

Volatile Organic Compounds (VOC) and Organophosphates in Blood and Urine Samples of Flying Personnel after "Fume and Smell Events"

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no conflicts of interest to declare

Fume and Smell Events (FuSE) - Definition

- **Fume or smell** appearing in the **cockpit or cabin** of an aircraft.
- Concerns focus on fumes from a **technical source (oil smell)**.
Odours of other origins (passengers, animals, food) may appear to be FuSE as well.
- The current discussion especially focuses on the **bleed air**.



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Questions

1. Are crew members and passengers exposed to potentially hazardous substances during FuSE?

2. Could this exposure be a reason for
 - a. short term health effects?
 - b. chronic diseases?

headache
dizziness
nausea
vertigo

neurological disorder
breathing problems
fatigue
cognitive disturbances

Frequency of FuSE

- 1 event / 2,000 flights
(British Committee on Toxicity, 2007)
- 0.09-3.8 events / 1,000 flights
(van Netten, 2005)

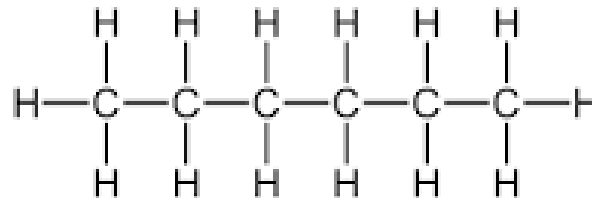
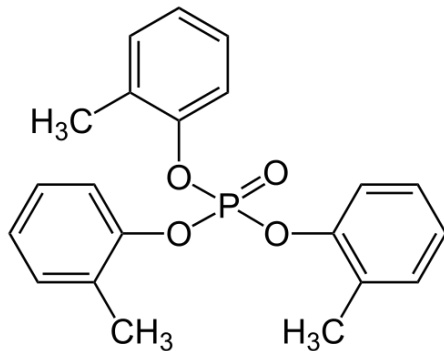
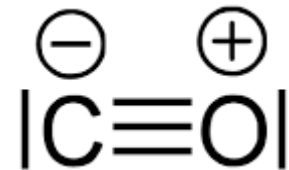


What we know

- Odours have different sources.
- Engine oil may contain esters of fatty acids and polyols, TCP isomers and aromatic amines.
- Hydraulic oil may contain butyl phosphates and phenyl phosphates.
- Pyrolysis may modify the components.
- TCP, TBP and TPP have been found in air and wiping samples (traces).
- Organic acids and aldehydes may lead to mucous membrane irritation.
- Odours are plausible due to organic acids (C₅ – C₇) or cresols.
- Exposure to typical conditions like low humidity, mild hypoxia etc. may have an influence on the perception.
- The exposure level is low.

What we want to know

- Is there any chemical substance responsible for FuSE-symptoms?
- If yes, what is it?
 - CO?
 - VOC?
 - Organophosphates like TCP?
 - Something else?



Measurements (Cabin Air)

Substance	Limit value (Occupational Exposure Limit - OEL)	Measurement	Literature (expl.)
CO	30 ppm (Germany)	0.1 – 7 ppm	Cranfield, ASHRAE, van Netten,...
TVOC	-	1 – 5 mg/m ³	Nagda, BRE, Solbu, ...
n-Hexane	180 mg/m ³ (Germany, NIOSH)	-	
Toluene	190 mg/m ³ (Germany) 375 mg/m ³ (NIOSH)	< 1 mg/m ³	Cranfield, Nagda, ASHRAE, ...
Formaldehyde	370 µg/m ³ (Germany)	12 – 44 µg/m ³	ASHRAE, Rosenberger
total TCP	20 - 100 µg/m ³ <u>T-o-CP</u> , US-OSHA)	< 1.0 µg/m ³	Cranfield, van Netten, Rosenberger
tot. TCP (mil. AC)		0.5 – 51 µg/m ³	Hanhela, Denola
TBP	11 mg/m ³ Germany	0.02 – 4.1 mg/m ³	Solbu
TPP	3 mg/m ³	< 0.11 µg/m ³ (LOD)	Solbu

Measurements (Body Liquids)

Substance	Limit values	Measurement	Literature
CO-Hb (blood)	max 1.6% (smoker: max. 10%)	occasionally 5% - 8.7%	Schindler 2013
n-Hexane (blood)	-	?	
Toluene (blood)	600 µg/l (BEI - Biol. Exp. Ind.)	?	
2,5-Hexandione (urine)	5 mg/l (BEI)	?	
Acetone (urine)	80 mg/l (BEI)	?	
T-o-CP (met. urine)		not detected	Schindler 2013
T-m-CP (met. urine)	0.5 µg/l (LOD)	once(!) 0.62 µg/l	Schindler 2013
T-p-CP (met. urine)	0.5 µg/l (LOD)	once(!) 0.55 µg/l	Schindler 2013
DBP (met. TBP, urine)	2.0 µg/l (Reference Erlangen)	1.38 µg/l (95-percentile)	Schindler 2013
DPP (met. TPP, urine)	5.0 µg/l (Reference Erlangen)	6.25 µg/l (95-percentile)	Schindler 2013

