

DETERMINATION OF TRICRESYL PHOSPHATE AIR CONTAMINATION IN AIRCRAFT TYPE BAE 146/AVRO RJ

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For many years, the exposition to tricresyl phosphates (TCP) and tri-*o*-cresyl phosphate (ToCP) in particular of cabin crews in commercial aircrafts is described as a cause of occupational diseases. The Aircraft BAE 146/Avro RJ was identified as a particularly striking. This small short-haul aircraft with four jet engines was reported more frequently than other aircrafts by so-called fume events.



Figure 1:
BAE-146/AVRO RJ Aircraft

Tricresyl phosphates are components of aircraft engine oils, such as those used for many years. The *o*-cresyl phosphates (*o*CPs) are known neurotoxins. From studies of engine oils it is known that the critical *o*CPs are minor contaminants with less than 0.1 % of ToCP in total.

In 2012, the BG Verkehr and the IFA had the opportunity to perform extensive measurements in five aircrafts of type BAE 146/Avro RJ. In addition to the samples on organo phosphates, samples were also drawn to other volatile organic compounds in the air on the plane. The samples were analysed in two independent laboratories.

Both laboratories used combined vapour-particulate sampler for sampling the organo phosphates. Laboratory 1 used a glass fibre filter for sampling particulate and a silica gel tube for sampling gaseous organo phosphates mounted in a GGP-sampler. The airflow was adjusted to 2 L/min and the samples were analysed after extraction with methyl tertiary-butyl ether (MtBE) with GC/NPD [1]. In laboratory 2 sampling was carried out by drawing the air through a quartz filter spiked with tributyl phosphate-d27 and PUR foam spiked with triphenyl phosphate-d15. The adsorbed organo phosphates were extracted with dichloromethane according to the soxhlet procedure. After adding toluene as a keeper evaporation was carried out by means of a rotary evaporator and a nitrogen evaporator, the organo phosphates were redissolved in toluene/ethyl acetate and subsequently determined by gas chromatography with a mass-selective detector (GC-MS) [2].

The investigations showed that the main target compound ToCP only in trace amounts is present in the air of the aircraft cabins, all results are far below the OEL of 100 µg/m³ [3]. However, other phosphates such as tri-*n*-butyl phosphate and tri-phenyl phosphate are detected which could have their origin in the hydraulic oil (see Table 1).

Table 1: Organo-phosphates in an aircraft type BAE-146

Laboratory	Measuring site	TPP [µg/m ³]	TiBP [µg/m ³]	TnBP [µg/m ³]	ToCP [µg/m ³]	TmCP [µg/m ³]	TpCP [µg/m ³]
1*	Cockpit	< 2	< 2	< 2 - 12	< 2	< 2	< 2
2**	Cockpit	0,03 – 0,23	0,05 – 0,16	1,4 – 15,4	0,002 – 0,42	0,10 – 0,82	0,003 – 0,58
1	Passenger cabin	< 2	< 2	< 2 - 21	< 2	< 2	< 2
2	Passenger cabin	0,02 – 0,83	0,05 – 0,20	1,3 – 21	0,004 – 0,95	0,10 – 4,8	0,003 – 1,3
1	Board kitchen	< 2	< 2	< 2 - 35	< 2	< 2	< 2
2	Board kitchen	0,03 – 0,20	0,05 – 0,11	1,6 – 29	0,002 – 0,60	0,048 – 0,91	0,01 – 0,44

* triple measurements; ** double measurements, TPP = triphenyl phosphate; TiBP = tri-*i*-butyl phosphate; TnBP = tri-*n*-butyl phosphate; ToCP = tri-*o*-cresyl phosphate; TmCP = tri-*m*-cresyl phosphate; TpCP = tri-*p*-cresyl phosphate

Additionally to the air samples wipe samples (100 cm²) were taken at all measuring sites and analysed by laboratory 1. The results fully agree to

the air samples only very low amounts of TPP, TnBP and TiBP were found.

The load of volatile organic compounds (VOC) in the aircraft was in a range, such as occurs in offices in a TVOC concentration range of 50 µg/m³ to 250 µg/m³. Only on one flight where the plane had to be de-iced before take-off components of de-icing fluid could be detected. However, these substances were no longer detectable after about 30 minutes of flight time (see Table 2).



Figure 2:
Sampling of organo phosphates
and VOCs in the board kitchen

Table 2: TVOC and de-icing fluid in an aircraft type BAE-146

Flight status	Measuring site	TVOC [µg/m ³]	Propylene glycol [µg/m ³]
1	Cockpit	460	150
2	Cockpit	580	53
1	Passenger cabin	760	360
2	Passenger cabin	150	58
1	Board kitchen	470	304
2	Board kitchen	130	53

1 Runway, take off, climb and about 15 minutes in altitude; 2 about 15 minutes in altitude, landing and runway to park position
TVOC = total volatile organic compounds

In another study, a moisture trap from the ventilation system of a retired BAe 146 aircraft was examined for deposits. The inside surface was extracted with MtBE and analysed for organo phosphates. The inside surfaces of the filter are reflecting several years of operation and non-volatile organophosphates such as TCP can be accumulated. Also here, the critical ToCP is detectable only in traces, while the other phosphates were very well detectable (Figure 3).

