant pressurised aircraft, on 26 March 2003, CASA advised that it did not consider the fitment of those systems in Beech 200 and other single-pilot pressurised aeroplanes was warranted by the potential safety benefits. CASA noted that:

> ...no manufacturer or certifying Authority in the world requires mandatory fitment of such aural warnings and the initiative is opposed by key industry stakeholders in Australia.

That day, CASA contacted all relevant certificate of registration holders and recommended that, if a pressurised aircraft did not have an aural cabin pressure warning, the owner should seriously investigate the installation of such a warning system. Subsequently, CASA advised that the take up rate of aural warning systems was very low.

Similar cabin pressurisation warning system recommendations were not included in ATSB investigation report 200003771 as the recommendations from investigation 199902928 were still underway.

ANALYSIS

Aircraft operation

The single-pilot flight under the instrument flight rules placed the pilot under a higher and more demanding workload when compared with multi-crew operations. In this occurrence, while in instrument meteorological conditions and moderate turbulence, the pilot was distracted during a critical phase of the flight by a problematic autopilot system. That distraction resulted in the pilot not completing the transition pressurisation checks and continuing the climb in an unpressurised aircraft to flight level (FL) 210 (equating to 21,000 feet).

The situation was further compounded by the failure of the aircraft's cabin altitude warning system to alert the pilot to the aircraft's unpressurised state due to a previously undetected electrical wiring connection fault. The timely operation of that system could have alerted the pilot to the unpressurised cabin at an altitude prior to the onset of hypoxia and potentially prevented the occurrence.

The pilot's confused state once in cruise flight, and subsequent inability to resolve the higher-than-expected altitude that was displayed on the dual cabin altimeter display, was consistent with his sustaining hypoxia. That would explain the pilot's fixation on the distance-to-run figures on the aircraft's Global Positioning System display, and the mistaken interpretation of those figures as the aircraft's speed over the ground. Fortuitously, that confusion resulted in the pilot descending in response to the apparent, but non-existent headwind, placing himself and his passenger in a more oxygen-rich environment. Had the pilot continued at cruise altitude for an extended length of time, it is probable that he and the passenger would have lapsed into an unconscious state, from which neither may have recovered.

Consistent with a graduated recovery from hypoxia, it was only after being at FL150 for about 30 minutes that the pilot realised what had happened, and descended to below 10,000 ft, where the risk of hypoxia was minimal. This event reinforces the insidious nature of hypoxia during flight. Had the pilot fixated on other than the aircraft's (perceived) groundspeed, it is probable that the outcome would have been far more serious.

Pressurisation system anomalies

The conduct of the pre-flight pressurisation system test, by overriding the operation of the left landing gear squat switch, prevented the identification of that switch as being out of adjustment and the system tested serviceable. The switch's intermittent operation during flight meant that the system would unreliably pressurise the aircraft, as in this case.

No other anomalies were identified that would have prevented the correct operation of the aircraft's pressurisation system, had the squat switch been correctly adjusted.

Cabin altitude warning system maintenance and documentation

System maintenance

Given the requirements of the maintenance manual for confirming the serviceability of the cabin altitude warning system, the action by maintenance personnel to install the new and therefore, they believed, serviceable replacement pressure switch without test relied on its previous successful off-aircraft test in a barometric chamber. The indication in the supporting documentation for the switch that it was serviceable supported that conclusion.

The incorrect wiring of the cabin altitude warning pressure switch in 2007 prevented its operation during the occurrence. The undetected maintenance planning error meant that a 12-monthly operational test of the cabin altitude warning system was omitted from the aircraft's maintenance schedule. That omission meant that a functional test of the aircraft's cabin altitude warning system was not carried out on several occasions following the fitment of the replacement pressure switch. It could be expected that the test, if carried out, would have detected the system fault, enabling its rectification prior to the occurrence.

Documentation

The presence of three terminal posts on the rear of the cabin altitude warning pressure switch, and need for the connection of only two wires to the switch, increased the risk that either wire could be unintentionally connected to an incorrect terminal. The lack of a clear indication in the maintenance manual (MM) of the correct terminals to which each wire should be connected further increased that risk.

