2019 INTERNATIONAL AIRCRAFT CABIN AIR CONFERENCE

CONFERENCE PROCEEDINGS

Presentations of the

2019 International Aircraft Cabin Air Conference

17-18 September 2019

Imperial College London

GCAQE

Global Cabin Air Quality Executive

Tristan Loraine (Conference Director)
Dieter Scholz, Susan Michaelis (Editors)

CONFERENCE PROCEEDINGS

Presentations

2019 International
Aircraft Cabin Air Conference

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London: Global Cabin Air Quality Executive (GCAQE)

2019

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https://www.aircraftcabinair.com

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Introduction

The International Aircraft Cabin Air Conferences are developing into a series of conferences **organized every two years**. The conferences are mapping the business, regulatory and technical solutions to aircraft cabin air contamination.

The conferences in 2017 and 2019 provided networking opportunities for those seeking to **understand the subject of contaminated air**, the flight safety implications, the latest scientific and medical evidence investigating the contaminated air debate and the solutions available to airlines and aircraft operators. The two conferences held so far have been the most in-depth conferences ever on the topic of aircraft cabin air contamination.

By way of expert global independent and industry speakers, the Aircraft Cabin Air Conferences seek to achieve the following key **objectives**:

- Provide a historical overview of the contaminated air issue and its causes.
- Map out the flight safety aspects of contaminated air through case studies, discussion and air accident investigation findings.
- Disseminate the latest medical and scientific theories and findings on the health aspects of exposure to contaminated air.
- Give guidance of the regulatory aspects of cabin air quality.
- Examine the latest development towards bleed air filtration, contaminated air warning sensor systems and other potential solutions.
- Provide an opportunity for networking and sharing good practice to facilitate better inter-agency working.

Please refer to the
Conference Programme 2019 (https://doi.org/10.5281/zenodo.4554737)
for additional information not repeated here:

- Sponsors and Supporters
- Welcome by the Conference Director, Captain Tristan Loraine
- Contaminated Cabin Air Key Timeline 1930 – 2019
- Agenda
- Introduction to the GCAQE
- Bleed Air Simplified
- Conference Speakers

In total 30 presentations were given at the 2019 International Aircraft Cabin Air Conference (ACA 2019). **This document** contains the 25 presentations provided by the authors. It combines the presentations into one PDF for further dissemination and archiving.

Single presentations can be retrieved for reading and can be quoted conveniently also by their individual Digital Object Identifier (DOI). They are listed on the Conference Proceedings Homepage: https://zenodo.org/communities/aircraftcabinair. The DOI of each presentation is given in the Table of Contents.

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SCHOLZ, Dieter, MICHAELIS, Susan (Ed.). *2019 International Aircraft Cabin Air Conference: Conference Proceedings – Presentations*. London: GCAQE. Available from: https://doi.org/10.5281/zenodo.4626253

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LASTNAME, FirstName, 2019. *ArticleTitle*. Presented at the 2019 International Aircraft Cabin Air Conference (Imperial College London, 17-18 September 2019). Available from: https://doi.org/10.5281/zenodo...

29 filmed presentations of the Aircraft Cabin Air Conference 2019 are available at https://vimeo.com/ondemand/aca2019 for purchase. A trailer can be played and gives an impression of the two conferences.

The presentations were formatted by the authors. They are given here in alphabetical order by author last name.

Neither the conference organizers nor the editors or publishers can be held responsible for inaccuracies or errors in any included presentation.

Dieter Scholz

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https://doi.org/10.5281/zenodo.4464637

Fume events on aircraft: "How often?"

Judith Anderson, MSc CIH
Industrial Hygienist
Air Safety, Health and Security Department
Association of Flight Attendants-CWA, AFL-CIO

Aircraft Cabin Air Conference 2019
Imperial College London
Sept. 18, 2019

Study: 'Toxic Air Events' Happening On More Flights Than FAA Reports

By Susie Steimle   September 24, 2018 at 11:44 pm   Filed Under: Air Safety, airplane travel, Alaska Airlines, FAA, fume event, Strange Odor, Toxic Air

If something negative doesn't happen very often, then it's easy to justify not doing anything about it, especially if the consequences of it happening can be downplayed and dismissed.

(Little or no data = little or no problem)

What events must be reported?

- Service Difficulty Reporting regulation 14CFR121.703
  - Requires US airlines to report each "failure, malfunction, or defect" that causes "smoke, vapor, toxic or noxious fumes" to accumulate/circulate during flight (wheels up) or, technically, on the ground IF the airline is of the "opinion" that flight safety could have been "endangered"
  - Excludes events that are reported at the gate, during taxi out, after landing (UNLESS the airline deems that flight safety could have been compromised)
  - Excludes "NFF" – such as slow internal leak, worn but not failed seal, overservicing

