Australian Government

Australian Transport Safety Bureau

ATSB RESEARCH AND ANALYSIS REPORT

B2006/0142

Final

Depressurisation Accidents and Incidents Involving Australian Civil Aircraft

1 January 1975 to 31 March 2006

Dr David G. Newman

MB, BS, DAvMed, PhD, MRAeS, FAICD, AFAIM

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Depressurisation Accidents and Incidents Involving Australian Civil Aircraft: 1 January 1975 to 31 March 2006

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EXECUTIVE SUMMARY

Commercial aircraft involved in high altitude operations are generally pressurised to protect the occupants from the adverse effects of hypoxia, decompression illness and hypothermia. Failure of the pressurisation system is a potential threat to flight safety. The purpose of this study was to determine the prevalence and consequences of aircraft decompression events in Australian civil aviation. The aim was to document the prevalence, nature, type, degree and extent of decompression events in Australian civil aviation, as well as the consequences of such events, especially hypoxia and pressure-related medical effects. A search of all incidents and accidents on the ATSB database was made for pressurisation failure events between 1 January 1975 and 31 March 2006. A total of 517 pressurisation failure events were found (two accidents, eight serious incidents and 507 incidents). Only one pressurisation failure event was fatal (0.2 per cent of the total events). Hypoxia was reported in four of the events, and ear barotrauma was also reported in four events, due to the subsequent emergency descent. A total of 10 events involved death, hypoxia or minor injury. Mechanical factors were responsible for the majority of pressurisation system failures (73 per cent). The average rate of cabin pressure change was 1,700 feet per minute, and the average maximum cabin altitude reached was 10,978 feet. In general, the results of this study show 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. Aircrew should maintain a high level of vigilance with respect to the potential hazards of cabin pressurisation system failure.

ABBREVIATIONS

ATSB	Australian Transport Safety Bureau
fpm	Feet per minute
TUC	Time of useful consciousness
US	United States

1 INTRODUCTION

While commercial jet aircraft operate most efficiently at high altitudes, humans do not survive for long at such altitudes. To ensure passenger comfort and survivability at the high cruising altitudes of jet aircraft, the passenger cabin of the aircraft is generally pressurised to a much lower altitude than the ambient cruising altitude. In general, cabin pressurisation systems are designed to provide a cabin altitude lower than 10,000 feet, so that the risks of hypoxia, decompression illness, and hypothermia are avoided and minimised (see references 8, 12, 14).

Passenger-carrying aircraft involved in commercial transport operations almost exclusively have high differential cabin pressurisation systems (12-14, 20). The term “high differential” refers to the large difference between the cabin pressure and the ambient atmospheric pressure at the altitude at which the aircraft is operating. The maximum differential pressure varies with aircraft type and design, but for each aircraft this value represents a structural limit.

Modern cabin pressurisation systems generally result in a cabin pressure equivalent to an altitude in the range of 4,000 to 8,000 feet at an ambient aircraft altitude anywhere from 30,000 to 40,000 feet (12, 17). Changes in cabin pressure are kept to a minimum to avoid uncomfortable pressure change effects in the passengers. The recommended rates of cabin pressure change are 500 feet per minute (fpm) during the climb phase of flight, and 300 fpm during the descent phase (13). These values can be controlled by the crew, but the automatic mode usually operates at these recommended values.

Since the development of regular public transport air operations, there have been a number of well-publicised events in which failure of the cabin pressurisation system occurred. The series of Comet disasters in the early days of commercial jet aircraft operations brought to the public eye the importance of structural integrity of the aircraft cabin. Catastrophic failure of the pressure cabin led to the loss of three aircraft and all crew and passengers (2, 9). Aloha Airlines Flight 243 on 28 April 1988 suffered an explosive decompression at 24,000 feet when a large part of the ceiling section of the forward passenger cabin of the Boeing 737 detached in flight (10, 15). In this case, only one person was lost – a flight attendant who was walking down the aisle at the moment of the cabin failure. The aircraft was subsequently landed successfully, and although a number of passengers were injured, all survived. In recent years, in addition to Australia’s fatal accident[1], there have been several other occurrences – Payne Stewart’s Lear Jet accident (18), United Airlines Flight 811, where a cargo door separated in flight with a section of fuselage (11) and the Helios Boeing 737 accident, in which a presumed cabin pressure failure led to the loss of the aircraft and all on board.

