GCAQE critique of the EASA and EU Commission cabin air quality studies. [1,2,3,4]

15 December 2017

The GCAQE is concerned about the significant airline industry reliance upon industry-initiated cabin air monitoring studies. These have been consistently utilised to suggest the air quality in aircraft is deemed of good quality in normal flight. Therefore, the two recent EASA-initiated studies and the follow-on EU Commission/EASA 'FACTS' air quality study are reviewed below, highlighting the key weaknesses of these studies if truth is being sought.

1. EASA CAQ study 2017 [1]

Quality of cabin air: A clear pattern of bleed air sourced oil triggered contaminants was identified. This related to cabin air quality technical events (fume events) and low-level permanent oil leakage. However, the suggestion that all levels identified in the study were of *'good quality'* in terms of exposure limits and other indoor air quality guidelines is flawed. The suggestion that cabin air is less polluted than homes and offices based upon the reliance on such exposure limits and guidelines, in combination with the high air exchange rates at altitudes in pressurised cabins, is inappropriate and therefore not accepted. Reasons given supporting our assertions include:

- Exposure limits should not be applied to the aircraft environment. [5] No physiological effects are expected in healthy adults at altitudes up to 5000 feet (132 torr), while adverse effects can be expected in unacclimatized workers at oxygen partial pressures less than 120 torr (equivalent to around 5000-7000 feet) with such symptoms *'recognized as being incompatible with safe performance of duties.'* [6] Published limits, where available should not be used for shift work longer than 8 hours and for mixtures with many components, such as thermal decomposition products. [6] The Aerospace Medical Association has advised that *'OSHA standards (and others throughout the world) are not applicable to aircraft cabin air. Rather they were designed for the industrial workplace.'* [7] EASA has even reported that *'the conditions in cabin air may differ from the standard conditions on which exposure limits are normally based, for example the air pressure, humidity and longer working hours. These aspects need further consideration. In addition, possible effects relating to mixture toxicology need further investigation.'* [2] A recent Boeing FAA funded study has reported that *'Typical concentrations found in aircraft can cause transitory symptoms in healthy individuals questioning the adequacy of current standards.'* [8]

- Occupational exposure limits (OELs):

    - Will not protect all workers;
    - Apply to individual substances;
    - Do not represent a fine line between healthy and unhealthy work environment;

- Do not apply to the public.
- Apply to work shifts up to 8 hours
- Should not apply to complex thermally degraded mixtures,
- Should not apply above 5000 feet…

- The aircraft cabin is a unique environment and should not be compared to other indoor air environments such as offices and homes. This is a unique environment from which removal and cessation of duties is generally not possible. OELs are not designed to address the chronic continual exposure pattern to a complex low dose mixture. [9]*'Safe'* limits always come down … with very few exceptions.[10]

Oil contamination pattern: The identification of primary and secondary non-permanent oil triggered events, identified as 'Technical cabin air contamination (TCAC) events' fails to fully recognise the engineering and design mechanisms using pressurised oil bearing chambers & sealing systems that will allow permanent low-level leakage in normal operations. [11] The permanent low-level oil emissions are recognised to be occurring, but at levels below the limits of quantification of the measuring technology used.

Adverse effect on CAQ: It is quite inappropriate to suggest that all levels of oil contaminants via the permanent or non-permanent release mechanisms are too low to adversely affect the aircraft air quality or to be harmful. This suggestion is inaccurate as high dose acute exposures above exposure limits are only being considered as harmful, ignoring levels below safe limits and other factors such as the following:

- Non-cholinergic mechanisms of repeat exposure to OPs at very low levels. [12]
- A pattern of acute on chronic effects identified in those repeatedly exposed to this environment of low-level oil leakage. [13,14]
- Repeat low-level exposure to OPs causing increased susceptibility to neurotoxic damage. [15]
- Individual susceptibility to OPs. [16]
- Pyrolysed complex mixture. [17,18]
- Exposure to ultrafine particles (UFPs) allowing increased adverse effects of organic compounds including OPs. [19]
- Neurotoxic assessment for aircraft cabin exposure to TCP has not been undertaken. [20]
- Oil and hydraulic fluid cans advise suspected of damaging fertility /do not breathe mist or vapour from heated material/ suspected of causing cancer.
- No safe level for TOCP exposure/ TOCP is a major hazard to human health.[21]

Dismissal of Aerotoxic Syndrome & Aerotoxicity: It is quite inappropriate for the study to suggest the follow-on study should be designed to provide data to *'end the misguided discussion on cabin air quality once and for all.'* It is clear from this statement that it is biased. The authors of the study and EASA, in making such a statement, have an incomplete understanding of the concerns related to oil fumes and other fluids exposures and little if any desire to address it.