The installation of a superseded cabin altitude warning pressure switch without relevant supporting documentation in the MM suggested that the switch was installed based on tacit knowledge or experience. The lack of manufacturer documentation in regard to the superseded switch would explain that action.

Aural cabin altitude warnings

Although in this instance the cabin altitude warning system did not operate, numerous studies into hypoxia have shown that when affected by hypoxia, human beings respond better to an audible warning, rather than a visual warning as fitted to the aircraft. Had the aircraft been fitted with an audible warning system in addition to, and that operated independently of its visual system, it is likely that, even in the high workload at the time, the pilot would have been alerted to the pressurisation event well before the onset of hypoxia.

Oxygen mask connection

The as-stowed disconnection of the pilot's oxygen mask hose from its wall outlet meant that, in the case of a depressurisation event, smoke or fumes event or other requirement for being on oxygen, the pilot would have been required to connect the mask to the oxygen supply as part of the emergency response.

The mask was not used in this instance because the pilot did not recognise the developing hypoxia. However, had the pilot recognised his predicament and attempted to wear the mask, the time taken to connect to the oxygen supply in his possibly already hypoxic state would have lengthened the time spent with insufficient oxygen. During that time, any hypoxia would have worsened, possibly preventing him connecting the mask into the outlet at all, and depriving him of oxygen at a critical time in the resolution of the emergency.

FINDINGS

From the evidence available, the following findings are made with respect to the cabin depressurisation and subsequent hypoxic event that occurred en route from Perth to Wiluna, Western Australia on 16 July 2009 and involving Beechcraft King Air C90 aircraft, registered VH-TAM. They should not be read as apportioning blame or liability to any particular organisation or individual.

Contributing safety factors

- During the climb, the pilot in command became distracted by autopilot problems and did not effectively monitor the aircraft's cabin pressurisation instrumentation.
- The aircraft's pressurisation system did not operate normally during the flight despite testing serviceable during the pre-flight checks.
- The left landing gear squat switch operated intermittently and prevented the aircraft from pressurising.
- The aircraft's cabin altitude warning pressure switch was incorrectly connected, preventing operation of the cabin altitude warning system during unpressurised flight.
- The cabin altitude warning pressure switch maintenance manual wiring diagram did not provide a clear indication of the wiring connections for the superseded switch. *[Minor safety issue]*
- The annual maintenance check of the aircraft's cabin altitude warning system had not been completed.

Other safety factors

- The pilot's oxygen mask was not connected to the relevant oxygen outlet.
- The aircraft maintenance manuals did not include the operating specifications of the replacement cabin altitude warning pressure switch, hampering the required verification of switch serviceability. *[Minor safety issue]*

SAFETY ACTION

The safety issues identified during this investigation are listed in the Findings and Safety Actions sections of this report. The Australian Transport Safety Bureau (ATSB) expects tha*t all safety issues* identified by the investigation should be addressed by the relevant organisations. In addressing those issues, the ATSB prefers to encourage relevant organisations to proactively initiate safety action, rather than to issue formal safety recommendations or safety advisory notices.

All of the responsible organisations for the safety issues identified during this investigation were given a draft report and invited to provide submissions. As part of that process, each organisation was asked to communicate what safety actions, if any, they had carried out or were planning to carry out in relation to each safety issue relevant to their organisation.

Aircraft manufacturer

Cabin altitude warning pressure switch wiring diagram

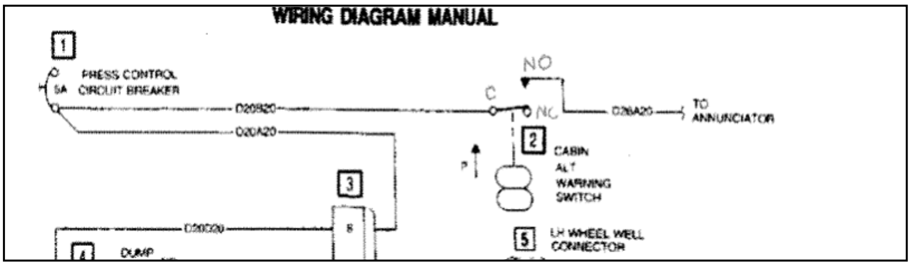
Minor safety issue

The cabin altitude warning pressure switch maintenance manual wiring diagram did not provide a clear indication of the wiring connections for the superseded switch.

