FEDERAL INSTITUTE FOR RISK ASSESSMENT

AEROTOXIC SYNDROME: FIVE CASES IN GERMANY

Is tricresyl phosphate indeed the responsible factor?

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Background:

Aerotoxic Syndrome

The term "Aerotoxic Syndrome" describes the health impairment attributed to an alleged short- or long-term exposure to contaminated cabin air during flights. The Aerotoxic Syndrome is usually associated with so-called "fume or smell events". Such events are estimated to occur in 1/2000 flights. In general, persons affected described the smell they perceived by terms such as "wet dog", "stinky socks" or, in case of fume events, also "burnt plastic".

Symptoms associated with the Aerotoxic Syndrome are rather non-specific and difficult to differentiate from symptoms of other origins. Therefore Aerotoxic Syndrome is not an officially recognized health impairment. The list of symptoms includes:

- Exhaustion, tiredness
- Breathing difficulties
- Blurred vision
- Dizziness, nausea
- Neuropathies such as paresthesia
- …

Fig 1: Smoke event in a plane (www.wdr.de)

Problems of air supply with bleed air:

- Aeration consists generally of compressed bleed air, drawn in through the gas turbine engines
- Usually separated ventilation for passenger cabin and the flight deck
- Contamination of air with oil fumes is possible if engine oil leaks through worn seals

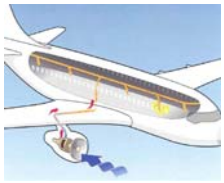
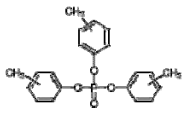


Fig. 2: Air supply with bleed air (http://www.brodkowitzlaw.com)

Tricresyl phosphate (TCP)

Adverse health effects are mostly hypothesized to result from exposure to tricresyl phosphate mixed esters in engine oils.



- Up to 3% TCP are added to engine oils as an anti-wear agent, < 0.01% *o*-TCP
- Also present in many other products, e.g. as a flame retardant in plastics
- Mixure of 10 isomers
- *o*-cresyl containing isomers are suspected of causing neurotoxic effects
- Historical mass poisonings: adulteration of Jamaica ginger (1920s) or cooking oil (1959) with high doses of TCP led to many deaths
- However, inhalation toxicity of TCP might be rather small because of its low volatility, information is limited so far

Method:

German physicians are obliged to notify cases of poisoning (§ 16 German Chemicals Act) to he BfR. Individual reports of Aerotoxic Syndrome as well as cases reported so far under §16e were analyzed, evaluated and recorded in the form of standardized case reports.
The existing data were evaluated and assessed regarding possible risks for fume events associated with TCP-contaminated cabin air. The categorisation of the health impairment followed the Poison Severity Score (PSS). The causality (exposure vs. symptoms/signs) was assessed by the BfR-standard "Three-Level-Model".

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Results:

The following table summarize further cases reported to BfR. Since fall 2012 the BfR registered an increasing number of cases of Aerotoxic Syndrome. The first 5 cases of the table are presented on the right side.

case	Event		severity	symptoms							causality	detection of TCP (unk/ pos/ neg)
	smell	smoke		drowsiness/ dizziness	headache	nausea	breathing difficulties	oropharyng. burning	paresthesia	others		
1*	x		moderate	x		x			x		possible	unk
2*	x		minor	x					x	restricted field of vision	possible	unk
3*	x		minor	x			x				possible	neg
4*	x		minor		x				x		possible	unk
5*	x	x	minor	x	x		x	x	x	coryza	possible	unk
6	x		minor	x					x		possible	neg
7	x		minor		x		x		x		possible	neg
8	x		minor	x	x		x		x		possible	neg
9	x		minor	x	x		x				possible	neg
10	x		minor	x				x		palpitation	possible	neg
11	x		minor	x			x	x		palpitation, eye irritation	possible	unk
12	x		minor	x							possible	unk
13	x		minor					x			possible	unk
14	x		minor	x							possible	unk
15	x		none								possible	unk
16	x		none								possible	unk
17	x		none								possible	unk
18		x	minor	x		x					possible	unk
19		x	minor	x		x					possible	unk
20		x	minor					x			possible	unk
21	x		minor	x	x			x		abdominal pain	possible	unk
22	x		minor								possible	unk
23			none								possible	unk
24	x		minor								possible	unk
25	x		minor					x			possible	unk
26	x		minor		x						possible	unk
27	x		minor			x				eye irritation	possible	unk