The purpose of this study was to determine the prevalence and consequences of aircraft decompression events in Australian civil aviation. The aim was to document the prevalence, nature, type, degree and extent of decompression events in Australian civil aviation, as well as the consequences of such events, especially hypoxia and pressure-related medical effects.

1 The ATSB report on the so-called ‘ghost flight’ involving the fatalities of the pilot and seven passengers of a Beech Super King Air 200 VH-SKC on 4 September 2000 (BO/200003771) released in March 2001.

2 METHODOLOGY

2.1 Data sources

A comprehensive search of the accident and incident database held and managed by the Australian Transport Safety Bureau (ATSB) was conducted. The search period was from 1 January 1975 to 31 March 2006. The database was searched for terms such as depressurisation, pressurisation system malfunction, life support system failure, and decompression.

The ATSB database records events according to occurrence type in accordance with the *Transport Safety Investigation Act 2003*. The occurrence types searched were accidents, serious incidents and incidents. The ATSB definition of an accident is "an investigable matter involving a transport vehicle where: (a) a person dies or suffers serious injury as a result of an occurrence associated with the operation of the vehicle; or (b) the vehicle is destroyed or seriously damaged as a result of an occurrence associated with the operation of the vehicle; or (c) any property is destroyed or seriously damaged as a result of an occurrence associated with the operation of the vehicle."

A serious incident is an occurrence involving circumstances indicating that an accident nearly occurred. According to the International Civil Aviation Organization, the difference between an accident and a serious incident is essentially in terms of the end result. An incident is defined as all other investigable and reportable matters where safety was potentially affected.

2.2 Method of analysis

The data collected was then tabulated in a commercially-available spreadsheet program and analysed. For each event, the following parameters were recorded: occurrence date, occurrence type, event type, occurrence altitude, maximum cabin altitude reached, rate of change of cabin altitude, aircraft manufacturer, aircraft type, nature of operations, highest injury level sustained, type of injury sustained, and cause of pressurisation system failure.

3 RESULTS

The ATSB database, for the search period 1 January 1975 to 31 March 2006, comprised an all-cause, all-classification total of 8,302 accidents, 95 serious incidents, and 151,941 incidents, giving an overall occurrence total for the study period of 160,338 occurrences.

3.1 Pressurisation failure events by occurrence type

In terms of loss of cabin pressurisation events for the study period, there were a total of 517 occurrences. As such, depressurisation events accounted for only 0.3 per cent of the total number of ATSB occurrences held in the database. Of the 517 depressurisation events, two were classed as accidents, eight as serious incidents and 507 as incidents. These figures are shown in table 1.

Table 1: Pressurisation failure events by occurrence type

Occurrence type	Number
Accident	2
Serious Incident	8
Incident	507
Total	***517***

3.2 Pressurisation failure events by operation type

Table 2 shows the type of air operations being conducted for each event. Sixty-seven per cent of these events occurred in airline operations, involving both low capacity and high capacity air transport operations. Charter operations comprised the next most common type of air operations (15 per cent).

Table 2: Pressurisation failure events by operation type

Operation type	Number	Percentage of total
Airlines	344	66.5%
Business	8	1.5%
Charter	78	15.1%
Commuter	16	3.1%
Flying Training	3	0.6%
Military	19	3.7%
Other Aerial Work	34	6.6%
Private	10	1.9%
Unknown	5	1.0%
Total	***517***	***100%***

3.3 Pressurisation failure events by aircraft type

Table 3 shows the aircraft types involved in these events. Sixty-two different aircraft types from 26 different aircraft manufacturers were represented in the study period, reflecting the diverse and wide variety of the civil aircraft fleet operated in Australia. The vast majority of depressurisation events occurred in the large passenger-carrying commercial transport aircraft category. This is not surprising, given that these aircraft fly the most frequently and have the highest pressure differential.