Action by the aircraft manufacturer

In response to this occurrence, the aircraft manufacturer advised that:

> A technical Publications Change Request (PCR) has been submitted to change the Beechcraft Electrical Wiring Diagram Manual, P/N 90-590012-15, Cabin Pressurisation diagram covering LJ-919 to identify the cabin altitude warning switch poles NO and NC as follows:



ATSB assessment of action

The ATSB is satisfied that the action by the aircraft manufacturer will, when included in the maintenance manual wiring diagram, adequately address the safety issue.

Replacement cabin altitude warning pressure switch documentation

Minor safety issue

The aircraft maintenance manuals did not include the operating specifications of the replacement cabin altitude warning pressure switch, hampering the required verification of switch serviceability.

Action by the aircraft manufacturer

In response to this occurrence, the aircraft manufacturer advised that:

> The 101-384028-47 switch is a replacement for the 101-384028-3 switch and has the same pressure parameters as the -3 switch; 10,500+000/-500 feet. The Electrical Wiring Diagram parts listing will contain the following at the next revision “Order 101-384028-47 for spares.”

ATSB assessment of action

The ATSB is satisfied that the action by the aircraft manufacturer will, when implemented, adequately address the safety issue.

Aircraft operator

No organisational or systemic issues were identified during the investigation for which the operator was responsible. However, as a result of this occurrence, the aircraft operator advised of the following proactive safety action.

Pressurisation checks

No later than October 2009, the operator had re-briefed all pilots on the aircraft’s pressurisation system. In addition, the operator devised and implemented a change to Part B of its Beechcraft B1900 and Beechcraft King Air C90 Operating Procedures. Those changes stated that:

> Crew should scan the pressurisation gauge during the climb check, transition check and every subsequent 5000ft in the climb to ensure cabin pressurisation is normal.

Oxygen mask stowage

The operator reminded all pilots of the content of Part B3.2.2 of the Operations Manual to ensure the correct stowage of the crew oxygen mask such that the microphone and oxygen tube were be plugged in at all times.

Australian Transport Safety Bureau

Cabin pressure warning systems in single-pilot, turbine-powered, pressurised aircraft

The increased effectiveness of an auditory warning in eliciting a response from a pilot in the case of a depressurisation is well known. There is an immediacy to an auditory warning that may not be apparent with visual warnings, and an auditory warning allows events both in and outside a pilot's field of view to be monitored.

The ATSB has previously investigated a number of depressurisation events involving single-pilot, turbine-powered, pressurised aircraft that resulted in the aircraft occupants being fatally injured. On 17 December 2000, the ATSB issued safety recommendation R20000288 to the Civil Aviation Safety Authority (CASA) recommending that an aural depressurisation warning should be mandated in all Beechcraft Super King Air and other applicable aircraft.

In response, CASA recommended to all relevant certificate of registration holders that, if their pressurised aircraft did not have an aural cabin pressure warning, the owner should seriously investigate the installation of such a warning system. That recommendation had little effect, and the take up rate of aural warning systems by operators was very low.

Civil Aviation Safety Authority

In the case of this investigation, no organisational or systematic issues were identified in respect of CASA that might adversely affect the future safety of aircraft operations. However, in response to this incident, CASA advised that it would revisit its earlier consideration of the installation of aural cabin pressure warning systems in single-pilot, turbine-powered, pressurised aircraft. As a result of that work, on 13 October 2010, CASA circulated a letter to the owners/operators of those aircraft advising them, in part, of the following proposed action:[23]

> Due to continued occurrences of depressurisation events in single pilot turbine powered aircraft, CASA is now considering mandating the fitment of aural cabin pressure warning systems to all single pilot, turbine powered, pressurised aircraft.

CASA requested responses to that proposal by Friday 19 November 2010 for their consideration.

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23 The whole text of the CASA letter is at Appendix B.