Federal Aviation Administration

Run Query | Clear Query Criteria | Return to the Main Menu

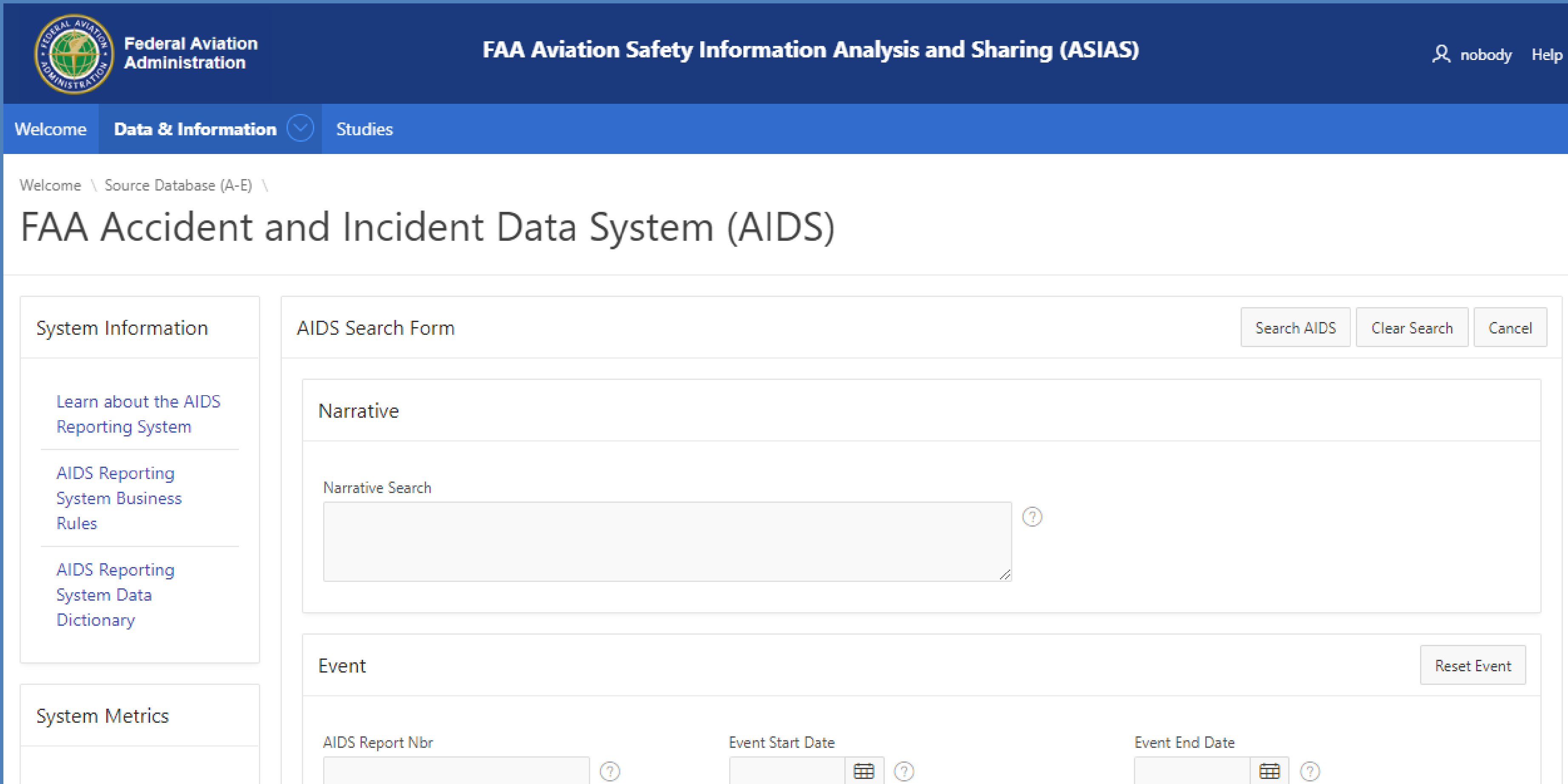
Query Criteria
(Note: Recently submitted SDR's are not available until the FAA approves the submission.)

Operator Control #	(Searching by Operator Control Number will allow you to check the status of a submission.)		
Operator Designator		Registration Number	
Difficulty Date: From	To (mm/dd/yyyy)		
^JASC (ATA) Code			
^Aircraft Make		^Aircraft Model	
^Engine Make		^Engine Model	
^Propeller Make		^Propeller Model	
^Part Name		^Part Make	
^Part Number			
^Problem Description	(Searching this field will affect query time!)		

https://av-info.faa.gov/sdrx/Query.aspx

More reporting rules in US

- Mechanical Interruption Reporting regulation 14CFR121.705
  - Each “interruption to a scheduled flight,” diversion, tail swap, etc. caused by known or suspected mechanical difficulties or malfunctions not required to be reported under SDR rule
  - So this could include fumes on the ground that caused cancelation, diversion, etc. even if a mechanical difficulty was only suspected…
- Hard to tally/track because there is no central database (the Certificate Management Office for each airline maintains them), and they are only kept for one year.