Table 3: Pressurisation failure events by aircraft type

Manufacturer	Aircraft type	Number
Aero Commander Div	690	5
Aeronautica Macchi S.P.A.	MB-326	1
Airbus	A300	4
Airbus	A310	3
Airbus	A320-211	17
Airbus	A330-342	1
Airbus	A340	1
Armstrong Whitworth Aircraft	AW650-222	2
Avions Marcel Dassault	Falcon 200	1
Beech Aircraft Corp	200	55
Beech Aircraft Corp	1900D	7
Beech Aircraft Corp	65-A90	1
Beech Aircraft Corp	A23-24	1
Beech Aircraft Corp	A60	1
Beech Aircraft Corp	B300	1
Beechcraft/British Aerospace	BH125-F400A	2
Boeing Co	727	20
Boeing Co	737	82
Boeing Co	747	25
Boeing Co	767	19
Boeing Co	707-338C	1
Boeing Co	717-200	2
Boeing Co	777-21BER	1
Bombardier Aerospace	Learjet 45	1
British Aerospace Plc	748	1
British Aerospace Plc	3107	4
British Aerospace Plc	BAe 146-100	20
British Aircraft Corp	BAC 1-11	1
Cessna Aircraft Company	340	1

Table 3: Continued

Manufacturer	Aircraft type	Number
Cessna Aircraft Company	425	1
Cessna Aircraft Company	441	27
Cessna Aircraft Company	500	4
Cessna Aircraft Company	550	6
Cessna Aircraft Company	414A	1
Cessna Aircraft Company	421B	1
de Havilland Canada	DHC-8-102	27
Douglas Aircraft Co Inc	DC9-31	21
Embraer-Empresa Brasileira de Aeronautica	EMB-120 ER	9
Fairchild Industries Inc	SA227-AC	15
Fokker B.V.	F100	1
Fokker B.V.	F27 MK 100	32
Fokker B.V.	F28 MK 100	22
Gates Learjet Corporation	35	11
Gates Learjet Corporation	45	1
Gates Learjet Corporation	24D	1
Gulfstream/Aerospace Corp	695A	1
Gulfstream/Aerospace Corp	Gulfstream I	1
Gulfstream/Aerospace Corp	Gulfstream IV	1
Israel Aircraft Industries Ltd	1124	7
Lockheed Aircraft Corp	188A	2
Lockheed Georgia Co	C-130	7
McDonnell Douglas Corporation	DC-10	3
Mitsubishi Aircraft Int	MU-2B	4
Pilatus Aircraft Ltd	PC-12	5
Piper Aircraft Corp	PA-31	4
Piper Aircraft Corp	PA-42	1
Piper Aircraft Corp	PA-46	1
Rockwell International	685	1
Rockwell International	690A	2
Saab Aircraft AB	SF-340A	4
Swearingen Aviation Corp	SA226-T	11
Unknown	Aeroplane	1
Total		***517***

3.4 Pressurisation failure events by cause

Table 4 details the reasons for the loss of cabin pressurisation. The most common cause of pressurisation system failure was malfunction of the control system. Twenty-seven cases were due to human error, consisting of 16 cases of operator error (ie flight deck crew) and 11 cases that occurred as a result of maintenance errors.

Structural failures were rare, and only happened in two events. In one event, the structural failure was a loss of a fuselage panel, leading to an explosive decompression. The other event occurred in a Beech 200 aircraft involved in low capacity air transport operations, with two crew and nine passengers on board. At an airspeed of 200 knots, and descending through 17,000 feet en-route to Sydney, New South Wales, the main cabin door separated from the aircraft. After a rapid descent was carried out to 11,000 feet, the aircraft successfully landed at Sydney. There were no injuries sustained in either of these cases. Door seal problems, faulty door locks, and leaking and/or cracking of windows occurred in 78 events (or 15 per cent of the total cases).

Excluding the non-specified cause and those due to human error, the rest of the causes can all be collectively grouped under mechanical causes, which as a single group account for 73.7 per cent of all pressurisation system failures.

Table 4: Pressurisation failure events by cause

Operation type	Number	Percentage of total
Air leak	2	0.4%
Control problem	228	44.1%
Door problem	62	12.0%
Engine failure	1	0.2%
Maintenance error	11	2.1%
Operator error	16	3.1%
Outflow valve problem	28	5.4%
Seal problem	2	0.4%
Structural problem	2	0.4%
System failure	42	8.1%
Window failure	14	2.7%
Not specified	109	21.1%
Total	***517***	***100%***

3.5 Pressurisation failure events by injuries sustained

Table 5 shows the injury outcomes for the 517 depressurisation events.

