Meeting

Volatile organic compounds in European aircraft cabin air: concentrations and comparison with regulatory standards

This is a paper for discussion.

This does not represent the views of the Committee and should not be cited.

Introduction

1. This paper is part of the series on aircraft cabin air and follows papers TOX-2022-46 and TOX-2022-55 presenting worldwide concentrations of volatile organic compounds (VOCs) in modes of transport and work environments. This paper focusses on the levels of VOCs in different modes of transport and different work environments in Europe including the UK and compares such values to UK occupational values, UK air quality guidelines as well as health-based guidance values (HBGVs).

Background

2. In 2007, the Committee on Toxicity (COT) published a statement on aircraft cabin air, relating to organophosphate (OP) compounds, the cabin air environment, ill-health in aircraft crews and the possible relationship to smoke/fume events in aircraft (COT, 2007). Subsequently, the COT reviewed the results of Department for Transport (DfT)-funded aircraft cabin environment research commissioned in response to recommendations made by COT in 2007, after which the COT issued a position statement on cabin air (COT, 2013).

3. The COT has now been asked by DfT to investigate if any new data have been published and to re-evaluate their previous view in the original statement from 2007 (COT, 2007) and position statement from 2013 (COT, 2013).

The COT reviewed an introductory paper on this topic on cabin air in May 2022 (TOX-2022-30), which provided a full background to the Committee's previous conclusions. Following the May 2022 COT meeting, the request of COT has been further refined to: "Is there evidence of exposure to chemical contaminants in cabin air that could have long-term health impacts, either from acute exposures or due to long-term low level exposures including mixtures, e.g., of VOCs?"

4. The COT has already considered papers outlining the concentrations of VOCs in different modes of transport worldwide (TOX-2022-46) and in different work environments (TOX-2022-55) compared to concentrations in aircraft, to support consideration of whether exposures to VOCs in aircraft are different to exposures elsewhere. As part of the discussion of these papers, the COT agreed to focus on concentrations from UK and European flights, other modes of transport and work environments, and where feasible to compare these with available HBGVs. This is addressed in the current paper.

Comparison of VOCs in European aircraft and European modes of transport and work environments

5. The highest mean concentrations of VOCs measured in aircraft flying within Europe were compared against levels of VOCs in other modes of transport in Europe and other European work environments.

6. For 1,2-propanediol, 2-phenoxyethanol, decanal, ethanol, hexanoic acid and octanal the highest mean concentration reported in aircraft is above all available highest reported mean concentrations for other modes of transport or work environments Table 1.

7. For all other VOCs for which data are available, there is at least one mode of transport or work environment where the highest mean concentration is above the highest mean concentration reported in aircraft (Table2).

8. Highest mean concentrations of tetrachloroethylene in aircraft were lower than those in cars or taxis but higher than those reported in four modes of transport or work environments, namely buses and offices, hospitals and schools.

9. The highest mean concentrations of naphthalene were lower than those in cars or taxis but higher than concentrations in offices, hospitals and schools. The highest mean concentrations of limonene were lower than in schools but higher than cars or taxis, offices and hospitals.

10. The highest mean concentrations of benzene, ethyl acetate, formaldehyde and toluene were higher in aircraft compared to two work environments, but lower than other modes of transport. The highest mean concentrations of benzene, formaldehyde and toluene were higher in aircraft compared to hospitals and schools whereas ethyl acetate was higher in aircraft compared to offices and schools. The highest mean concentrations of hexane were higher in aircraft compared to schools and cars or taxis but lower than offices.

11. The highest mean concentrations of acetic acid were higher in aircraft compared to offices but lower than cars or taxis. The highest mean concentrations of 3-carene were higher in aircraft compared to schools but lower than offices.

12. For all other VOCs reported, the highest mean concentration in aircraft were lower compared to the highest mean concentration for all other modes of transport (cars/taxis or buses) and all work environments (offices, schools or hospitals) where data were available (Table 2).

Comparison of VOCs in UK and European aircraft with occupational standards, indoor air quality guidelines and health-based guidance values

13. The highest mean concentrations of VOCs that were higher in aircraft than all other highest mean concentrations reported in other modes of transport or work environments were compared against UK EH40 occupational standards (HSE, 2020), PHE indoor air quality guidelines (IAQ) (PHE, 2019) as well as European chronic and acute derived no effect levels (DNELs) for workers via inhalation exposure cited in REACH dossiers (ECHA) (Table3)

14. The highest mean concentration of all VOCs considered in this comparison were below available UK occupational standards, UK indoor air quality guidelines and EU-REACH DNELs.