2. EASA AVOIL oil pyrolysis study. [2]

127 compounds were identified upon heating the engine oils to high temperatures at atmospheric pressure, including aldehydes at relatively high concentrations. Carbon monoxide *'drastically increased'* at temperatures of 375 +/- 25^{o}C. 634 peaks of volatile and less volatile compounds were found, of which, only 27% could be identified.

Acute high dose effects examined are inadequate to dismiss adverse effects related to neurotoxic pyrolysis products.

It was encouraging to see that there was recognition that: prolonged exposure (48 hours) to pyrolysis products may aggravate potential neurotoxicity, exposure limits may not apply to the specialised cabin environment and further investigation of the toxicology to complex mixtures and individual variability is required.

However, it is clear that there is a lack of appreciation of the available published literature, given that effects are assessed in terms of TOCP. This TOCP focussed understanding of the effects of exposure to oil fumes is inadequate. Therefore, it is inappropriately suggested that a causal connection to the occupational environment cannot be made until all substances are identified along with the specific levels, full identification of molecular targets and no effect levels are established. Consequently, somatically unexplained physical symptoms are suggested with future studies to focus in part on personality situational factors, triggering, maintaining and perception factors that may enhance reactions.

Examples of other inadequacies include an incomplete literature review, no data on the age of the engines and subsequent impact on the used oil and used oil selected for one brand of oil only. Additionally the temperatures used for the studies will not represent the maximum temperature to which the oil will have been subjected within the lubrication system. [22]

3. EASA/EU Commission DG MOVE FACTS Cabin air study- 2017 [3,4]

This cabin air study has been established based on the 2 prior EASA studies as shown above, with the CAQ study overtly suggesting cabin air toxicity concerns should be dismissed once and for all with this major study. This can in no way allow one to expect objectivity and a clear willingness to respect independent science.

The study as explained by EASA and the scientific oversight committee advised that the in vivo and in vitro studies will look at acute exposure only as there is not the time or money to look at chronic low-level exposures. [23] Similarly, the studies would simulate high dose exposures only: 1) maximum permissible leakage (MPL) and 2) failure condition (> MPL), but not chronic low-level exposures, as again this would be too costly and time consuming, with no budget allocated. [23] This is quite unacceptable as it will not provide the answers to questions related to chronic low-level exposures, which are suggested to be quite different to single, acute exposure events and very relevant for the cabin air environment. [12,13,14,15,16,19,20]

The scope of the FACTS study states that the general objective is to investigate cabin air quality and its potential adverse consequences on health in light of European legislation on the quality of indoor air and professional exposure limits. [3] This is despite the inapplicability of such limits for this environment as identified above. Additionally, one of the key objectives of the study is to identify any short- or long-term health effects, yet as stated above, the study design will not be able to address such effects, either short-or long-term in reality as it is based

on high dose exposures only and cannot assess effects in a robust manner for the aircraft cabin environment and the manner in which the fugitive emissions occur.

The following statements by EASA in their overview [4] are deeply concerning as we do not agree the studies demonstrated any of these points:

- Very good cabin/cockpit air quality - at least in normal conditions– compared to other indoor environments;
- Pyrolysed engine oil released compounds not a concern at concentrations involved;
- Infrequent traces of OPs identified.

The actual study reported:

1) Traces of meta and para isomers of TCP, dicresylphenyl phosphates and diphenylcresyl phosphates were detected in nearly all samples. (p.53)

2) Oil leakage (Including TCP) was not detected in over 200 of the bleed air samples undertaken. (p.102) (there were *461 samples on main bleed air aircraft study. Therefore TCP was detected in around 261 samples ~57%)*

3) In 67 percent of over 500 investigated flight phases (main study and B787 study) the TCP contamination occurs only sporadically regardless of the investigated type of aircraft, and most of the TCP occurrence can be attributed to a few flight phases (Table 28). Furthermore, these notable flight phases belong without exception to aircraft with bleed-air supply investigated in the main study. (p.97)

SUMMARY:

The GCAQE submits that there is a fundamental difference with the health pattern between aircrew exposed to aircraft contaminated air and the general population. This has been increasingly recognised and published internationally. The questions raised by the EASA and EC studies have not been undertaken in a manner capable of identifying the pattern of effects being reported. There is already sufficient evidence and science available identifying a genuine problem that requires solutions to be introduced now. While it is possible that further properly designed and conducted science will serve to identify something new, it is more likely to serve only to make the current estimates more precise. We have identified how severely flawed the EASA/EC studies are. Our position is that by undertaking poor science, EASA/EC are delaying the action already justified and needed to protect workplace safety and health and the travelling public.