FAA Accident and Incident Data System (AIDS) which contains incident records "gathered from several sources" including incidents reported on FAA Accident and Incident Reporting Form (8020-23), that is mandatory, per FAA Order 8020.11D (2018)

https://www.asias.faa.gov/apex/f?p=100:12:::NO:::

FAA Form 8020-23: Accident/Incident Report Form

- Incidents must be reported -- “An occurrence other than an accident, associated with the operation of an aircraft, which affects or could affect the safety of operation.” (FAA Order 8020.11D, 2018)

Excerpt from reporting form:

21A.	**TECHNICAL FACTORS**		☐ NONE
☐	GEAR COLLAPSE	☐	LOST POWER
☐	GEAR UP LANDING	☐	FOD
☐	FIRE OR EXPLOSION	☐	AUTO/IMPROPER FUEL
☐	FUEL CONTAMINATION	☐	CORROSION
☐	BLADE/ROTOR FAILURE	☐	INFLIGHT FIRE
☐	DESIGN OF AIRCRAFT	☐	SMOKE/FUMES
☐	METAL FATIGUE	☐	INFLIGHT BREAKUP

- The FAA guidance to its inspectors on how to meet this incident reporting order lists various incident types; NMAC, PD

4) **Unidentified Flying Object (UFO).** If any FAA employee receives a report of a UFO, t
on of higher learning that has expressed interest in such reports. If concern is expressed that li

- "If any FAA employee receives a report of a UFO, the individual making the report should be referred to the nearest scientific establishment or institution of higher learning that has expressed interest in such reports. If concern is expressed that life or property might be endangered, refer the individual to the local police department." (FAA Order 8900.1, Vol. 7, Ch.1, 7-36(C)(4))

http://fsims.faa.gov/wdocs/8900.1/v07%20investigation/chapter%2001/07_001_002_chg_54c.htm

One answer to "how often"

- On Feb. 14, 2012, US Congress passed this law:

FAA MODERNIZATION AND REFORM ACT OF 2012

SEC. 917. RESEARCH AND DEVELOPMENT OF EQUIPMENT TO CLEAN AND MONITOR THE ENGINE AND APU BLEED AIR SUPPLIED ON PRESSURIZED AIRCRAFT.

(a) In General. -- Not later than 60 days after the date of enactment of this Act, the Administrator, to the extent practicable, shall implement a research program for the identification or development of appropriate and effective air cleaning technology and sensor technology for the engine and auxiliary power unit bleed air supplied to the passenger cabin and flight deck of a pressurized aircraft.

Aug 16, 2013
(18 months later)…

REPORT TO CONGRESS

Pub. L. No. 112-95, 126 Stat. 11 (2012)
FAA MODERNIZATION AND REFORM ACT OF 2012

SECTION 917
RESEARCH AND DEVELOPMENT OF EQUIPMENT TO CLEAN AND MONITOR THE ENGINE AND AUXILIARY POWER UNIT (APU) BLEED AIR SUPPLIED ON PRESSURIZED AIRCRAFT

Data Search:

Reported events considered in this assessment were collected through the Service Difficulty Reporting System (SDRS), National Transportation Safety Board (NTSB), FAA Accident Incident System (AIDS), and the FAA Voluntary Disclosure Reporting Program (VDRP). Each of these data sources was searched, using a text mining concept (including the terms: fume, odor, smell, smoke, and bleed air), for air carrier events of cabin air contamination by hydraulic or oil particulates.

A total of 69 events over a ten year period between 2002 through 2011 were found and reviewed. None of these reported events involved known injuries, fatalities, or damage as defined by 49 CFR Part 830[1]. These events are summarized as follows:

- Events involving oil contamination, 18.
- Events involving hydraulic oil contamination, 0.
- Events involving other contamination (smoke, fumes, other unknown), 51.

Summary of that FAA "report"