Tab 1: Cases of Aerotoxic Syndrome, reported to BfR between 2009-04/2013; cases described in the text on the right side are shown by an asterisk; cases in one frame belong to the same smell/smoke event; TCP: unk.: unknown, pos.: positive, neg.: negative

Case report 1/2: "Near-crash" during the landing at a German airport, acoording to various newsletter articles:

- While landing both pilots perceived suddenly a strange mix of "burnt and electrical smells"
- Both got then increasing problems with their physical and cognitive functions (drowsiness/dizziness/tunnel vision)
- After donning of oxygen mask the pilot felt better, while the co-pilot's condition worsened. The pilot managed to land with his last strength, while the co-pilot felt almost completely incapable to assist
- Both pilots were brought to a nearby hospital
- There was no report of smell or problems from the cabin
- During the subsequent checkup by airline's technicians smell was also perceived and described as most probably originating from de-icing fluid

Fig. 3: www.focus.de

Objective findings:

- Situation was initially reported to the responsible authority as a harmless incidence. Two years later the story was published in the newspaper as a near-crash. As all flight data were later deleted, no further investigation was possible.
- Medical examination at a hospital in the same evening revealed that the pilots had almost no health impairment (except an elevated creatine kinase level for the co-pilot resulting from another cause)
- Subsequent inspection and maintenance flight did not indicate any damage or strange smell

Further cases: 3 stewardesses

- Case 3: During a flight, a stewardess perceived a strange smell and subsequently felt dizziness and difficulties to breathe; medical examination was without pathological findings; neither di-*meta*-TCP nor di-*para*-TCP were detectable, diphenyl phosphate and carboxyhaemoglobin (CO-Hb) levels were unremarkable; health impairment disappeared within 3 days
- Case 4: A stewardess attributed her frequent headache to toxic gases in the cabin air, especially in Boeing 757s; no further information available
- Case 5: A stewardess reported hydraulic oil smell and a slight fog; during the flight she felt prickling and agitation, later she also developed symptoms of a cold (headache, cough, coryza, …); medical examination was without pathological findings

Fig. 4: www.welt.de

Discussion:

Rising number of cases reported to the BfR with the diagnose Aerotoxic Syndrome might be related to increased awareness due to the huge actual media circus.

Fig. 5: Articles about smell events (http://www.aerotoxic.org)

Patients of all reported cases were aircrew members. No case of affected passengers has become known to BfR. Possible reasons:

- More time spent on board. More stress? More contact to potential toxic gases? Cumulative effect?
- More aware of the problem?
- Spatial reasons: e.g. smells and fumes in the galley ?

In most reported cases, symptoms were rather non-specific. TCP poisoning is unlikely and none of the tested patients showed elevated values for the TCP metabolites. This is in accordance with a study of Schindler et al. (2012) who analyzed 332 urine samples of crew members after smell events. None of the samples contained *o*-TCP metabolites above the limit of detection.

Other factors potentially involved in symptoms assigned to Aerotoxic Syndrome/smell events are:

- Undersupply with oxygen/ Hyperventilation
- Carbon monoxide
- Other chemicals in airplanes, e.g. flame retardants
- Smell: food, burnt particles in stove, perspiration, …
- Stress: flight turbulences, jetlag, noisiness, very dry cabin air

Fig.6: Stove in a galley (http://www.airportzentrale.de)

Further investigation and toxicological analysis are necessary to clarify the reasons for incidences leading to Aerotoxic Syndrome. TCP poisoning is unlikely and overstatement in mass media regarding this topic should be constrained to avoid exaggerated concern in population.

Literature:

Schindler et al.; Occupational exposure of air crews to tricresyl phosphate isomers and organophosphate flame retardants after fume events; Arch Toxicol. 2013 Apr;87(4):645-8. doi: 10.1007/s00204-012-0978-0. Epub 2012 Nov 21.

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