Table 5: Pressurisation failure events by injuries sustained

Injury level	Number	Percentage of total
Fatal	1	0.2%
Major	4	0.8%
Minor	5	0.9%
None	507	98.1%
Total	***517***	***100%***

Only one occurrence resulted in the loss of an aircraft and fatal injuries to the occupants. This case involved a Beech 200 on a charter operation with one pilot and seven passengers. The aircraft departed Perth, Western Australia, but not long into the flight all occupants had apparently lapsed into unconsciousness. Five hours after taking off from Perth, the aircraft impacted the ground in Queensland, and was destroyed. The investigation concluded that “the incapacitation of the pilot and passengers was probably a result of hypobaric hypoxia due to the aircraft being fully or partially unpressurised and their not receiving supplemental oxygen.” This case represents 0.2 per cent of the depressurisation events in this study period. Put another way, the chances of surviving an aircraft depressurisation event are 99.8 per cent.

There were only a small number of depressurisation occurrences in which injuries to either the crew or the passengers were reported. For the purposes of this analysis, symptoms and or signs of hypoxia were assessed as a major injury, given the potential adverse flight safety outcome of such an event in the crew; even though the hypoxic insult was temporary and no persistent effects were reported. There were four events in which passengers sustained minor ear problems (most likely otic barotrauma) due usually to the emergency descent initiated by the crew following the depressurisation. All of these events occurred in high capacity air transport operations involving airline aircraft (McDonnell Douglas DC-9, Boeing 727, 737 and 747). One of these events involved a depressurisation at 37,000 feet when, for a short period of time, the cabin pressure indicated a 1,500 fpm rate of descent.

There were also four events in which hypoxia symptoms were reported (0.8 per cent of total depressurisation events). Only one of these involved loss of consciousness of the pilot, who was a military pilot operating a civil-registered Beech 200 aircraft. The other crew of this aircraft managed to initiate a descent and the aircraft was successfully landed[2]. In another case, the pilot of a Boeing 737-700 on a high capacity air transport operation suffered symptoms of light-headedness and nausea at 40,000 feet. The aircraft cabin altitude was observed to be climbing at 4,000 fpm. The aircraft descended to 10,000 feet and continued on to its destination. No other

2 The ATSB issued several safety recommendations associated with this investigation report (BO/199902928) on the subject of oxygen systems, including cabin alert aural warning systems.

injuries were sustained in this event. The other two cases involved cabin crew reporting mild symptoms of hypoxia on board a Fokker 27 at 25,000 feet, and a Rockwell International 685 pilot who suffered symptoms of hypoxia following cabin pressurisation failure during climb. Both aircraft subsequently landed without further incident.

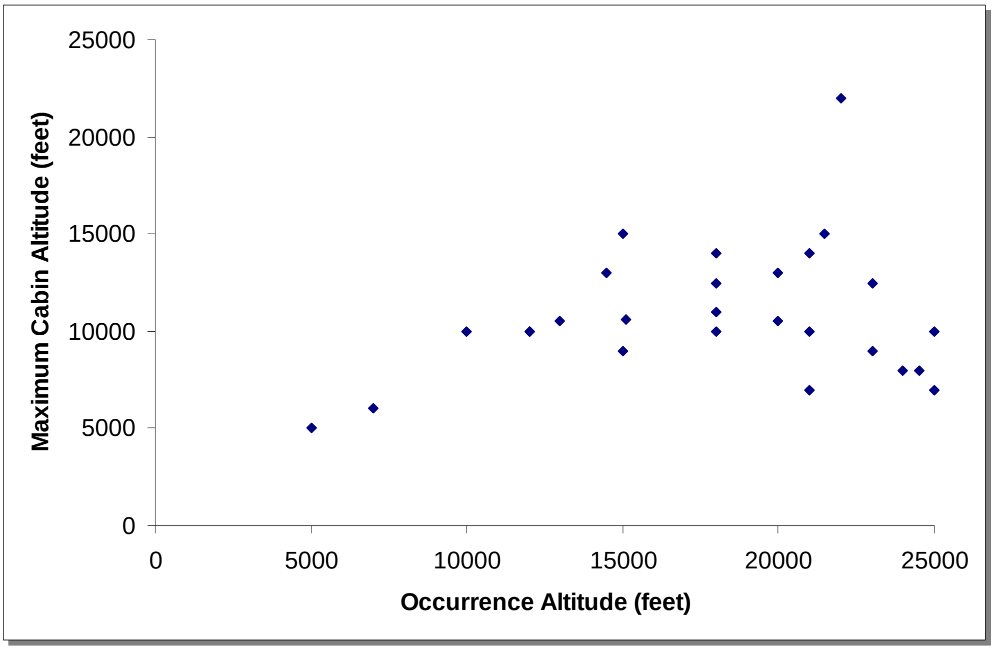
One incident was reported in which 13 passengers' sustained minor injuries, although the nature of these minor injuries was not specified. There were no reports of decompression illness being sustained by either crew or passengers, no occupants were lost from the aircraft through the mass flow of air associated with breach of the cabin pressure vessel (as with loss of a door or window).