Subsequently, on 15 June 2011, CASA provided the following update in respect of mandating the installation of aural warning systems in single-pilot, turbine-powered aircraft:

> Page 22 of the [draft ATSB] report [AO-2009-044] indicates that CASA circulated a letter to owners/operators of relevant aircraft advising that it was considering mandating the fitment of aural cabin pressure warning systems to all single pilot, turbine powered, pressurised aircraft. CASA requested responses to this proposal by Friday, 19 November 2010. Industry response to fitment of an aural cabin pressure warning system was not favourable. The proposed fitment would be a uniquely Australian requirement. In addition to the negative responses to the letter regarding fitment, CASA was also unable to find support for the proposal to mandate the fitment of an aural warning device from the FAA, the State of Design for the aircraft. After due consideration, CASA will not mandate the fitment of such a warning system at this time.
>
> CASA conducted its own investigation into the incorrectly wired pressurisation gauge [sic][24], and took appropriate action in relation to identified maintenance issues.
>
> The manufacturer has taken action to improve the assured function of the cabin altitude warning pressure switch resulting in a more reliable visual warning of falling cabin pressure.

The ATSB acknowledges the safety action by CASA and the industry to date in consideration of the need to mandate the installation of aural cabin pressure warning systems in single-pilot, turbine-powered, pressurised aircraft in Australia. The ATSB can understand CASA’s and the industry’s preference to not mandate uniquely Australian requirements.

However, the ATSB remains concerned with the continuing incidence of serious incidents and fatal accidents in which the occupants of single-pilot, turbine-powered, pressurised aircraft have been affected by, or have succumbed to unrecognised hypoxia in an unpressurised cabin. In those occurrences, the pilots have either not noticed existing visual warning systems, or those systems failed to operate correctly.

Following two of the more serious of those occurrences, one of which resulted in the death of the eight people in Australia in 2000, a number of operators have proactively fitted aural warning systems to their aircraft. Such equipment is manufactured in Australia for a purchase price of about $1,000.

The Australian aural warning system provides a voice prompt warning through the aircraft’s cockpit speakers and via the pilot’s radio headset. The ATSB has been advised by the manufacturer of that system that an enhanced system, with a separate cabin pressure sensor to that already in the aircraft, could be produced for about $1,250.