18 oil/hydraulic fume events per 104.9 million flights

= 0.00000017 or 1.7 x 10^{-7} events per flight

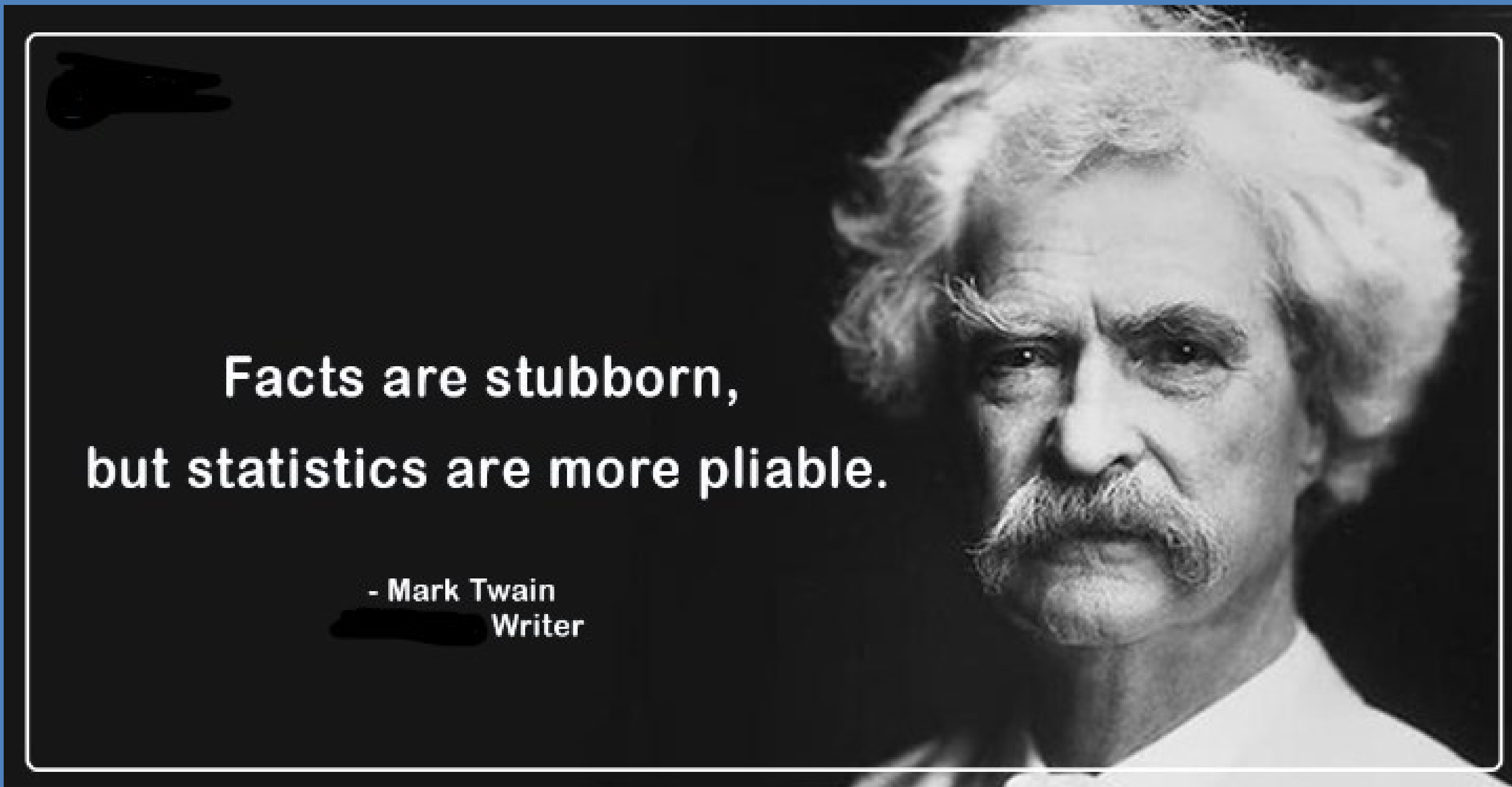
Or 1 event per 5.8 million flights

The FAA conducted a safety database assessment of airliner cabin air quality events involving Part 121 commercial airline operators. The results of the analysis indicate an extremely low occurrence involving bleed air contamination from engine oil or hydraulic fluid. While there

As shown by the search summary, the occurrence of oil or hydraulic based contamination of bleed air is extremely low. In formulating the annual aviation safety research portfolio, the FAA evaluates the relative risk of aviation safety hazards and the potential for safety improvement. The FAA will continue to consider cabin safety risk and sponsor research in this area appropriate to the risk level.

If something negative doesn’t happen very often, then it’s easy to justify not doing anything about it, especially if the consequences of it happening can be downplayed and dismissed.

(Little or no data = little or no problem)


[redacted]
Facts are stubborn,
but statistics are more pliable.
- Mark Twain
[redacted] Writer