Of a total of 517 depressurisation events, only 10 involved loss of life or any form of injury. This suggests that in 507 cases, or 98 per cent of events, there were no reported injuries (either physical or physiological) sustained by the crew or passengers.

3.6 Cabin altitude

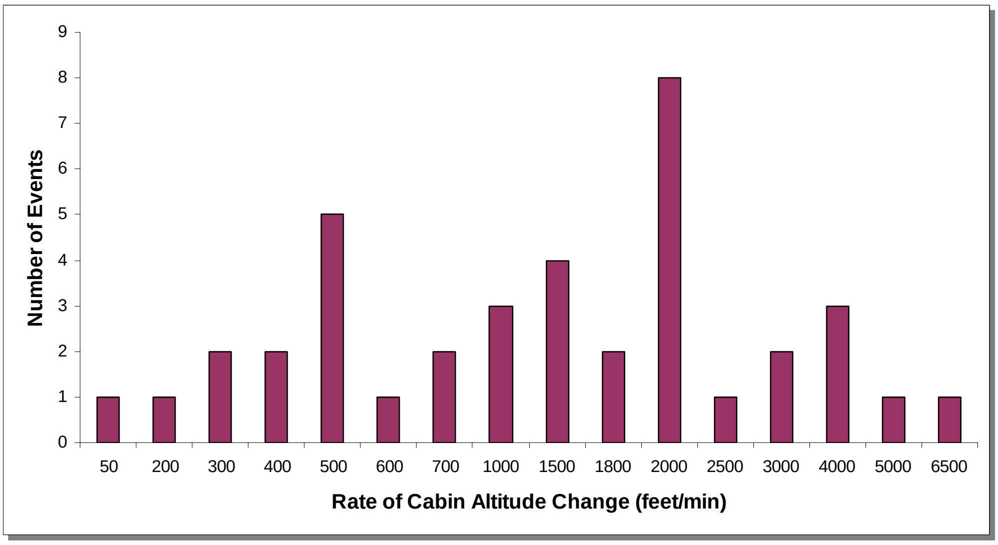
Figure 1 shows the maximum cabin altitude reached during the depressurisation as a function of the altitude of the aircraft when the pressurisation failure occurred. Only 55 events were recorded in the ATSB database where this information was available for analysis. The highest maximum cabin altitude reached was 22,000 feet, following an instantaneous dumping of the cabin pressure at a cruising altitude of 22,000 feet in a Fairchild SA227C on a charter flight. Only six depressurisation events resulted in a cabin altitude of greater than 14,000 feet being reached. The average cabin altitude reached was 10,978 feet, at an average occurrence aircraft altitude of 25,800 feet.

Figure 1: Maximum cabin altitude reached as a function of occurrence altitude



In 39 cases, information regarding the rate of cabin altitude change was available. This data is shown in figure 2. The most common rate of decompression was 2,000 fpm (20 per cent of events). Using this value as a cut-off value, 23 events (59 per cent) involved a rate of cabin altitude change less than 2,000 fpm, while 16 events (41 per cent) involved a cabin altitude change equal or greater than 2,000 fpm. The maximum rate of cabin altitude change was 6,500 fpm, in only one event. The average rate of cabin altitude change was 1,712 fpm.