Conclusion

15. The highest mean concentrations of a small number of VOCs reported in UK and European aircraft exceed highest mean concentrations reported in all other modes of transport in UK and European countries and all other UK and European work environments in so far as data are available. For a number of

other VOCs, the highest mean concentrations in UK and European aircraft exceed some, but not all, highest mean concentrations in other modes of transport and/or other work environments in the UK and Europe.

16. Where the highest mean concentration was reported in aircraft, such levels were all below UK occupational standards, UK indoor air quality guidelines and EU REACH chronic and acute DNELs, indicating no risk to health is anticipated.

Questions on which the views of the Committee are sought

17. Members are invited to consider this paper and in particular the following questions:

i. Based on information in this paper, do Members want further information on any specific VOC?

ii. Are there any candidate VOCs, for which a risk assessment should be considered in the context of aircraft cabin air in a future paper?

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Table 1. List of VOCs where the highest mean concentrations in aircraft were higher compared to highest mean concentrations for all other modes of transport or work environments in the UK and Europe.

VOC	Lowest mean ($\mu g/m^3$) Aircraft	Highest mean ($\mu g/m^3$) Aircraft	Highest mean ($\mu g/m^3$) Car/taxi	Highest mean ($\mu g/m^3$) Bus	Highest mean ($\mu g/m^3$) Office	Highest mean ($\mu g/m^3$) Hospital	Highest mean ($\mu g/m^3$) School

1,2-Propanediol	10.9	45.2 Highest value	NR	NR	7	NR	NR
2-Phenoxyethanol	1	4.6 Highest value	NR	NR	1.6	NR	NR
Decanal	2.7	14 Highest value	NR	NR	8	NR	NR
Ethanol	80.7	386 Highest value	NR	NR	127	NR	NR
Hexanoic acid	3.8	6.2 Highest value	NR	NR	5.5	NR	NR
Octanal	1.3	4.2 Highest value	NR	NR	3	NR	NR

NR=not reported.

Table 2. List of VOCs where highest mean concentrations of VOC in aircraft were lower compared to at least one other modes of transport or work environments in the UK and Europe.

VOC	Lowest mean (µg/m^3) Aircraft	Highest mean (µg/m^3) Aircraft	Highest mean (µg/m^3) Car/taxi	Highest mean (µg/m^3) Bus	Highest mean (µg/m^3) Office	Highest mean (µg/m^3) Hospital	Highest mean (µg/m^3) School
1,4-dichlorobenzene	2.4	2.4	NR	5.41 Highest value	NR	NR	NR
1-butanol	0.9	2.4	NR	NR	5 Highest value	NR	NR
2-Ethylhexanol	2.9	4	NR	NR	4.7 Highest value	NR	NR
3-Carene	1.1	1.1	NR	NR	1.7 Highest value	NR	0.24
Acetic acid	7.5	11.8	14 Highest value	NR	7.1	NR	NR
Acetone	10.1	15.7	250 Highest value	NR	48.6	NR	NR

VOC	Lowest mean (µg/m^3) Aircraft	Highest mean (µg/m^3) Aircraft	Highest mean (µg/m^3) Car/taxi	Highest mean (µg/m^3) Bus	Highest mean (µg/m^3) Office	Highest mean (µg/m^3) Hospital	Highest mean (µg/m^3) School
α-Pinene	0.5	1.2	200 Highest value	NR	136.3	3.8	5.6
Benzaldehyde	1.7	2	NR	NR	29 Highest value	NR	NR
Benzene	3.4	8.2	42 Highest value	10.25	14.6	0.8	3.01
β-Pinene	0.3	0.6	1.8	NR	10.9 Highest value	NR	NR
Decane	1	1.7	1300.6 Highest value	NR	24.8	NR	1.71
Dichloromethane	0.8	1.1	NR	NR	50.2 Highest value	NR	NR

VOC	Lowest mean ($\mu g/m^3$) Aircraft	Highest mean ($\mu g/m^3$) Aircraft	Highest mean ($\mu g/m^3$) Car/taxi	Highest mean ($\mu g/m^3$) Bus	Highest mean ($\mu g/m^3$) Office	Highest mean ($\mu g/m^3$) Hospital	Highest mean ($\mu g/m^3$) School
Dodecane	1.3	3.1	163.4 Highest value	NR	13.7	NR	NR
Ethyl acetate	3.9	6.5	11.5 Highest value	NR	2.1	NR	3.55
Ethylbenzene	0.3	2.3	85 Highest value	4.89	22	NR	NR
Formaldehyde	5.4	5.4	38.2 Highest value	NR	26.9	4	3.5
Eucalyptol	0.5	2	NR	NR	3.8 Highest value	NR	NR
Heptane	0.7	0.9	670.1 Highest value	NR	31.7	NR	3.3