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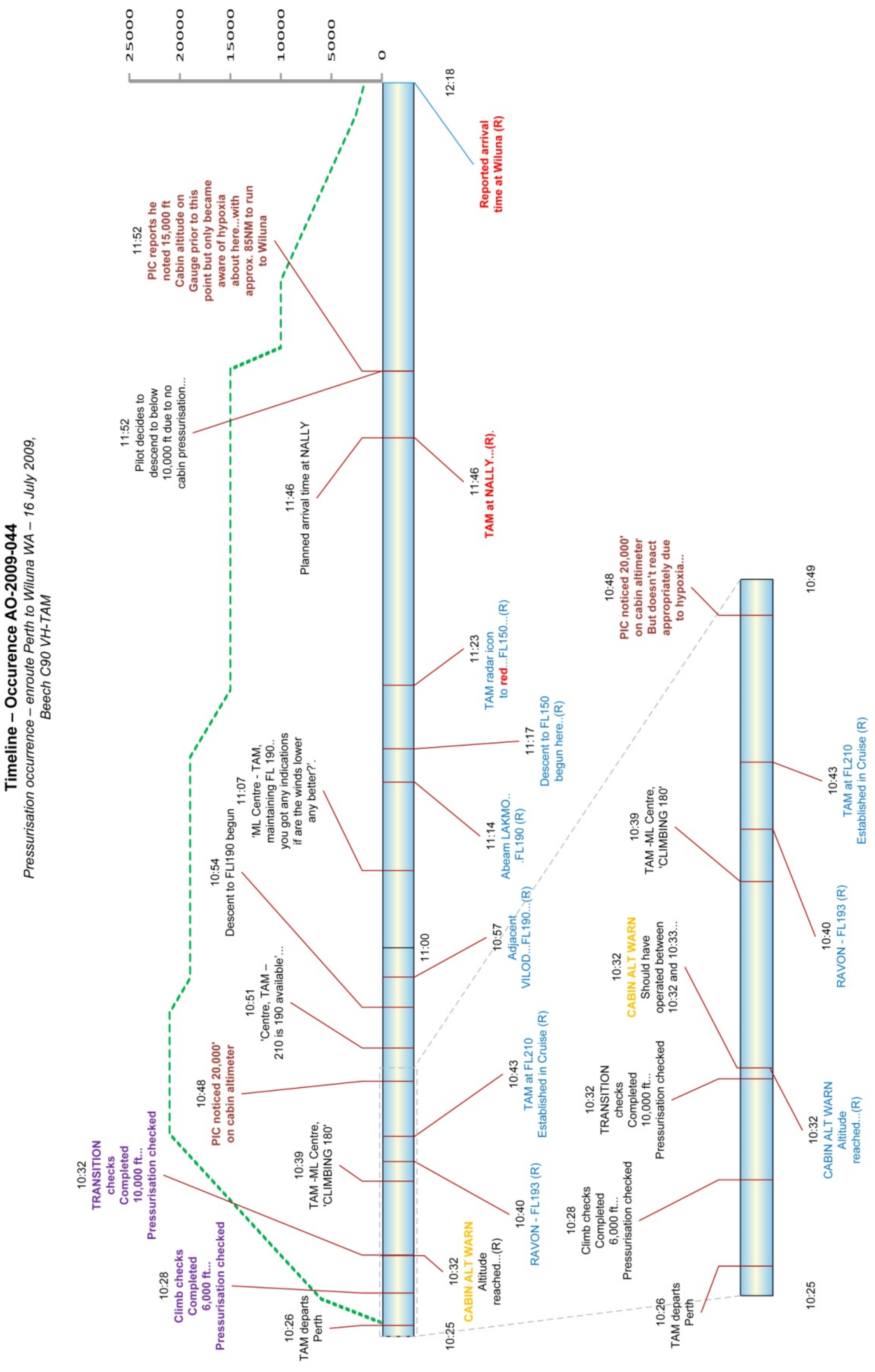
24 Actually the cabin altitude warning pressure switch (see the section of this report titled *Cabin altitude warning system maintenance and documentation - system maintenance*).

Considering the probable serious outcome if an aircraft's existing visual depressurisation warning is missed, or fails to operate, this additional and independent system would represent a valid additional safety defence in the case of depressurisation. On that basis, the ATSB issues the following safety advisory notice.

ATSB safety advisory notice A0-2009-044-SAN-068

The Australian Transport Safety Bureau encourages all operators of single-pilot, turbine-powered, pressurised aircraft to consider the installation of an aural cabin altitude pressure warning system that operates separately to their aircraft's visual warning system.

APPENDIX A: OCCURRENCE TIMELINE



APPENDIX B: CIVIL AVIATION SAFETY AUTHORITY MANDATORY AURAL WARNING PROPOSAL LETTER

Australian Government

Civil Aviation Safety Authority

Standards Development & Future Technology Division

File Ref: EF09/8039

13 October 2010

OWNER AND OPERATORS OF AUSTRALIAN-REGISTERED PRESSURISED AIRCRAFT

Aural cabin pressure warning system

In 2000 the Australian Air Transport Safety Bureau (ATSB) recommended that the Civil Aviation Safety Authority (CASA) make it mandatory for all Beech 200 and other applicable aircraft to be equipped with an aural warning of low cabin pressure. This recommendation[1] was based on an incident in which a Beech 200 aircraft suffered an uncommanded cabin depressurisation. The visual warning system activated but the pilot's performance was degraded to the point that he did not respond correctly. In that incident an accident was avoided by the actions of a passenger.

On 4 September 2000 a Beech 200 aircraft took off from Perth and flew for five hours before crashing in Queensland. There were no survivors. The ATSB investigation concluded that, while there are several possible reasons for the pilot and passengers being incapacitated, this was probably a result of hypobaric hypoxia due to the aircraft being fully or partially unpressurised and the occupants not receiving supplemental oxygen.

