THE UNIVERSITY OF
NEW SOUTH WALES

COMMENTARY ON:

DEPARTMENT OF TRANSPORT, EIRE, AIR ACCIDENT INVESTIGATION UNIT REPORT NO 2010-008: SERIOUS INCIDENT: AIRBUS A319-132 D-AGWK, 27 MAY 2008

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SUMMARY

At 11:33 am, on 27 May 2008, a Germanwings Airbus A319 took off from Dublin airport on a flight to Cologne, Germany. Approximately 8 to 12 minutes into the flight, as the airplane passed 10,000 ft (~3,050 m), the purser contacted the flight crew by intercom to report that cabin crew appeared unresponsive and almost all the passengers had fallen asleep. As the airplane passed 20,000 ft (~6,100 m), the pilot also noted some symptoms of unwellness, and a decision was made for the flight crew to don oxygen masks, declare an emergency (logged at 11:41 am), and return to Dublin airport. The airplane landed at 11:57 am without incident, and was towed to a terminal stand at 12:56 pm, where an AAIU team arrived at 1:08 pm. This meant that passengers were kept on the airplane on the ground for well over an hour. By that time, (possibly because of circulation of fresh air through the ventilation system) crew and passengers appeared to have recovered from any adverse symptoms. Investigations by the AAIU and airline on the day of the flight and the following days was unable to find anything unusual, other than a report of a strong smell in the cabin by two members of a fifteen member team. The airplane was then flown to the Airbus facility at Toulouse, France, where it was subjected to another six days of testing, including flight tests. No abnormalities were identified. On the ground atmospheric testing conducted by the Dublin Airport Fire Service and the airline on the day of the flight and at Airbus, Toulouse some days later, was unable to identify any appreciable levels of atmospheric contaminants, although such monitoring (after the event and after any contaminants have had the opportunity to disperse) is meaningless. The airplane has since returned to service and there has been no recurrence of unwellness in air crew or passengers. While these investigations have been extensive, they have worked on the basis of exclusion of possible causes, and have failed to identify the cause of symptoms in air crew and passengers. Of of the Report's three recommendations, two suggest that Dublin Airport should have adequate medical services, and a third, of having better response procedures so that passengers and crew are not unduly detained in a potentially toxic

environment, are reactive, are not preventive and do not address the root cause of this incident.

INTRODUCTION

The presence of general symptoms of unwellness can be problematic, in terms of identifying causes, diagnosis of any possible health problem(s), and determining appropriate treatment(s).

In the case of such symptoms occurring in people on an airplane in flight, other issues may also arise, such as the hypoxia of flying, or the possibility of poor air quality from bleed air.

This document is a commentary of symptoms of fatigue, unwellness and sleep in aircrew (being either flight crew or cabin crew) on a flight in an Airbus A319 departing Dublin airport on 27 May 2008, and described in a the Air Accident Investigation Unit Report of the Department of Transport, Eire.[1]

TIMELINE

Prior to 27 May 2008

The Airbus A319 D-AGWK airplane first flew on 15 April 2008 (six weeks before the incident), and was therefore fairly new.

27 May 2008

Prior to flight On 27 May 2008, the airplane was on multi-leg flights with flights from Cologne to Munich, Munich to Cologne, and Cologne to Dublin. The airplane was crewed by the same crew for these flights.

11:33 am Airbus A319 departs Dublin Airport

As the airplane passed 10,000 ft (~3050 m) the Purser contacted cockpit by intercom, reporting other cabin crew appeared unresponsive, and that almost all passengers had fallen asleep.

With a maximum vertical speed of 4,656 ft/min, the airplane would have taken over two minutes to travel from 10,000 ft to 20,000 ft.

As the airplane reached 20,000 ft (~6100 m) the Captain:

- noted he was felling unwell (and recalled tingling in his right arm);
- dismissed the possibility of a pressurisation problem when the cabin pressurisation altitude was noted as being 1,700 ft (~540 m);
- decided to don oxygen, declare an emergency, and descend.

11:41 am The airplane declared to Manchester Air Traffic Control that they have a problem and have to return to Dublin.

11:43 am The airplane made a Mayday call to Dublin Air Traffic Control.

11:57 am Airplane landed safely at Dublin; and was held at a remote stand.

12:56 pm The airplane was towed to a terminal stand.

1:08 pm AAIU team arrived; began a preliminary investigation.

After an initial debriefing of flight crew by AAIU and discussions with the Irish Police, passengers were allowed to disembark and escorted to a secure area in the terminal.

After 27 May 2008

The airplane was removed to a maintenance facility at Dublin Airport. Over the next three days, a series of tests was conducted. Apart from a report of a strong smell in the cabin by two members of a fifteen member team (later dismissed as being off-gassing of new interior furnishings in a new airplane), nothing unusual was reported.

