Aviation air quality. Again.

by Chris Winder and Christiaan van Netten

In December 2000, an International Aviation Air Safety Symposium was held at the Australian Defence Force Academy, Canberra.[1] The symposium was held because aviation air quality had emerged as an occupational health and aviation safety issue (particularly in respect of health problems arising from oil and hydraulic fluid entering the ventilation system of the flight deck and passenger cabin of commercial aircraft (that is, bleed air contamination)). The symposium followed on from the 1999–2000 Australian Senate Inquiry into cabin air safety in the BAe 146, and was held while other inquiries were also looking into this matter (notably, the United Kingdom House of Lords inquiry).[2,3]

The proceedings of the 2000 symposium (published in 2001) were groundbreaking in many ways because the symposium had examined a variety of environmental exposures and health effects of flight crew members that had not been considered to be part of mainstream aviation.

A great deal has happened since 2000. It is therefore timely that this matter be re-examined, the latest findings reviewed, and feedback from the various stakeholders obtained. The recent Contaminated Air Protection Conference (called for by UK members of parliament, Paul Tyler (now Lord Tyler) and John Smith) focused on past and present research/inquiries into a number of relevant issues, for example, contaminated bleed air, the

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medical effects being seen in aircrews and passengers, the ways to detect contaminants, the latest medical and scientific thinking on the medical aspects of exposure, the number of exposure events, the filtration technologies available to remove bleed air contaminants, and so on.

The conference was held at Imperial College, London, on 20–21 April 2005. It was sponsored by the British Airline Pilots Association (BALPA), and co-sponsored by Pall Corporation (a manufacturer and supplier of cabin air quality filtration systems), Sofrance (a manufacturer and supplier of filtration and depollution technologies), and the Aviation Organophosphate Information System (AOPIS; a website and information resource); it was coordinated by Neil Stewart Associates.

Aviation air quality has been called an "issue" — but calling something an issue just buries it. Poor air quality in some types of aircraft is a problem. The word "problem" has negative connotations but is a true reflection of the experiences of aircrew who have to ensure their own safety, and that of the passengers, when exposed to contaminated air while flying.

A selection of papers presented at the conference is reproduced in this special issue of the journal. In all, a wide range of issues were explored.

The political dimension of this problem was covered at the conference by the presentations of two parliamentarians, Paul Tyler of the UK House of Commons and the Reverend John Woodley, former Senator for Queensland in the Australian Senate and Chair of the 1999–2000 Senate Inquiry into cabin air quality in the BAe 146 (see pp 379–400 and pp 401–407 of this issue of the journal).[2] Both remained unconvinced by the activities of aviation regulators and the aviation industry as a whole to properly recognise the importance of the problem.

The toxicological dimension of the problem was addressed by two researchers who have been working the longest on aviation air quality from oil leaks, that is, Professor Christiaan van Netten of the University of British Columbia and Associate Professor Chris Winder of the University of New South Wales. One jet oil used extensively in aviation contains ingredients that are known to cause irritation, sensitisation and neurotoxicity. Exposure to mists and vapours from that oil induces symptoms of irritation, sensitisation and neurotoxicity. The symptoms have occurred on a number of aircraft (the MD-80, the BAe 146, and the B757, to name a few) and seemed consistent enough to suggest a specific condition. While significant underreporting of "exposure events" has occurred, the numbers that have been reported were sufficient to warrant much closer attention. The chemicals involved (known ingredients of jet oils) were the neurotoxic tri-cresyl phosphate, the sensitiser phenyl-alpha-naphthylamine, and the environmentally toxic dioctyldiphenylamine, as well as a wide selection of volatile organic compounds and thermal degradation chemicals that are present in the air during exposure events. Professor Vyvyan Howard from the University of Liverpool focused on possible effects on the developing foetus and made the point that, while there were data gaps, any competent risk assessment would indicate that a prudent, precautionary approach is needed.

The medical dimensions of these problems were addressed by a number of physicians who treated flight attendants and pilots after bleed air incidents. Professor Malcolm Hooper of the University of Sunderland drew similarities between the problems of exposed aircrew and other groups with similar problems, such as organophosphate-exposed farmers or Gulf War veterans. Professor Robert Haley of the University of Texas Southwestern Medical Center used the United States experience with Gulf War Syndrome to illustrate the pitfalls and lessons to be learned when attempting to resolve conditions where chronic but non-specific fatigue, pain and cognitive symptoms arise.