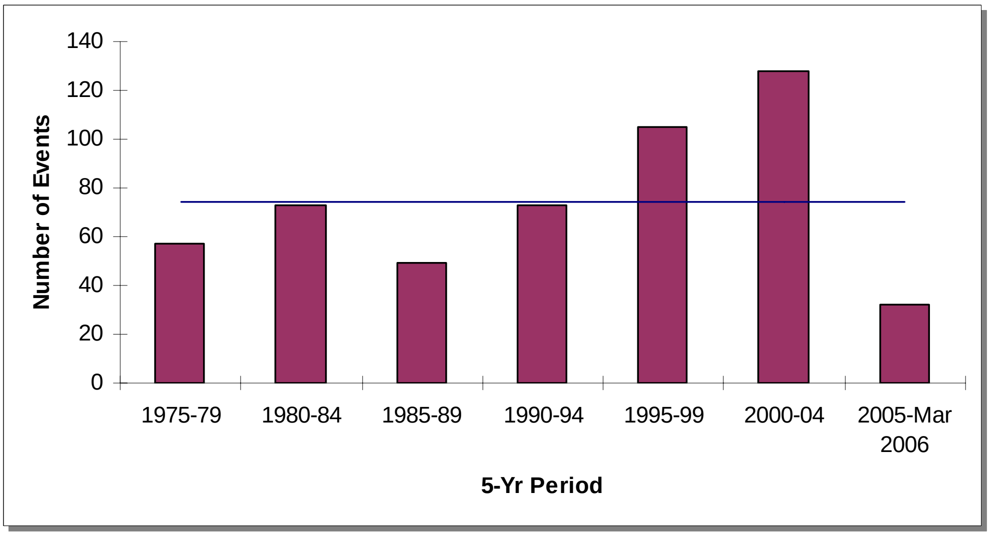
Figure 2: Rate of change of cabin altitude



3.7 Depressurisation events by 5-year periods

Figure 3 shows the incidence of these occurrences in 5-year epochs across the study period. The majority of the reported occurrences in the study period were in the 2000 to 2004 period. The average number of depressurisation events per 5-year epoch is 74 (shown on the graph). The 2005 to 31 March 2006 epoch represents an incomplete 5-year epoch (15 months rather than 60). The apparent increase in depressurisation incidents from 1985-89, to a peak in 2000-04 may be due to several factors, such as changes in reporting and recording of events, differences in aircraft fleet composition with each epoch, differences in hours flown per 5-year period, etc. In the absence of more information, it is not possible to attribute any specific significance to this apparent trend.

Figure 3: Depressurisation events by 5-year periods



4 DISCUSSION

The overall results of this study show that the risk of a depressurisation problem occurring is low. There is also a corresponding low risk of the aircraft occupants sustaining any form of injury. If cabin pressurisation fails, the most likely outcome would be a gradual loss of cabin pressure (at less than 2,000 fpm), resulting in a maximum cabin altitude of just under 11,000 feet, followed by a controlled descent to safe altitude. The most likely cause of the pressurisation failure would be system malfunction or component failure rather than structural failure of the cabin or a breach of the cabin's integrity. The chances of sustaining any sort of injury are extremely low. Similarly, the chances of experiencing a degree of physiological impairment or symptoms of the hostile environment at altitude such as decompression illness, thermal injury or hypoxia are also very low.

Hypoxia is one of the most significant hazards of operating aircraft at high altitude (1, 6, 7, 8, 12, 16, 18-22). It is defined as a lack of oxygen to the tissues of the body sufficient to cause impairment of function. At the typical cruising altitudes of commercial transport aircraft, the atmosphere contains significantly less oxygen than at ground level. The pressurised cabin is designed to maintain an altitude equivalent to less than 10,000 feet, since this is the threshold altitude above which the signs and symptoms of hypoxia become more marked[3]. These signs and symptoms include (but are not limited to) light-headedness, confusion, tremors, impaired judgement, impaired decision-making, dizziness and ultimately loss of consciousness (8).