March 4, 2014

Federal Aviation Administration

FOIA Form

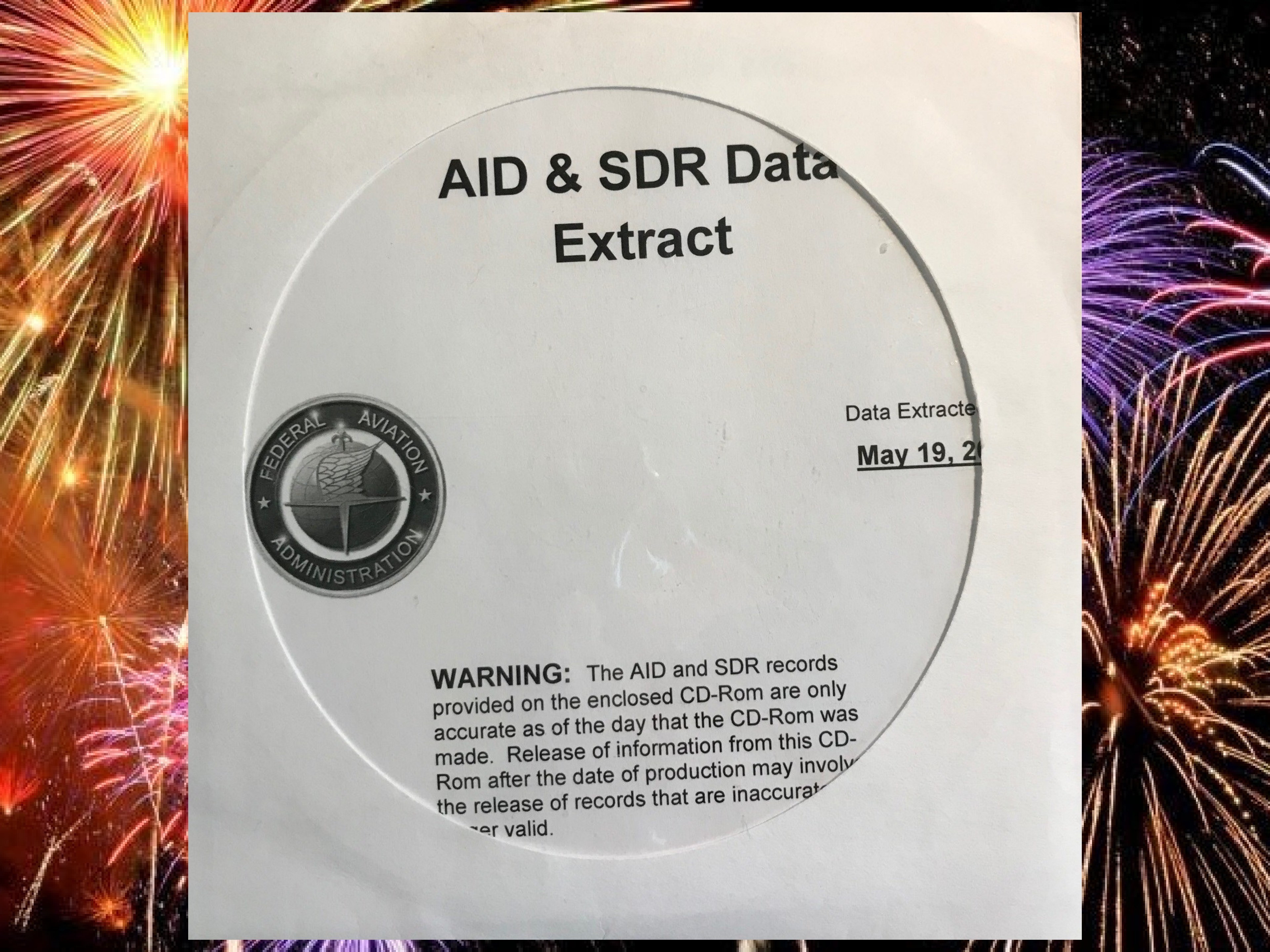
Your request has been submitted

Under the Freedom of Information Act (FOIA), Title 5 U.S.C. 552, I am requesting a copy of reports of smoke and fumes in the cabin/flight deck that the FAA received from US carriers from Jan. 1, 2002 through Dec. 31, 2011. Please include reports that contain one or more of the following search terms: fume, odor, smell, smoke, bleed air.

FAA response to FOIA request

- By law, FAA must make an initial response to FOIA request within 20 business days.
- I received my first response after 83 business days

- 383 business days after my initial request, including resubmitting it, making phone calls and sending countless emails…


AID & SDR Data
Extract
FEDERAL AVIATION ADMINISTRATION
Data Extracte
May 19, 2
WARNING: The AID and SDR records
provided on the enclosed CD-Rom are only
accurate as of the day that the CD-Rom was
made. Release of information from this CD-
Rom after the date of production may involv
the release of records that are inaccurat
er valid.

10 years of fume event data

- That CD listed 15,885 SDR records, each of which contained one or more of these words: fume, odor, smell, smoke, bleed air; also, 365 AIDS reports
- Focusing on the SDRs, I excluded 3,448 SDRs that did not involve fumes/smoke/haze in the cabin/flight deck…

JUMP SEAT AREA RIGHT SIDE SMOKE GOGGLES NEED REPLACED LENS CRACKED. REPLACED SMOKE GOGGLES.

- I reviewed the remaining 12,437 SDRs and sorted each into the groups on the next slide, according to defined criteria. An expert mechanic and a pilot helped me with the 586 reports I wasn’t sure about, general questions…
- Data on next slide has undergone “first pass” review and classification, subject to review. Please do not cite (yet).

Category	Total	% reports
Electrical	4,531	36%
Bleed source (but specifics not defined)	**1,799**	**14%**
Oil	**1,336**	**11%**
Fan	1,027	8.3%
Fuel	635	5.1%
Oven	387	3.1%
Hydraulic fluid	**168**	**1.4%**
Deicing fluid	137	1.1%
Duct (blown, disconnected, clogged)	106	0.9%
Battery	73	0.6%
Bird strike	42	0.3%
Engine wash	40	0.3%
Other, defined but not listed (mostly packs)	**1,019**	**8.2%**
Source UNKNOWN or too vague to classify	**1,193**	**10%**

	Category description	N reports	% total
1	Confirmed/consistent with oil fumes in supply air	1,336	11%
2	Contaminated bleed source (specifics not defined)	1,799	14%
3	Other (mostly defective/failed pack issues)	1,019	8.2%
4/5	Unknown (fault not found or insufficient details)	1,193	10%

1 APU AUTO SHUTDOWN WITH SMOKE IN CABIN. FOUND THREADS STRIPPED AT THE GEARBOX HOUSING OIL OUTLET PORT. THIS CONDITION LEAD TO AN EXTERNAL OILLEAK. THE OIL WAS THEN DRAWN INTO THE INLET THUS CAUSING THE SMOKE IN CABIN. BORESCOPE OF THE POWER SECTION REVEALED DIFFUSER VANE EROSION AND HOT SECTION DETERIORATION. REPLACED APU

2 DURING CLIMB, THE LEFT AFT SMOKE DETECTOR SOUNDED AND FLIGHT ATTENDANTS REPORTED ODOR IN THE CABIN. FLIGHT CREW RETURNED TO DEPARTURE AIRPORT. MAINTENANCE REPLACED COALESCER SOCKS AND PERFORMED A PACK BURNOUT. APU ON MEL.