Two physicians working in Western Australia, Dr Moira Somers and Dr Andrew Harper, reported on the cases they had seen, that is, 39 and 60 crew members, respectively (see pp 440–449 and pp 433–439). They reported a striking similarity between exposures, symptoms and outcomes. Dr

Harper went a step further and subjected his findings to *Hill's Criteria of Causation* (which is considered as a cornerstone of establishing causation).[4] He found them to be in agreement, thereby removing one criticism of the medical findings to date (that the medical findings did not meet the criteria for causation). Dr Gunnar Heuser et al reported their findings in 26 flight attendants using physical and neuropsychological examinations, as well as a PET (Positron Emission Tomography) and SPECT (Single Photon Emission Computed Tomography) functional brain scans (see pp 455–459). His study found significant abnormalities and arrived at a diagnosis of toxic encephalopathy in allcases. Dr Jonathon Burdon and Dr Allan Glanville, respiratory physicians working in Melbourne and Sydney, provided evidence of the respiratory problems in 14 BAe 146 aircrew who had been exposed to oil mists and vapours (see pp 450–454). All of these doctors agreed with industry statements that there were short-term effects from exposure to these vapours and mists but, for the first time, their presentations confirmed the existence of long-term, that is, chronic (continuing for longer than 12 months), effects.

The psychological dimension of the problem was addressed by neuropsychologists from Australia and the UK. Dr Sarah Mackenzie Ross of University College, London, reported on the cognitive disabilities in 25 agricultural workers exposed to organophosphate pesticides. Dr Peter Julu and Dr Goran Jamal of Imperial College, London, also reported on their work that looked at organophosphate exposure in sheep dippers. They found that a unique pattern of autonomic dysfunction is part of long-term neurological sequelae of acute organophosphate intoxication or repetitive low-level exposure to the compounds and noted a similarity with pilots tested to date. Leonie Coxon, a clinical and forensic psychologist from Western Australia, reported on her research in workers who are occupationally exposed to neurotoxicants. These workers included eight aircrew flying on the BAe 146 who showed significant cognitive deficits in standardised neuropsychological testing. Professor Abou-Donia of Duke University, Durham, North Carolina has been investigating the toxicity of organophosphorus compounds for over 30 years and provided a wide-ranging review but, most particularly, a description of the condition of organophosphorus ester-induced chronic neurotoxicity, which is characterised by long-term, persistent, chronic neurotoxicity symptoms in individuals who have been exposed to long-term, low-level, subclinical doses of these chemicals (see pp 408–432).

Two papers covered the military aspects of this problem. Dr Bhupinder Singh of the Royal Australian Air Force Institute of Aviation Medicine reported on air leaks in Australian Defence Force aircraft, sources of smoke and fumes, and aircrew protective systems. He also discussed RAAF guidelines for the medical management of exposed aircrew. Dr Wally Masurek of the Australian Defence Science and Technology Organisation reported on contaminant levels in military aircraft. Tri-cresyl phosphate, phenyl-alpha-naphthylamine and dioctyldiphenylamine have been detected in these aircraft, albeit at low levels. Additionally, Professor Christiaan van Netten has detected tri-cresyl phosphate in swab samples from commercial aircraft, including a sample from a pilot's trousers.

The way forward was also discussed at the conference. Dr Byron Jones of Kansas State University discussed the development of American Society of Heating, Refrigerating and Air-Conditioning Engineers standard 161P for *Air Quality Within Commercial Aircraft*. Karen Bull of Pall Aerospace discussed the latest technologies for air filtration systems on commercial aircraft. Pascal Contini, from the Sofrance-Snecma Group, discussed how carbon fibres might assist in filtering and treating contaminated air. Stuart Calwell, an attorney from West Virginia, examined some of the legal issues that might arise if injured aircrew were to challenge their employers over exposure to jet oil mists and vapours and their consequent health effects.