In addition to the above, on 20 July 2009, the pilot of a Beech C90 aircraft also reported an incident where he suffered effects of hypoxia probably due to an uncommanded cabin depressurisation.

Cabin altitude significantly above 10,000 feet leads to hypoxia, a condition which impairs human performance, caused by inadequate oxygen in the blood. One of the early symptoms of hypoxia is impairment of vision and deterioration of situational awareness. There is general consensus that when suffering hypoxia a pilot's ability to react to an aural warning is impaired less rapidly than the ability to react to a visual warning. In an uncommanded cabin depressurisation the occupants' physical and mental functions will suffer progressive impairment and early recognition and rectification of the situation is vital.

Aural warning recommended

CASA responded to the ATSB recommendation by publishing a Discussion Paper in 2001 and a Notice of Proposed Rule Making (NPRM) in 2002. Both these consultation

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[1] [1] ATSB Recommendation 20000288

GPO Box 2005 Canberra ACT 2601 Telephone 131 757

Canberra, Brisbane, Darwin, Cairns, Townsville, Tamworth, Bankstown, Mascot, Moorabbin, Melbourne, Adelaide, Perth

documents proposed that CASA would issue an Airworthiness Directive to mandate an aural cabin pressure warning in turbine engine, pressurised aircraft. The response of the aviation community to the NPRM was mixed, but the most persuasive responses were opposed to CASA's proposed action. In particular, it was indicated that the cost of mandatory fitting of aural warnings could be prohibitive for some aircraft.

As a result, CASA decided not to mandate aural cabin pressure warnings in any aircraft at that time.

For many years CASA has, however, strongly recommended that the cabin pressure warning system in pressurised aircraft include an aural warning in addition to the visual warning. Recent technology advances indicate that lower-cost aural cabin pressure warning systems are now more readily available.

Safety measure
An aural cabin pressure warning system is a positive safety measure for all pressurised aircraft. Clearly, the benefit could be substantial for an aircraft operated by a single pilot, especially for an aircraft that routinely operates at high altitude, above 18,000 feet. If your pressurised aircraft does not have aural cabin pressure warning and is routinely operated above 18,000 feet, by a single pilot, CASA strongly recommends you give prompt consideration to the use of an aural cabin pressure warning system.

While CASA has not yet made it mandatory for pressurised aircraft to be equipped with aural cabin pressure warning systems, it strongly encourages each operator of a pressurised aircraft to give serious consideration to the benefit of voluntarily using such a system, if the aircraft presently has only a visual warning system.

Proposed Action
Due to continued occurrences of depressurisation events in single pilot turbine powered aircraft, CASA is now considering mandating the fitment of aural cabin pressure warning systems to all single pilot, turbine powered, pressurised aircraft.

If you are the owner, or registered operator, of an aircraft that will be affected by a mandate of these systems, we are seeking your feedback on this proposal. Your comments can be provided to [CASA Officer] by Friday 19 November.

Yours sincerely

[CASA Officer]

APPENDIX C: SOURCES AND SUBMISSIONS

Sources of information included:

The sources of information for the investigation included the:

- pilot of VH-TAM (TAM)
- owner of TAM
- operator of TAM
- maintenance personnel
- aircraft manufacturer
- Civil Aviation Safety Authority (CASA)
- Bureau of Meteorology.

Submissions

Under Part 4, Division 2 (Investigation Reports), Section 26 of the *Transport Safety Investigation Act 2003* (the Act), the Australian Transport Safety Bureau (ATSB) may provide a draft report, on a confidential basis, to any person whom the ATSB considers appropriate. Section 26 (1) (a) of the Act allows a person receiving a draft report to make submissions to the ATSB about the draft report.

A draft of this report was provided to: CASA; the pilot, owner and operator of TAM; the personnel responsible for the aircraft’s maintenance and who carried out the post-occurrence maintenance investigation; and the aircraft manufacturer.

All submissions from those parties were reviewed and, where considered appropriate, the text of the draft report was amended accordingly.

Air system event - 74 km NE of Perth Airport, WA, 16 July 2009,
VH-TAM, Beechcraft King Air C90