After these three days of testing, the airplane was flown to the Airbus facility at Toulouse and subjected to a further six days of testing.

SYMPTOMS REPORTED

Symptoms reported by air crew and passengers included:

Person	Symptoms
Captain	Felt somewhat unwell; later recalled a tingling sensation in his arm
Purser at front of airplane	Felt unwell, noted that the other flight attendant was unresponsive
Flight attendant sitting at front of airplane	Felt tired and somewhat unwell
Flight attendant sitting at rear of airplane	Felt tired, sleepy and dizzy
Flight attendant sitting at rear of airplane	Felt tired and somewhat unwell
Some passengers	Felt drowsy or were asleep

SYMPTOM BASIS FOR HYPOXIA

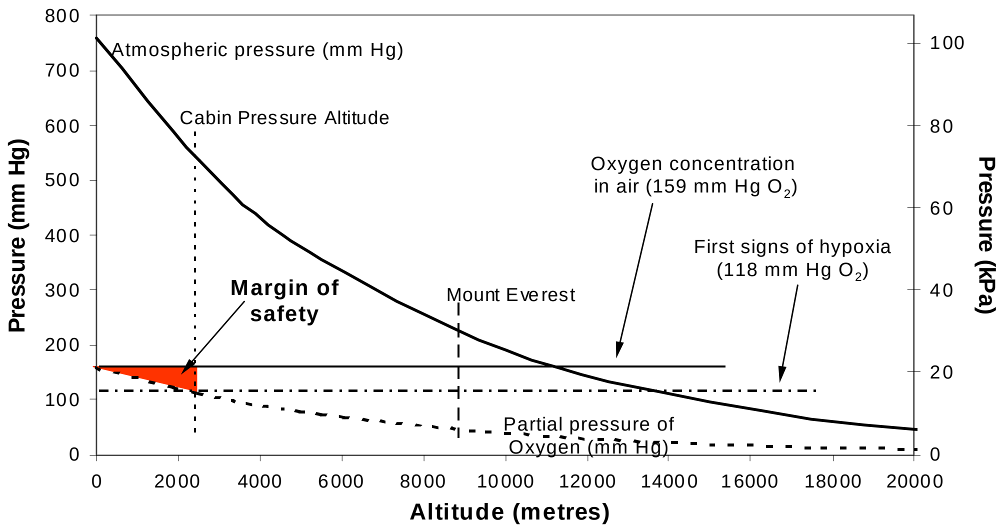
Hypoxia is the lowered presence of oxygen. At sea level, the air contains 20.9% or 159 mm Hg Oxygen (partial pressure). The concentration of oxygen at increasing altitude remains constant, at 20.9%. This suggests that oxygen levels are unchanged. This is not true. Basically, as altitude increases, the atmospheric pressure declines. While the relative proportion of oxygen in air remains unchanged, the actual amount of oxygen in air decreases.

Atmospheric pressure at sea level is 760 mm Hg, with the corresponding partial pressure of oxygen in air is 159 mm Hg (20.9% of 760 mm Hg). The minimum O_2 concentration for work is considered to be about 136 mm Hg (18 kPa or 18%) O_2 in air at sea level.[2] A minimum oxygen partial pressure of 118 mm Hg (equivalent to an altitude of 2,438 m or 8,000 ft) is required to prevent hypoxic cabin air in commercial aircraft during normal operations. This partial pressure is maintained by the cabin pressure system (a second requirement for release of oxygen dispensing units at 4,572 m or 15,000 ft is recommended).[3] As altitude increases the absolute concentration of oxygen falls.

The altitude at which the partial pressure of 136 mm Hg is reached is also quite close to the pressure at which airplane cabins are pressurised (118 mm

Hg). There is little margin of safety in people working at altitude, and in many cases, such workers may start to become hypoxic.[4] This is shown in the Figure below (from[5]), where the area bounded by the dashed partial pressure of Oxygen in Air curve, and the dotted line representing the minimum physiological demand line represents the margin of safety at which workers can be considered to have sufficient oxygen to work safely). Further, the position of the cabin pressurisation line shows that in some cases, workers at altitude may not be obtaining enough oxygen for their physiological requirements.

Figure 1: Pressures and Oxygen Concentrations at Altitude



Assumptions:
Atmospheric pressure: 101 kPa (760 mm Hg) at sea level
Proportional concentration of O_2 in air: 20.9% (21 kPa or 159 mm Hg) at sea level)
Aircraft Pressurisation Pressure: Equivalent to an altitude of 2,500 m (about 8,000 ft).