Failure of the pressurisation system to maintain a cabin altitude of less than 10,000 feet potentially exposes the aircraft occupants to a high ambient altitude, with a significant potential risk of developing hypoxia (8, 12, 14). This is especially true if the rise in cabin altitude is not detected by the operating crew or made known to them via the aircraft's warning systems. In the event that cabin altitude is not able to be maintained, the carrying out of the appropriate emergency procedures (use of supplemental oxygen and immediate descent to lower altitude, generally 10,000 feet) should ensure the safety and survival of all those on board. It has been demonstrated that delay in the donning of emergency oxygen masks is the most limiting factor in terms of tolerance to hypoxia (16). This is even more crucial when one considers that there is a time of useful consciousness (TUC) associated with exposure to altitude. At 35,000 feet, the TUC is in the order of 2 to 3 minutes, but this time reduces following a rapid decompression (14). This time interval is the time available to a pilot to don the oxygen mask and carry out the emergency procedures. If these actions are not carried out in this time interval, there is a high risk of unconsciousness. Rapid decompression to 40,000 feet can lead to loss of consciousness within 20 seconds (14). Reaction time is thus of critical importance during a cabin pressurisation failure. Clearly the occurrence of hypoxia in a pilot represents a significant potential hazard to flight safety.

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3 Smokers, and those with lung-related ailments such as asthma, may experience symptoms of hypoxia at lower altitudes. The consumption of alcohol can also impact in this manner.

In the present study, there were only four incidents in which hypoxia were reported[4], with one of these resulting in loss of consciousness of one of the pilots. While the rate of hypoxia amounts to only 0.8 per cent of all pressurisation system failure events in this study, it is important to bear in mind that in two of these cases there were significant numbers of passengers on board each of the aircraft involved. Had the pilots of those aircraft lost consciousness due to hypoxia, the end result could well have been significant loss of life.

In two studies involving Canadian Forces aircraft, only two cases (4 per cent) of hypoxia in transport aircraft and three cases (6.4 per cent) in ejection seat-equipped aircraft were recorded out of a total of 47 depressurisation events (4, 5). In a United States (US) Navy survey, there were 41 cases (20 per cent) of hypoxia out of a total series of 205 pressurisation failures (3). Another US study found that hypoxia occurred in 221 out of 1055 depressurisation events, or 20 per cent of cases (8). All of these studies involved military aircraft, many of which (such as fighter aircraft and jet trainer aircraft) have inherently different pressurisation systems. These aircraft tend to have low-differential pressurisation systems, and the nature of their operations exposes them to a greater risk of depressurisation than their civilian counterparts. In that respect, the results of the present study involving Australian civil aircraft are not directly comparable with these military studies. However, there is a paucity of studies investigating depressurisation rates and injury outcomes in civil aircraft.

Two other physiological hazards of altitude include decompression illness and cold. Decompression illness occurs in aviation at a much lower rate than in diving, but the physiological mechanisms are essentially the same. Exposure to sudden reductions in ambient pressure (as occurs with rapid or explosive pressurisation system failure) can lead to nitrogen bubbles forming in the body fluids, leading to the syndrome known as decompression illness. This illness can be incapacitating and even fatal. The threshold altitude for aviation-related decompression illness is 18,000 feet, but in practical terms it is rare below 25,000 feet (14).

Given this, there is a risk of aircraft occupants developing decompression illness in the event of a sudden loss of cabin pressure at cruising altitudes. The time spent at altitude is an important risk factor, and if the emergency descent is initiated immediately, the risks of decompression illness are significantly reduced. In the present study, no signs or symptoms of decompression illness were reported, due largely to the generally slow average rate of aircraft decompression, the relatively low maximum cabin altitude reached (14,000 feet) and the subsequent emergency descent. In the Canadian Forces study involving ejection seat aircraft, there were two cases (4 per cent) of decompression illness out of 47 total pressurisation system failures, and only 11 cases (5 per cent) in the US Navy study involving 205 pressurisation system failures (3, 4). A US study found that decompression illness occurred in 7.9 per cent of events (8). In overall terms, therefore, the risk of sustaining decompression illness as a result of aircraft pressurisation system failure is quite low (8).

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4 A number of other ATSB investigation reports list hypoxia as a possible contributing factor but these were not readily identifiable with the current search software.

Pressurisation system failure also exposes the aircraft occupants to an extremely cold environment. The ambient temperature may well be in the order of -56ºC, and when this is combined with the wind-chill factor associated with the speed of the aircraft through the air, there is potential for cold-related injuries to be experienced by the occupants. Since the aircraft usually initiates an emergency descent, the chances of this happening are relatively low, as the aircraft will reach a lower, warmer altitude within a short space of time (8, 12, 14).