3 FLT 5745 - HSV-CLT - RETURNED TO FIELD DUE TO SMOKE IN THE CABIN WITH PACK OPERATION. MAINTENANCE TROUBLESHOT AND ISOLATED THE RIGHT, CAUSING THE SMOKE. MAINTENANCE REPLACED THE RIGHT PACK. OP CHECKS GOOD. THE AIRCRAFT WAS RETURNED TO SERVICE. (M)

4 DURING CLIMB THROUGH 15,000 FT, THE CREW REPORTED THE ODOR OF SMOKE IN THE CABIN AND FLIGHT DECK. THE AIRCRAFT RETURNED TO IAH AND LANDED WITHOUT INCIDENT WHERE MAINTENANCE INSPECTED THE AIRCRAFT. ENGINE RUNS WERE PERFORMED OPERATING THE PRESSURIZATION, AIR CONDITIONING, AND BLEED SYSTEMS AND THE ODOR COULD NOT BE DUPLICATED. THE AIRCRAFT WAS TEST FLOWN SATISFACTORILY WITH NO ODOR OF SMOKE IN THE CABIN OR FLIGHT DECK.

5 DIVERSION DUE TO ODOR IN AFT CABIN. MX IN PROGRESS.

More findings

- The source of at least 10% of these fume events was unknown/undefined, and another 14%+ were consistent with a bleed source but not defined. Data shows:
  - …that FAA should add some more standardized questions on the SDR form that airlines submit, in order to more clearly define the causes.
  - …airlines struggle to define the sources of fumes and would benefit from reliable sensors that can, at a minimum, distinguish oil, hydraulic, and fuel, and also electrical (incl. fans), if there are suitable marker compounds.

FLIGHT 2140, LGA-BOS - STRONG ODOR DIRTY SOCK SMELL ON CLIMB. MAINTENANCE ACCOMPLISHED JOB CARD 43L00021001. NO DEFINITIVE ODOR PRESENT. REPLACED RECIRC FILTERS AS PRECAUTION PER AMM 21-24-02. RAN APU FOR 45 MINS WITH PACKS.

- FAA should not make up numbers to justify inaction to Congress and should not take 383 business days to respond to a simple data request.

Characterization of the frequency and nature of bleed air contamination events in commercial aircraft

Published 2016

M. Shehadi, B. Jones, M. Hosni

Mechanical and Nuclear Engineering Department, Kansas State University, Manhattan, KS, USA

Abstract Contamination of the bleed air used to pressurize and ventilate aircraft cabins is of concern due to the potential health and safety hazards for passengers and crew. Databases from the Federal Aviation Administration, NASA, and other sources were examined in detail to determine the frequency of bleed air contamination incidents. The frequency was examined on an aircraft

The average incident rate for all aircraft reported in this study is 0.2 incidents per 1000 flights, which is closer to the lower end of estimated range of 0.09 3.9 incidents per 1000 flights cited previously. However, the highest frequency model in this study was 0.8 incidents per 1000 flights. As long as the underreporting is more or less uniform, there should be no large relative impact in terms of the comparisons between aircraft models. It is entirely possible that underreporting could vary considerably from airline to airline due to reporting policies and other factors.

0.2 events per 1000 flights (6 years of data; 2007-12)

Another answer to "how often", based mostly on FAA data

- Researchers found that **US airlines <u>reported</u> 5.4 bleed air events fleet-wide per day (on average, over six years, from 2007-12)** (Shehadi et al., 2016).

- If you take the "5.4 per day" documented over those six years and apply it to the 10 years, **the number of fume events during the 10 years will be closer to 20,000 (not 18).**

Oil and hydraulic fumes: How often?

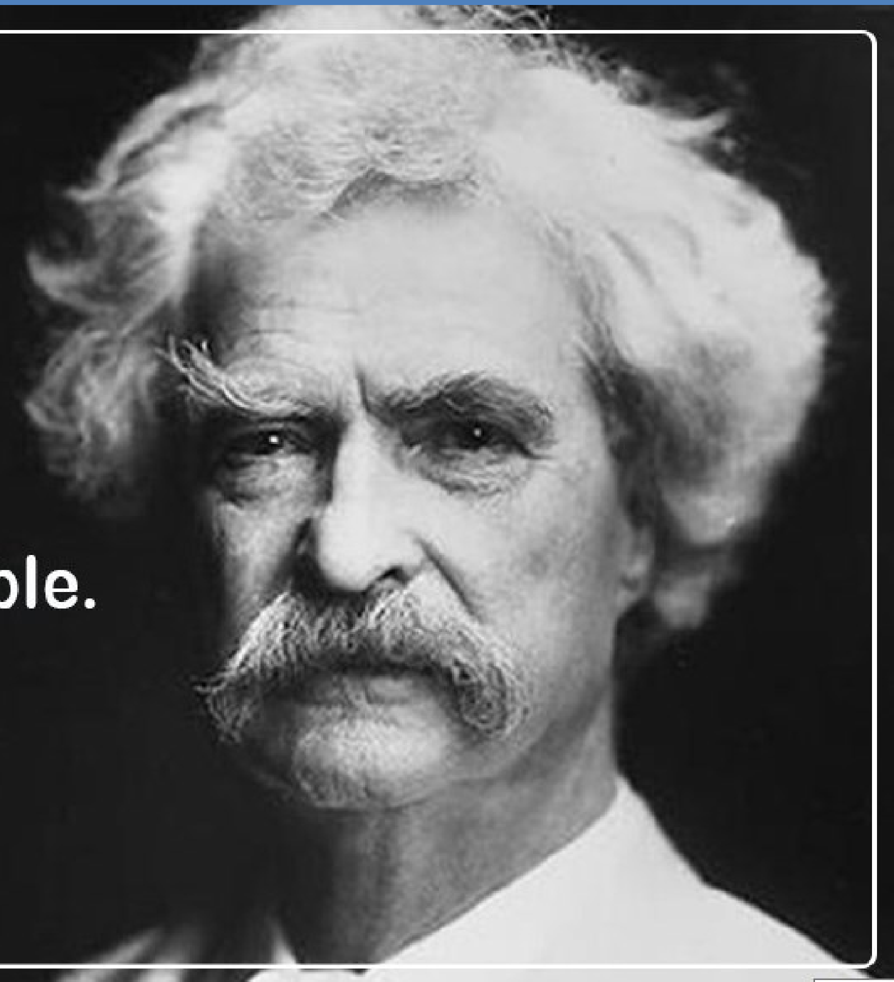
- **2016 – published research paper**
- FAA databases: 2007-12
- 1 event per 5,000 flights

