Workshop addressing ‘Cabin Air Quality Research’

Cologne, January Tuesday 17th – Wednesday 18th, 2023
1

Foreword: Why CAQIII?

2

Introduction to the CAQIII project
Why CAQIII?
Bleed Air Contamination with Engine Oil

Oil Fumes / Fume Events

What is the hazard?
What is the frequency?
Why CAQIII?
Risk Assessment

Only objective: Oil events and toxic effects of oil vapors!

Workshop Task: What are the definitions for Air Quality Event, Fume Event and Smell Event?

RISK = HAZARD x FREQUENCY

What counts?

What is toxic?
Why CAQIII?
Risk Assessment

Decision Body

Authorities in Aviation (FAA, EASA)

RISK = HAZARD x FREQUENCY
Why CAQIII?
Data Generation for Risk Assessment

RISK = HAZARD x FREQUENCY

Decision Body
Authorities in Aviation (FAA, EASA)

Research Panel
Analytical-Data
In-Flight-Data
Toxicity-Data
Ground-Test-Data

Literature -Data
What will the CAQIII project do – and not do?

“The regulatory system on aircrafts and chemicals is as it is – with regulation being based on scientific evidence (data).
Introduction to the CAQIII project

“Cabin air quality assessment of long-term effects of contaminants”
Introduction to the CAQIII project

Previous Campaigns

CAQI and CAQII (B787)
Objective: Cabin Air Quality and oil events during flight

Result: Cabin air quality for normal condition is good

“no oil-related fume event”
Introduction to the CAQIII project
HEPA-Filter Sampling Strategy
Introduction to the CAQIII project
HEPA-Filter Sampling – General Principle

Eckels et al. 2014 »»» 4 TCPs isomers & some Oil esters
CAQIII »»» 10 TCPs, Oil esters, Carboxylic acids, Aldehydes,
VOC, SVOC, Heavy Metals & Unknown Screening

Analytical Oil Characterization

Analytical Oil Fingerprint
Introduction to the CAQIII project
HEPA-Filter Sampling – Analytical Groundwork

1% N-Phenyl-(1-naphthyl)-amine

95% Pentaerythritol-esters with acid-lengths between C5 and C12

>5% alkylated Diphenylamines

3% mixture of mpTCP Isomers

Extensive Analytics

10 TCPs, Oil esters, Carboxylic acids, Aldehydes, VOC, SVOC, Heavy Metals & Unknown Screening
Introduction to the CAQIII project
HEPA-Filter Sampling – Analytical Groundwork

95% Pentaerythritol-esters with acid-lengths between C5 and C12

GC-MS of Mobil Jet Oil II

- 3% TCP isomers

molar weight [g/mol]

Sum of Peak-area TIC
Introduction to the CAQIII project
HEPA-Filter Sampling – Analytical Groundwork

95% Pentaerythritol-esters with acid-lengths between C5 and C12

“old socks or wet dog”
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HEPA-Filter Sampling – Analytical Groundwork

GC Resolution of the 10 TCP Isomers

10 TCP isomers with m/z = 368
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HEPA-Filter Sampling – Analytical Groundwork

Extensive Analytics
Introduction to the CAQIII project
HEPA-Filter Sampling – Analytical Groundwork

Extensive Analytics
Introduction to the CAQIII project
HEPA-Filter Sampling – Storage Procedure until Analysis

HEPA-Filter sampling and analytical method development in progress
(first results expected at the end of 2023)
# HEPA Filter Sampling Protocol

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<td>Date of complaint:</td>
<td>Filter type:</td>
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<td>□ No</td>
<td>Choose type</td>
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**Information on the filter use:**

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**Information on complaint:**

- [ ]
Introduction to the CAQIII project
HEPA-Filter Sampling – i) In-Flight ii)

i) HEPA FILTER SAMPLING IN-FLIGHT
- A320 fleet from participating air lines (fume event)
- Selected B787 aircraft from participating air lines

ii) HEPA FILTER SAMPLING ON GROUND
- Aircraft fume event simulation (Toulouse)

Analytical Oil Fingerprint

Extensive Analytics
Introduction to the CAQIII project
HEPA-Filter Sampling – iii) Fume Event Simulation without External Contamination

Engine Simulator    Mixer    Pre-cooler    Sampling Vessel

Bleed Air Contamination Simulator

HEPA Filter

Fume event

Bleed Air Contamination Simulation Vessel

Analytical Oil Fingerprint

Extensive Analytics
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ECS & Duct Sampling – Secondary Event Investigation

[Diagram showing the ECS and duct sampling system with labeled parts:
- P1 APU
- APU bleed valve
- APU check valve
- P2 APU bleed duct
- P3 Engine HP/LP bleed

[Image of a man standing next to a box with equipment, labeled 16/03/2022]
About 100 ECS & duct parts from three A320 aircraft:
Part selection and analytical method development in progress
(first results expected at the end of 2023)
Introduction to the CAQIII project

iii) Fume Event Simulation

![Diagram of Engine Simulator, Mixer, Pre-cooler, and Sampling Vessel with an arrow indicating a fume event.](image-url)
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Fume Event Simulation & Toxicity Study
Introduction to the CAQIII project
Fume Event Simulation & Toxicity Study

Sampling vessel

Test setup BACS sample transfer line

Mobile LAB for Animal Tests
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Fume Event Simulation & Toxicity Study

- AChE- and BChE-Assay
- Metabolome Analysis
- Brain hemisphere protein analysis
- Blood markers

Bioanalytics

- OECD TG 412: sub acute inhalation study

Animal Exposure

Dissection

- Brain hemisphere histopathology
- Lung histopathology

Neurotoxicity assessment

- Brain and behaviour analysis at GMC

Fraunhofer ITEM
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Bioanalytics: Choline-Esterase Assay

- AChE- and BChE-Assay

Assay adaptation required!
Introduction to the CAQIII project
Bioanalytics: Choline-Esterase Assay

- AChE- and BChE-Assay

Cresyl saligenin phosphate (CBDP)

- Cresol

Ox

oooTCP
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Bioanalytics: Choline-Esterase Assay

- AChE- and BChE-Assay

Organophosphate-Induced Delayed Neuropathy (OPIDN)

Cresyl saligenin phosphate (CBDP)

Bioanalytics
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Bioanalytics – Metabolom Analysis

1019 Metabolites
107 Small Molecules
912 Lipids (e.g. Sphingo myelin)

Changes in cell wall biochemistry

Organophosphate-Induced Delayed Neuropathy (OPIDN)

Nerve injury: OPIDN (Image by DING Qiang)
Introduction to the CAQIII project
Toxicological Hazard Assessment

Target Selection
and
Toxicological
Hazard/Risk
Assessment

Authorities in
Aviation
(FAA, EASA)

Decision Body

- Literature Data
- Bioanalytical Data
- TOX Database
- Simulation Data
- Ground Test Data
- In-flight Data

National Research Centre
for the Working Environment
Copenhagen
Introduction to the CAQIII project
The overarching goal... “Data Generation for Risk Assessment”

“The CAQIII project is intended to provide scientific evidence (data) related to the health effects of oil-related fume events.”

RISK = HAZARD x FREQUENCY
Thank you for your attention!