Loss of cabin pressure in an aircraft with a high differential pressurisation system exposes the occupants to considerable pressure-related effects. Any gas contained within the body will expand (in accordance with Boyle's Law), and may cause discomfort and pain. In general terms, most of the pressure-related effects occur as a result of the emergency descent into a higher ambient pressure (8). This directional pressure change is more difficult for some areas of the body (notably the middle ears and sinuses) to cope with. As such, most barotrauma of the ears and sinuses is generally a consequence of descent rather than the initial depressurisation event. This is true in the present study, with most of the injuries being ear-related pressure pain due to the emergency descent.

The fatal event rate in the present study was 0.2 per cent. This compares favourably with other published reports, which cite fatal event rates of 0 per cent (4, 5), 0.4 per cent (8) and 1.5 per cent (3).

It is interesting to examine the causes of depressurisation. In the present study, the majority of the failures were due to some form of mechanical failure, system failure or component failure. Human error and failure of the structural integrity of the cabin were less common. In the Canadian Forces transport aircraft study (involving aircraft with similar high-differential cabin pressurisation systems), the authors found that mechanical problems with the pressurisation system were responsible for 70 per cent of their occurrences (5). The US Navy study also found that mechanical factors were responsible for 73 per cent of their pressurisation system failures (3). The results of the present study in Australian civil aircraft were certainly consistent with these findings, with mechanical factors accounting for 73 per cent of Australian incidents.

In 5.4 per cent of cases, the problem with the pressurisation system was attributed to the outflow valves. Maintaining a constant cabin altitude is a balance between the entry of pressurised air and the outflow of this air. If the outflow valves are not operating properly, cabin altitude will not be maintained at the desired level. Similarly, if there is a leak in the cabin, pressure will be lost. In 14.7 per cent of cases, this leak was due to problems with doors and windows. The leaks were due to several reasons, including faulty door and window seals, cracked windows, or improperly closed doors. In general, these events resulted in inability to maintain the desired cabin altitude, even though the cabin pressurisation system was otherwise working normally. The rate of cabin pressure change in those cases was generally slow, readily identified by the crew, and an uneventful descent was generally carried out.

In the majority of cases in this study where the data was available, the rate of cabin pressure loss was relatively slow. In 59 per cent of cases the rate of cabin pressure change was less than 2,000 fpm, with an average rate of approximately 1,700 fpm. The finding in this study, that most decompressions tend to be relatively slow, is consistent with other studies. Files et al also found that 83 per cent of their series of 1055 depressurisation events involved a slow loss of cabin pressure (8).

It is important to understand why the maximum cabin altitude reached was generally lower than 14,000 feet, even though the aircraft was operating at a much higher altitude when the failure in pressurisation occurred. With the exception of those few events where the cabin pressurisation system failed entirely, or there was a breach of the structural integrity of the aircraft cabin leading to a rapid or explosive decompression, the majority of cases in this series were a result of in-flight failure of one or more components of the system. This means that while the aircraft might be at 35,000 feet, the cabin altitude just before the failure might have been at 6,000 feet. After the failure, the cabin altitude starts to rise, but the aircraft also begins an emergency descent. In many cases (such as a leak in the cabin or a sticking outflow valve) the system is still trying to pressurise the cabin, but not managing to maintain the desired cabin altitude. The end result of these factors is that in most cases the aircraft altitude and the maximum cabin altitude will intersect at an altitude somewhere below 14,000 feet.

5 CONCLUSIONS

Overall, it seems that the risk of suffering a loss of cabin pressurisation in Australian civil aircraft is low. When it does occur, it is likely that it will be due to a system or component failure, with a slow resultant decompression, which is generally recognised by the crew, who will then carry out the emergency procedures adequately. The risk of injury to passengers and crew is small. Nonetheless, vigilance is required, and training and preparedness should be ongoing[5]. The inherent risks of operating in the hostile environment at high altitude must not be taken for granted. While the rate of decompression events is low, the potential risks involved with such an event are considerable, especially if the event is rapid, not recognised by the crew and emergency procedures are not carried out promptly. It is important that the low risk of this event occurring is not translated into complacency. Often the failure of the cabin pressurisation system is unexpected. Given the significant potential risk of hypoxia, pilots need to always be prepared for this contingency.

5 In addition to the ATSB recommendations associated with reports BO/199902928 and BO/200003771, the ATSB is sponsoring a research project on aural warnings.

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