- **2013 - FAA report to Congress**
- Claimed FAA databases: 2002-11
- 1 event per 5.8 million flights
- "extremely low occurrence"

[redacted]

Facts are stubborn,
but statistics are more pliable.

--U.S. Federal Aviation Admin.



Are any of these data comprehensive?

The 69 events represent the actual values obtained from this specific data search. While this data search may not represent all engine and APU bleed air contamination events in Part 121 operations, it does provide an accurate accounting of these events during the period from 2002 through 2011, on a search of the terms "*fume, odor, smell, smoke, and bleed air*."

-FAA, August 2013 report to Congress

- Undoubtedly, these data are only a subset of the airline-reported fume events in the US.
  - "Fume, odor, smell, smoke, and bleed air" are not the only search terms for fume events.
  - The reporting rules are very limited in scope.
  - There is evidence that airlines underreport.

In summary:

- GLOBALLY, there are no national aviation fume event reporting systems for crews/passengers, despite decades of recommendations to create one.
- In the US, the "service difficulty reporting" regulation excludes ground-based fume events and "NFF" fume events, guaranteeing that the number of reported fume events will be significantly downplayed.
- There is evidence that US airlines significantly underreport (even reportable) fume events to all three databases.

Recommended action

1. SDR language needs to change:

Sec. 121.703

Service difficulty reports.

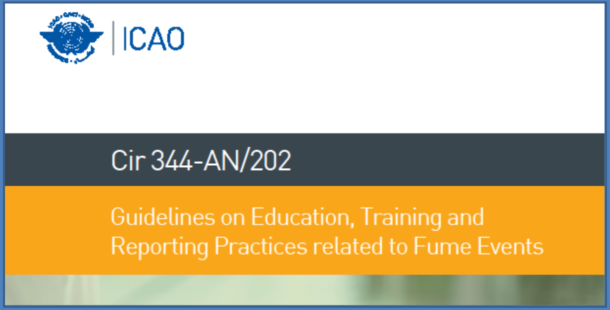
(a) Each certificate holder shall report the occurrence or detection of ~~each failure, malfunction, or defect concerning—~~

(1) ~~An aircraft component that causes accumulation or circulation of~~ smoke, vapor, or toxic or noxious fumes in the crew compartment or passenger cabin during ~~flight~~ operation;

(b) For the purpose of this section *during ~~flight~~* operation means the period from the moment ~~the aircraft leaves the surface of the earth on takeoff until it touches down on landing.~~ any person boards the aircraft with the intention of either flight or maintenance work and until such time as all such persons have disembarked.

And airlines should actually be held accountable to follow this regulation.

Recommended action:



2. **Mandate that airlines train crew and maintenance workers to recognize, respond to, and report fumes, per ICAO Circular 344-AN/202**

- Prompt recognition and response will mitigate exposure to fumes
- Reliable reporting essential to defining and addressing the problem
- Does not require any technology or changes to the aircraft; common sense

Recommended action:

3. **Airlines need to be more discriminating customers**

- Absent aviation regulators actually doing their job, airlines need to be more discriminating customers. Airlines need to create demand for non-bleed systems and bleed air filters/sensors by telling manufacturers that they want to buy them. (This is starting…)

In closing…

Federal Aviation Administration

FOIA Form

Your request has been submitted

- Late 2014, I filed another FOIA request with the FAA, asking for a copy of the 69 fume event reports (and especially the 18 oil fume reports) that they told Congress about, plus documentation for how those reports were selected.