Due to the problems associated with carrying sample collection equipment on aircraft, Professor Christiaan van Netten has developed a tiny gas sampler which can be taken on aircraft and used during exposure events to collect air contaminants which can be analysed later (see pp 460–468). Professor Clem Furlong of the University of Washington has suggested that the study of the normal genetic variability in human populations through toxicant specific biomarkers may provide better answers with regard to toxic exposures and their effects. As such, he has developed a briefcase-sized surface plasmon resonance biosensor system which is capable of detecting airborne toxicants. Dr Laurel Kincl (of the University of Oregon) et al discussed the Occupational Health Research Consortium in Aviation research project, which is divided into four components: incident reporting, incident monitoring, sampling feasibility study and ongoing surveillance study (see pp 469–474). The Aviation Secretary at the International Transport Workers Federation, Ingo Marowsky, restated the need for better maintenance and operating procedures. Finally, BALPA General Secretary Jim McAuslan reflected on the conference findings: there is a problem and it is causing short and long-term health effects in aircrews (see pp 475–477). The problem is happening in the workplace (that is, on aircraft). In spite of the substantial underreporting of bleed air incidents, the problem is already highly significant. Crew and passengers are at risk. With the right will, the problem can be fixed.

Although the conference was organised by a pilot's union, it was poorly attended by the airlines and aviation regulators — which is a pity. Their absence reinforced the feeling by the conference participants that these organisations remain in denial about the aviation air quality problem. To date, the aviation industry has attempted to deal with these problems reactively and somewhat flexibly, as reflected by its response statements to the emerging body of evidence:

> "There are no engine oil leaks."
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> "There may be some engine oil leaks, but they are very uncommon."
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> "There are more than a few engine oil leaks than we would like, but the oil is safe under normal conditions of use."
>
> "The oil may contain hazardous ingredients, but not at levels that affect the health of crew."
>
> "The health problems being reported by our workers are not related to the leaks."
>
> "If there are health problems, they are related to some other health condition."
>
> "There may be a few health problems from exposure to oil leaks, but they are transient or mild, and are reversible."

Somewhere in this sad litany of statements comes the crossover from "spin" to reality. Where the contamination of air in flight decks and passenger cabins occurs, or where it is sufficient to cause symptoms of discomfort, fatigue, irritation or toxicity, this contravenes the air quality provisions of aviation design regulations, which date back to the mid-1960s and which every nation adheres to. The current US Federal Aviation Regulation 25.831 states:

> "(a) Under normal operating conditions and in the event of any probable failure conditions of any system which would adversely affect the ventilating air, the ventilation systems must be designed to provide a sufficient amount of uncontaminated air to enable the crew members to perform their duties without undue discomfort or fatigue and to provide reasonable passenger comfort.
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> (b) Crew and passenger compartment air must be free from harmful or hazardous concentrations of gases or vapors."

Similarly, when suggestions such as having a lower pressurisation level in aircraft or building aircraft that do not need bleed air are made, experts in the aviation industry protest and proclaim that it cannot be done. Nevertheless, the new Boeing 787 "Dreamliner" proves them wrong. The sales pitch for this new generation of aircraft notes that it has "no engine bleed systems architecture" and that passengers will get a better experience because of a lower cabin altitude, that is, at 6,000 ft (1,800 m) instead of 8,000 ft (2,400 m).

The Contaminated Air Protection Conference has established that exposure to oil mists and vapours on aircraft constitutes a serious hazard to aircrew and passengers and is capable of producing long-term health problems: the effects are not "just transient or reversible". It's time for aircraft manufacturers and operators to stop pretending that aviation air quality is not important and to join the vision of at least one aircraft manufacturer that has addressed these issues in its latest design. The challenge, at present, is to expand this vision to the already existing fleet of aircraft.

The following conclusions were distilled from the conference:

There is a workplace problem resulting in acute and chronic illness (among flight and cabin crew).

The workplace in which these illnesses are being induced is the aircraft cabin environment.

This problem is resulting in significant flight safety issues, in addition to unacceptable health implications for aircrew.

Passengers may also be suffering from similar symptoms.

References

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2. Senate Rural and Regional Affairs and Transport References Committee. *Report into air safety and cabin air quality in the BAe 146 aircraft*. Canberra: Parliament of Australia, October 2000.
3. UK House of Lords. *Air travel and health*. Select Committee on Science and Technology. London: UK House of Lords, HMSO, November 2000.
4. Hill, AB. *A short text book of medical statistics*. London: Hodder & Stoughton, 1977.

The full conference proceedings will be published by BALPA and the University of New South Wales in: Winder, C (ed), *Contaminated Air Protection Conference*. Sydney: BALPA and the University of New South Wales, October 2005, ISBN 0 7334 2282 9.