Current Discussion (Heutelbeck, Göttingen)

VOC:

- butanone/MEK
- 2-heptanone
- 2-propanol
- **n-hexane**
- 2-methylpentane
- n-heptane, n-octane, n-decane
- toluene
- acetone

Human Biomonitoring Project

Blood

- VOC: butanone/MEK, 2-heptanone, 2-propanol, n-hexane, 2-methylpentane, n-heptane, n-octane, n-decane, toluene, acetone
- erythrocytic acetylcholinesterase (AChE – is slowed down by organophosphates)

Urine

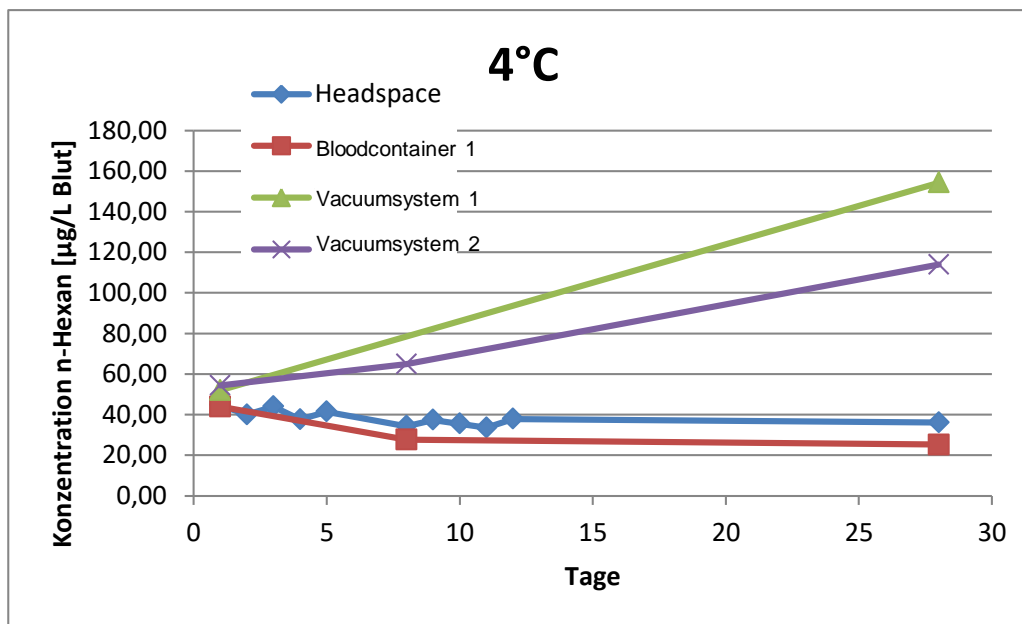
- 2,5-hexanedione (metabolite of n-hexane)
- o-cresol (metabolite of toluene)
- acetone
- metabolites of TCP, TPP and TBP

Problems in the Preanalytic Phase

- Quick absorption and emission of VOC, partly not metabolised, short half-life
- High risk of contamination (disinfectant, sample tube stoppers made from butyl rubber)
- Loss of analyte due to volatility and leaks



Blood Collection and Storage Systems



- contamination in sample tubes with butyl rubber stoppers
- loss of analyte through leakage
- no loss of analyte and no contamination in headspace tubes

Requirements for Analytics

- Blood collection system must be tested on being solvent-free.
- Collection systems should not cause loss or contamination of analytes.
- Disinfectants must be analyte-free.
- **Special collection procedures and storage systems for VOC analytics of urine and blood samples are necessary!**
- Transportation without cooling.

Only overall standardised and quality-assured methods can guarantee valid results of analysis

Procedure



standardised
shipment



IPA

**Institute for Prevention
and Occupational
Medicine of the DGUV
(Bochum, Germany)**

standardised sample collection,
possibly within 3-8 h

First Results (Preliminary Study started 4/2017)

Status 10/2018

- about 270 measured samples after FuSE
- about 80 AChE verification-samples

- 100 persons pre-employment medical examinations without FuSE (not part of the preliminary study)

Intermediate results

- indicate the necessity of standardised methods for sample collection and analysis.
- confirm familiar findings on organophosphate exposure.
- are plausible and valid.
- call for a study.

Answers

1. Are crew members and passengers exposed to potentially hazardous substances during FuSE?
Cannot be excluded, but the exposure dose is very low and it is not clarified yet, whether the exposure is really a result of FuSE.
2. Could this exposure be a reason for:
 - a. short term health effects?
Yes, because we have plausibility on e.g. acids, that may lead to irritation and on annoyance by odours, that may cause somatic effects.
 - b. chronic diseases?
Until now, we have no evidence or cause for chronic diseases being caused by FuSE. Research is going on.

**Thank you
for your attention!**

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