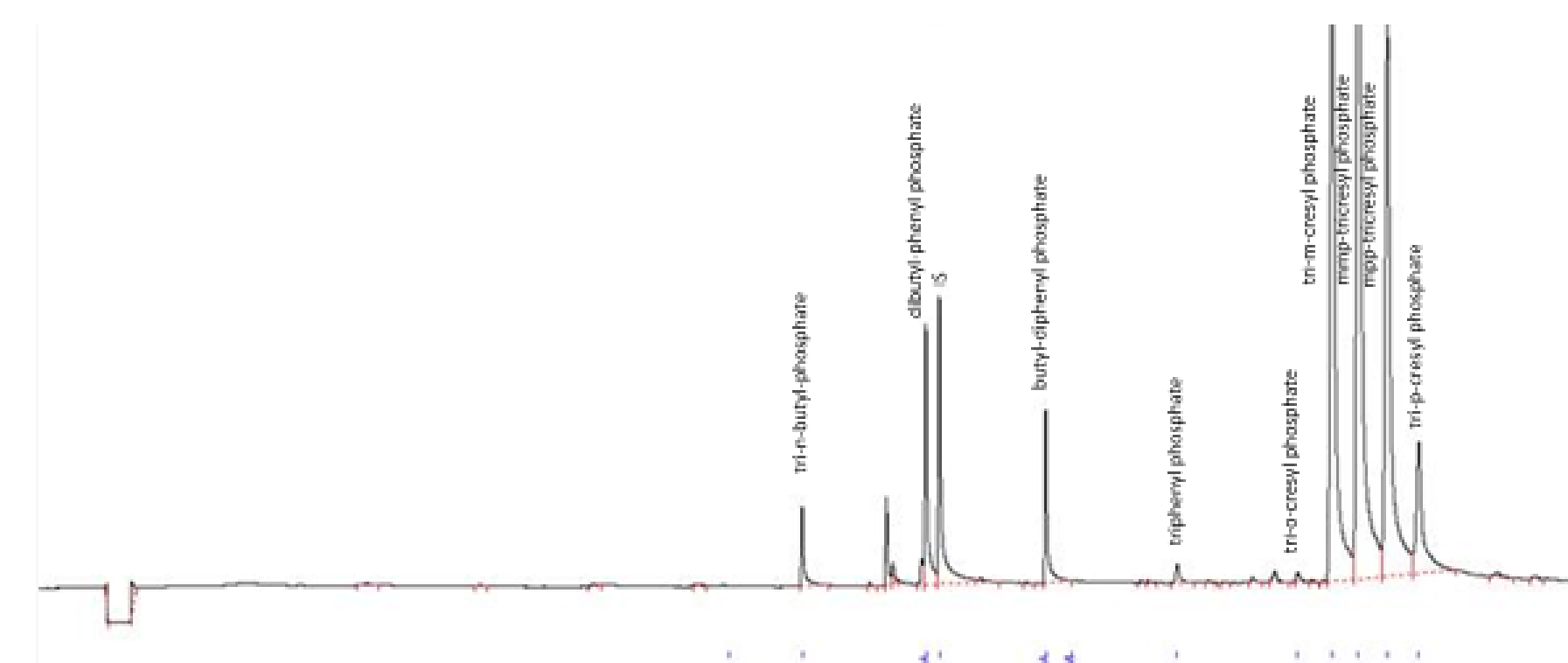


Figure 3:
Chromatogram of an
MtBE extract from a
moisture trap of an
BAE-146 aircraft

[1] Breuer, D., Werner, S., Friedrich, C., Rosenberger, W., Triaryl phosphates,

In: The MAK collection for Occupational Health and Safety, published 2013,

<http://onlinelibrary.wiley.com/doi/10.1002/3527600418.am7830e1713/pdf>

[2] Rosenberger, W., Bader, M., Breuer, D., Trialkyl- and triaryl phosphates

In: The MAK collection for Occupational Health and Safety, published 2013

<http://onlinelibrary.wiley.com/doi/10.1002/3527600418.am12671e1713/pdf>

[3] GESTIS - International limit values for chemical agents Occupational exposure limits (OELs), <http://www.dguv.de/dguv/ifa/Gefahrstoffdatenbanken/GESTIS-Internationale-Grenzwerte-für-chemische-Substanzen-limit-values-for-chemical-agents/index-2.jsp>