1. EASA. Research Project: CAQ Preliminary cabin air quality measurement campaign. Final report EASA_REP_RESEA_2014_4. Cologne: European Aviation Safety Agency, 2017
2. EASA. Research Project: AVOIL. Characterisation of the toxicity of aviation turbine engine oils after pyrolysis. Final Report EASA_REP_RESEA_2015_2. Cologne: European Aviation Safety Agency, 2017
3. European Commission. Call for Tenders N° MOVE C2/2016-363 -Research Study: Investigation of the quality level of the air inside the cabin of large transport aeroplanes and its health implication. Tender Specifications. Brussels: European Commission - DG Mobility and Transport, 2016.

4. EASA & European Commission. Cabin Air Quality- Background & EASA/EC studies: GCAQE-EC-EASA meeting. Cologne, 4 July 2017
5. Michaelis, S. The Inapplicability of Exposure Standards. 2017. http://www.susanmichaelis.com/caq.html
6. ACGIH. TLVs and BEIs - Threshold Limit Values For Chemical Substances And Physical Agents. American Conference of Governmental Industrial Hygienists;: Cincinnati, 2015.
7. Rayman R. Cabin Air Quality: An Overview. Aviat Sp Environ Med 2002; 73: 211–215.
8. Weisel CP, Fiedler N, Weschler CJ, et al. Human Symptom Responses To Bioeffluents, Short-Chain Carbonyls/Acids and Long-Chain Carbonyls in a Simulated Aircraft Cabin Environment. Indoor Air 2017; 38: 42–49.
9. Howard CV. (2017) European Commission FACTS CAQ Scientific Committee Meeting. Cologne. 29/11/17
10. Gee D. Associations and Causation : a Bradford Hill approach to Aerotoxic Syndrome. Presentation: International Aircraft Cabin Air Conference, Imperial College London. 19-20 September 2017
11. Michaelis S. Implementation of the requirements for the provision of clean air in crew and passenger compartments using the aircraft bleed air system [MSc thesis]. Cranfield: Cranfield University; 2016
12. Terry AV (2012) Functional consequences of repeated organophosphate exposure: potential non-cholinergic mechanisms. Pharmacol Ther 134(3): 355-65
13. Michaelis S, Burdon J, Howard CV. Aerotoxic Syndrome: A New Occupational Disease? Panorama WHO Public Health Panorama 2017:3:198-211
14. CV Howard, S Michaelis, A Watterson. The Aetiology of 'Aerotoxic Syndrome'-A Toxico-Pathological Viewpoint. Open Acc J of Toxicol. 2017;1(5): 555575. DOI: 10.19080/OAJT.2017.01.555575
15 Axelrad JC, Howard CV, McLean WG (2003) The effects of acute pesticide exposure on neuroblastoma cells chronically exposed to diazinon. Toxicology 185(1-2): 67-78.
16. Cherry M, Mackness N, Durrington P, Povey A, Dippnall M, Smith T et al. Paraoxonase (PON1) polymorphisms in farmers attributing ill health to sheep dip. Lancet. 2002; Mar 2;359:763-4.
17. Carvalho R, Arukwe A, Ait Aissa S, Bado-Nilles A, Balzamo S, Baun A et al. Mixtures of chemical pollutants at European legislation safety concentrations: How safe are they? Toxicological Sciences. 2014;141(1): 218–233.
18. The Interdepartmental Group on Health Risks from Chemicals (IGHRC). Chemical mixtures : A framework for assessing risks to human health. Cranfield: IEH, Cranfield University; 2009
19. Elsaesser A, Howard CV (2012), Toxicology of nanoparticles , Adv. Drug Deliv. Rev. 64: 129–137
20. ECHA. Decision On Substance Evaluation Pursuant To Article 46(1) Of Regulation (EC) NO 1907/2006. For Tris(methylphenyl) phosphate, CAS No 1330-78-5. Helsinki. 26 July, 2016. https://echa.europa.eu/information-on-chemicals/evaluation/community-rolling-action-plan/corap-table/-/dislist/details/0b0236e180694747
21. WHO. International Programme On Chemical Safety (IPCS). Tricresyl Phosphate -Environmental Health Criteria 110.
22. Johnson D. Lubricant and Lubricant Additive Degradation : Implications for Cabin Air Quality. In: International Aircraft Cabin Air Conference, Imperial College, london. 19-20 September, 2017. https://www.aircraftcabinair.com/films
23. EASA. Cabin air quality Background & EASA/EC studies – Presentation by T Buck & Scientific Committee delegates AT CEN TC 436 Bordeaux meeting. 19 October, 2017.