Other problems with lowered oxygen concentrations include changes in sensitivity to toxic exposures (for example, the toxicity of carbon monoxide is 50% higher at 8,000 ft than at sea level), and the possibility that incipient hypoxia may lead to higher respiratory rates and therefore increased exposure.[6,7,8]

The main symptoms of hypoxia in flight (including from exposure over many hours) are:[9,10]

- At or above 5,000 ft (~1,500 m), the first oxygen dependent process is the body is impaired by hypoxia, of diminished dark adaptation.

For this reason (based on a standard that was set decades ago from studies of healthy servicemen in altitude chambers) the flight deck and passenger cabin of airplanes are usually pressurised to 8,000 ft (~2,500 m).[11]

- At or above 8,000 ft (~2,500 m), effects of hypoxia related fatigue will be felt after many hours.
- At or above 10,000 ft (~3,000 m), the general effects of hypoxia begin. These include los of higher mental functions, such as problem solving, concentration and efficiency.
- At or above 14,000 ft (~4,250 m), a range of symptoms are present, including lassitude, fatigue, clouding of thinking, memory problems, errors in judgement, muscular tremors, and the start of blueness of fingernails or lips (cyanosis).
- At or above 16,000 ft (~4,900 m), symptoms include disorientation, serious loss of mental function, and euphoria or belligerence.
- At or above 18,000 ft (~5,500 m), symptoms include primary shock or loss of consciousness. Symptoms of discomfort due to abdominal gas pain.
- Death may result at higher altitudes. While uncommon, airplanes have been lost with loss of all life where the cabin pressurisation mode selector was in the (manual) position during the performance of the various Pre-flight, Before Start and After Take Off procedures.[12]
- Stagnant hypoxia is a condition in which there is a temporary displacement of blood in the head. It occurs as a result of positive "g" forces (as in an abrupt pull out from a high speed dive), and, can be attributed to the fact that the circulatory system is unable to keep blood pumped to, the head.

This list is included here so that the example of passengers falling asleep can be put into context. As the A319 was pressurised to 1,700 ft (~540 m) (assuming the pressurisation monitor was reading correctly), then it is unlikely that the symptom reported by air crew and passengers was due to hypoxia.

Outside of the aviation industry, other industries may also have problems of oxygen content in places where workers are working. The authorative American Conference of Government Industrial Hygienists (ACGIH) establishes exposure standards for many workplace contaminants and has examined the issue of minimal oxygen content in workplaces. The ACGIH document for the 2008 TLVs® and BEIs® recommends a minimal ambient oxygen pressure of 132 mm Hg, which is equivalent to an altitude of 5,000 feet or ~1,500 m.[13]

This recommendation suggests that an airplane pressured to an altitude of 8000 m (or 118 mm Hg) falls outside of what the ACGIH consider a minimal oxygen concentration for workers. As such, workers in such an environment are working in a specialised environment.

ANALYSIS OF CABIN AIR FOR CONTAMINANTS

Because of the types of symptoms reported, the possibility of exposure to chemical contaminants was suspected. Airborne contaminants are generally divided into two types: gas/vapour and particulates.[14]

While no smell of contamination was reported in this incident, in some cases detection of exposure to chemical contaminants by smell is not always detected before incapacitation (see for example, SHK, 1999 or AAIB, 2004).[15,16]

Testing in the Airplane: Testing by Dublin Airport Fire Service using a Growcon multi-gas detector on the day of the flight did not detect any abnormal levels of flammable or toxic gases, including methane, hydrogen sulphide, carbon monoxide or reduced levels of oxygen. However, monitoring was conducted after the airplane had been on the ground for enough time for any gases to disperse, and for the purposes of identifying any possible contaminants during the flight, would have been fairly pointless.

Some contaminant testing was conducted after the airplane had been transferred to Toulouse.

- Swabs were taken from the air conditioning ducts; no oil residue was found.

- Cabin air recirculation filters were checked for unidentified contaminants; low levels were reported.
- Air quality testing was also conducted after the airplane had been transferred to Toulouse. The basis of the air testing (either sampling or analysis) is not given. "Low" levels of carbon monoxide, carbon dioxide and some volatile organic chemicals were reported. It is not know whether these samples were tested for other contaminants.
- Analysis of cabin air for jet engine oil failed to find any.

In any event, and as with testing on the ground in Dublin, testing conducted some time after any possible contamination is completely pointless. While systems are available for real time collection or analysis of cabin air during air quality problems, they have not been used.