VOC	Lowest mean ($\mu g/m^3$) Aircraft	Highest mean ($\mu g/m^3$) Aircraft	Highest mean ($\mu g/m^3$) Car/taxi	Highest mean ($\mu g/m^3$) Bus	Highest mean ($\mu g/m^3$) Office	Highest mean ($\mu g/m^3$) Hospital	Highest mean ($\mu g/m^3$) School
Hexane	0.5	20	13.9	NR	52.5 Highest value	NR	2.98
Isoprene	5	9	NR	NR	10.5 Highest value	NR	NR
Isopropyl alcohol	3.5	12.6	NR	NR	65.1 Highest value	NR	NR
Limonene	0.65	51.49	38.8	NR	44.8	14.3	86 Highest value
Methylcyclohexane	0.6	0.9	122 Highest value	NR	14.2	NR	NR
m- and p-xylene	0.61	5.46	1570.7 Highest value	9.4	143	NR	8.8

VOC	Lowest mean (µg/m^3) Aircraft	Highest mean (µg/m^3) Aircraft	Highest mean (µg/m^3) Car/taxi	Highest mean (µg/m^3) Bus	Highest mean (µg/m^3) Office	Highest mean (µg/m^3) Hospital	Highest mean (µg/m^3) School
n-butyraldehyde/ butanal	1	1	NR	NR	143.9 Highest value	NR	NR
Naphthalene	0.8	1.4	10.6 Highest value	NR	1.3	0.38	0.5
Nonanal	1.9	7.8	NR	NR	15 Highest value	NR	NR
Nonane	1.8	2	2.72	NR	7.6 Highest value	NR	NR
o-Xylene	0.6	2.5	1400 Highest value	150	43.4	NR	5.45
Pentane	1	1.4	28 Highest value	NR	NR	NR	3.61

VOC	Lowest mean (µg/m^3) Aircraft	Highest mean (µg/m^3) Aircraft	Highest mean (µg/m^3) Car/taxi	Highest mean (µg/m^3) Bus	Highest mean (µg/m^3) Office	Highest mean (µg/m^3) Hospital	Highest mean (µg/m^3) School
Styrene	0.3	1	4.3	NR	6.52 Highest value	NR	1.75
Tetrachloroethylene	0.2	8.5	17.1 Highest value	0.49	8.5	0.43	0.55
Tetradecane	2.1	2.6	NR	NR	38.6 Highest value	NR	NR
Toluene	3.37	30.42	315.1 Highest value	31.29	287.3	1.73	10.3
Trichloroethylene	0.4	0.4	NR	NR	1.7 Highest value	0.35	0.45
Tridecane	1.2	1.7	687.1 Highest value	NR	NR	NR	NR

VOC	Lowest mean (µg/m^3) Aircraft	Highest mean (µg/m^3) Aircraft	Highest mean (µg/m^3) Car/taxi	Highest mean (µg/m^3) Bus	Highest mean (µg/m^3) Office	Highest mean (µg/m^3) Hospital	Highest mean (µg/m^3) School
Undecane	1.21	4.49	1615.8 Highest value	NR	32.9	NR	NR

Table 3. Lowest and highest mean concentrations VOC in UK and European aircraft compared UK occupational standards, UK Indoor Air Quality Guidelines and EU REACH chronic and acute DNELs.

VOC	Lowest mean (µg/m^3) Aircraft	Highest mean (µg/m^3) Aircraft	Occupational standard (µg/m^3)	PHE IAQ (µg/m^3)	DNEL chronic (µg/m^3)	DNEL acute (µg/m^3)
1,2-Propanediol	10.9	45.2	150000	NR	168000	NR
2-Phenoxyethanol	1	4.6	NR	NR	5700	NR
Decanal	2.7	14	NR	NR	24860	49710
Ethanol	80.7	386	1000000	NR	380000	NR
Hexanoic acid	3.8	6.2	NR	NR	no hazard	NR
Octanal	1.3	4.2	NR	NR	1300	NR

References

ECHA dossiers. Homepage - ECHA (europa.eu)

HSE (2020). EH40/2005 Workplace exposure limits. EH40/2005 Workplace exposure limits (hse.gov.uk)

PHE (2019). Indoor Air Quality Guidelines for selected Volatile Organic Compounds (VOCs) in the UK. Air quality: UK guidelines for volatile organic compounds in indoor spaces - GOV.UK (www.gov.uk)

List of Abbreviations and Technical terms

COT	Committee on Toxicity
DfT	Department for Transport
DNEL	Derived no effect level
HBGV	Health-based guidance value
IAQ	PHE indoor air quality guidelines
NR	Not reported
PHE	Public Health England
VOC	Volatile organic compounds