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Cabin Air Quality Monitoring – Organophosphates Sampling during Fume Events in Australia

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Extended Abstract

Purpose: The Australian Federation of Air Pilots (AFAP) presented the results of organophosphate analysis from cabin air sampling on VH-registered aircraft during pilot-reported fume events. As part of a wider Global Cabin Air Reporting System (GCARS) study, AFAP pilot members undertook a small-scale initial trial of the new GCARS reporting tool. Traces of the neurotoxin Tricresyl Phosphate (TCP) had previously been found in air samples taken on board various aircraft in other studies. The AFAP and its pilot members have an ongoing interest in cabin air quality and better understanding the extent and frequency of the incidence of TCP and other organophosphates in reportable fume events.

Methodology: Cabin air samples were collected by pilots during a reportable fume event using a small personal air monitor device – the 'VN sampler'. This small air sampling system employing standard air filter sampling technology was used to monitor cabin air in domestic passenger aircraft flying domestically within Australia over the trial period from July 2018 to June 2019. The device is a small ABS constructed cylinder (5 cm diameter x 9 cm height) that can be readily operated by pilots who were instructed to open the sampler if they detected a reportable fume event and collect ambient cabin air for up to one hour. Once activated, the sampler was in operation for the duration of the flight or for the life of the batteries (approximately 1 hour), whichever is shortest. The VN samplers were returned to a laboratory where the standard 37 mm filters (onto which volatile compounds had adhered) were removed and any organophosphates present were analysed by gas chromatography-mass spectrometry (GC-MS). The only air sampler to be approved by the Federal Aviation Administration, the VN sampler has previously been shown to be capable of monitoring air concentrations of TCP isomers in aircraft above 4.5 ng/m^3 (van Netten 2009). Note: ng, nanogram, 10^{-9} g.

Findings: A set of 20 samples taken by pilots during Australian domestic flights and analysed by GC-MS, showed the presence of organophosphates in 16 (80%) samples. Samples were taken on reasonable suspicion of a fume event that would be "reportable", usually (but not always) resulting from a notable odour (or smoke in more obvious incidents). Often the notable odour was so mild as to be imperceptible to some crew members. For instance, sample 115 was collected when only one crew member detected a very mild smell. This aircraft had another fume event six weeks

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later which engineers attributed to oil leaking from the auxiliary power unit (APU) into its air intake. Analysis of this set of samples indicated exposure to Tricresyl Phosphate (TCP) levels ranging from LOD to 3872 ng/m^3 (detection limit < 4.5 ng/m^3). Of the total samples analysed, 80% contained significant/high concentrations of Tricresyl Phosphate (TCP) and other organophosphates including Tributyl Phosphate (TBP). Given levels of TBP and TCP in normal flights are usually close to or below our detection limit, all the collected and analysed samples (except sample 83) identified that these organophosphates were present in significant concentrations.

Research Limitations: This small-scale trial was only a study of a limited number of reportable fume events (n=20). To obtain a better indication of the incidence of organophosphates during fume events, a larger study would be required. Elevated levels of Tributyl Phosphate (TBP) have been associated with the use of the auxiliary power unit (APU) in the aircraft. A larger-scale, controlled experiment designed to adjust for other variables such as this would be required.

Practical Implications: Tricresyl Phosphate (TCP) is an indicator of bleed air contamination of aircraft cabin air. It was noted that analysis of sample 119 gave one of the higher results for TCP (and TBP) yet there was barely a detectable odour during the flight. The implications for further research are significant. This data appears to indicate the value of continuous real-time air quality monitoring in the cabin to reveal any fume events that may escape reporting reliant on rudimentary detection by air crew through a noticeable odour or smoke.

Social Implications: The outcomes of this study have been presented to airline executives and others within the Aviation industry in attendance at the 2021 ACIAC.

Value and Originality: This trial study is the first multi-scale collection of real-time cabin air sampled by pilots *during* (rather than following) reportable fume events (and subsequently analysed to collect TCP isomers and TBP data).

Keywords

cabin air sampling, personal air monitor, organophosphates, air pollutants analysis, indoor air pollution, aircraft standards, air monitoring, gas chromatography, mass spectrometry

List of References

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About the Author

Marcus Diamond received the B.Sc. degree from the University of Melbourne, Victoria, Australia (1986) and later a Commercial Pilot Licence and an Air Transport Pilot Licence (1996). He has worked as an airline captain in Australia, New Zealand and Papua New Guinea and is currently the Safety & Technical Manager at the Australian Federation of Air Pilots in Melbourne, Australia. Captain Diamond also serves on the AusALPA safety and technical committee and has attended past Aircraft Cabin Air conferences.