Interpretation of Testing Results: The absence of specific information on the techniques of sampling and assessment makes interpretation of these results problematic. The absence of identity of specific chemicals that were actually monitored makes it difficult to assess the adequacy of the monitoring carried out. It is common in air quality reports to suggest that no adverse concentrations of contaminants have occurred, even though often in such studies only sampling and analysis of a small number of contaminants (usually of a gaseous or vapour form) were actually conducted.[17] Measurement of semi-volatile or particulate contaminants is rarely made. Further, as well as particulate and gas/vapour phases, consideration of the type of airborne contaminants, whether in unchanged, degraded, combusted or pyrolised forms is also critical for the success and relevance of a monitoring program. Unless analysis is made of a full range of gaseous (such as Carbon monoxide), volatile (such as the full range of organic compounds, not just a few), semi-volatile (such as the cresyl phosphates) and particulate contaminants (such as oil mists), the conclusion that air quality was satisfactory cannot be made.

Any levels detected from testing conducted after a number of days on the ground, or after another flight to Toulouse, where the airplane again was on the ground for a number of days, will bear utterly no relationship to any possible contamination during the flight from Dublin on 27 May 2008.

Nevertheless, the data in the AAIU report is presented as if it is representative of that flight.

In the testing conducted at Toulouse, the term "low" is used, is based on a comparison of the concentrations measured with the relevant occupational exposure limit (OEL) for those contaminants. However, the application of OELs at altitude is proscribed. The American Conference of Government Industrial Hygienists recommends a minimal ambient oxygen pressure for occupational environments of 132 mm Hg, equivalent to an altitude up to 5000 ft (~1500 m). As noted above, the flight deck and passenger cabin of airplanes are usually pressurised to 8,000 ft (~2,500 m), therefore OELs have no applicability in airplanes in flight. This is a common misconception in the aviation industry (and is included in the AAIU report). Further, OEL's do not reflect the aircraft cabin environment where contaminants may be present in a mixtures of contaminants, with altered toxicity effects at altitude.[18]

Also, OELs are not protective for everyone. Each regulatory body that recommends OELs usually contains a caution in their lists of OELs that they normally protect "nearly all workers" and therefore: not all workers. The uncritical use of OELs as being no effect levels for everyone is another common misconception in the aviation industry.

Further, OELs only apply to workers, and do not apply to non-workers, such as passengers. People in paid employment tend to be healthier than the population from which they are drawn, and to suggest that a given "acceptable" level for workers is acceptable for everyone is misleading. Indeed, OELs are often orders of magnitude different to environmental ambient standards for everyone. For example, the US EPA eight hour ambient standard for carbon monoxide is 9 ppm, not to be exceeded more than once/year. This compares to an OEL (or the equivalent German Maximale Arbeitsplatzkonzentration) of 30 ppm allowed every shift over an entire working lifetime.

Lastly, OELs apply to single substances, and should not be rigidly applied to situations where exposures to more than one chemical occurs. The possible interactions between the individual chemical components in such exposures are such that uncritical application of exposure standards will not be sufficiently protective.

To recap, OELs do not protect all workers, do not protect passengers, should not be applied without modification in situations where there is exposure to more than one chemical, do not apply is situations of low oxygen concentration, and should not be used in airplanes in flight.[19]

REPORT CONCLUSIONS

The report conclusions note what happened in the incident and briefly report the results of the investigations.

These investigations were fairly predictable, in that standard engineering checklists were followed and these were based on exclusion of possible causes. As such, they have failed to identify the cause of symptoms in air crew and passengers.

This being the case, the only option followed in the report was to minimalise and marginalise the health problems reported:

- Crew symptoms are dismissed as "reports of more serious symptoms (loss of sensation in limns) appear to have been limited to air crew".
- The fact that all six members of the crew reported adverse symptoms is not worthy of further attention, as the "symptoms disappeared when the individual members in question went on oxygen".
- Passengers falling asleep in the very early part of a flight is dismissed to "some passengers reported drowsiness" and "many passengers reported that they did not report anything unusual".

This minimisation of danger is fairly predictable where an organisation or an industry minimises risk through a culture of complacency. As such, these conclusions do nothing to assist in preventing another similar incident and for this one reason alone, are flawed.

REPORT RECOMMENDATIONS

The AAIU makes three recommendations.

The first two relate to the absence of medical services at Dublin Airport, and suggest that the absence of such facilities should be reviewed. This may be true, but is hardly relevant to the problems reported on the flight of the A319 on 27 May 2008. As such, they are not especially relevant to the topic of this report.

The last recommendation relates to a need to ensure that Dublin Airport response procedures do not allow passengers to be detained unduly in a potentially toxic environment following air quality events. This has some relevance to this incident, as the airplane was left on the ground for over an hour with crew and passengers kept on board. However, this recommendation is not preventive and again, is not especially relevant to the topic of this report.

Therefore, no recommendations in this report deal with the root cause of the incident on 27 May 2008. As such the possible causes of adverse symptoms in crew and passengers flying on the A319 on 27 May 2008 remains unknown. However, the description of ill effects are however consistent with previous reports of exposure to aircraft contaminated air,[20] and cannot be dismissed based on the inability of monitoring investigations to detect the source.

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