- And this time, after only 47 biz days and a few pestering emails, I received this response…

U.S. Department
of Transportation
**Federal Aviation
Administration**

800 Independence Ave., SW.,
Washington, DC 20591

FEB 10 2015

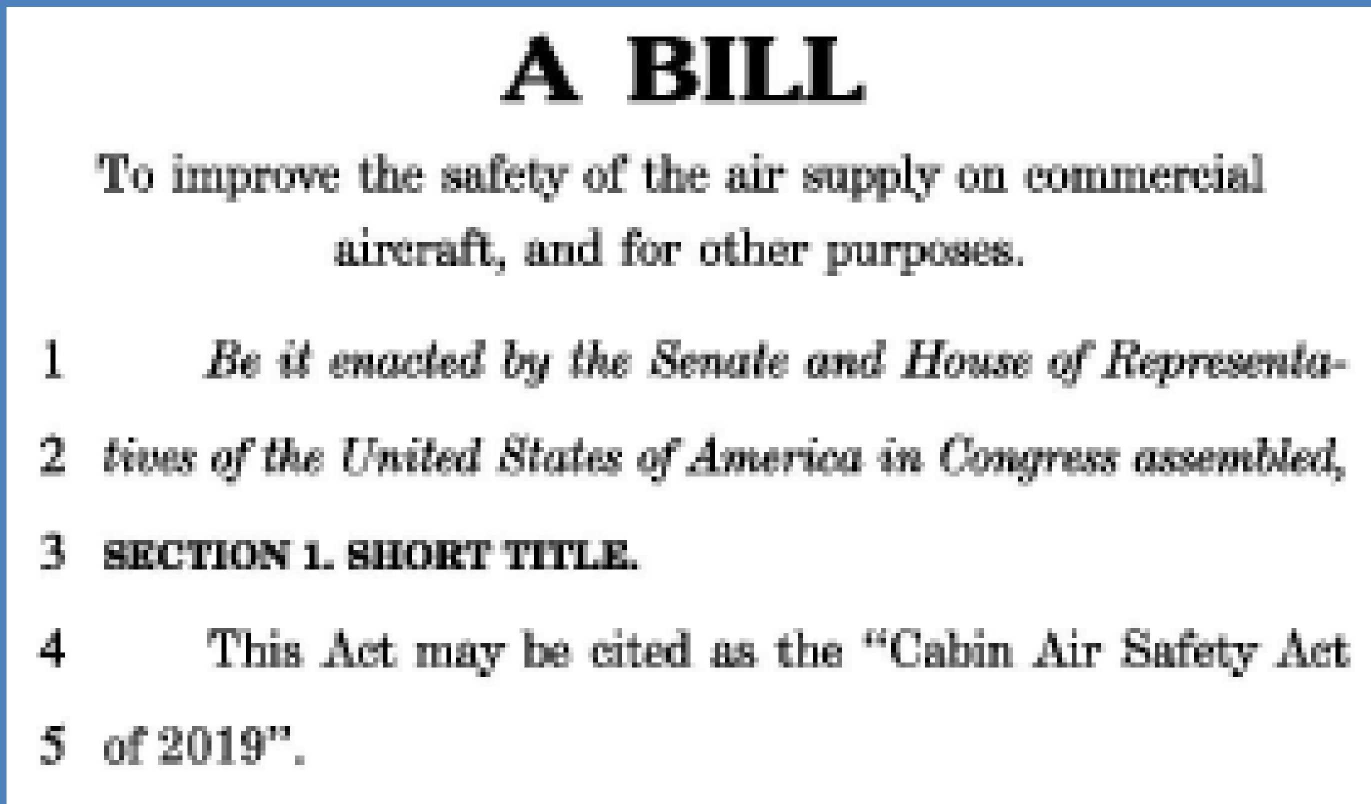
Dear Ms. Anderson:

This letter responds to your FOIA request dated December 3, 2014, concerning an AVS report to congress where the Federal Aviation Administration reported that it identified a total of 69 smoke/fume event reports found in its SDRS database over a 10-year period.

Your request was forwarded to multiple offices in the FAA to include the Office of the Associate Administrator for Aviation Safety (AVS). A records search was conducted in this office, but we did not locate any records or files pertaining to your specific request. Please be aware that your request was forwarded to the Office of Accident Investigation and Prevention, which prepared the referenced report. You will receive a separate response from that office.

Fume events on aircraft

Cabin Air Safety Act of 2019



A BILL

To improve the safety of the air supply on commercial aircraft, and for other purposes.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled,

SECTION 1. SHORT TITLE.

This Act may be cited as the "Cabin Air Safety Act of 2019".

Introduced April 10, 2019

Thank you for your attention.

PDX - EVIL, FOUL FISH ODOR EMINATING FROM AFT CABIN AREA. MAINTNEANCE COULD NOT DUPLICATE DISCREPANCY. NO PARTS REPLACED. AIRCRAFT RETURNED TO SREVICE.

Questions?

Judith Anderson, MSc CIH
Industrial Hygienist
Air Safety, Health, & Security Dept.
AFA-CWA, AFL-CIO
judith@AFAnet.org – (001) 206-932-6237

AN APPROACH TO THE INVESTIGATION OF SYMPTOMATIC PERSONS AFTER EXPOSURE TO AIRCRAFT FUME EVENTS

Jonathan Burdon MBBS, MD, FRACP, FCCP
S. Michaelis, V. Howard, L. Budnik, A. Heutelbeck, X. Baur, J. Roig, L. Coxon, J. Midavaine, H. Petersen, G. Hageman, C.L. Soskolne, D. Gee, C. Furlong

For DiMoPEX COST-Action and Collegium Ramazzini working groups on Cabin Air Quality

Aircraft Cabin Air Conference 2019

Background and Overview

- Term ‘Aerotoxic Syndrome’ - Not accepted by some
- Aerospace industry does not like term
- Not all present with same symptoms
- Aircraft related illness suggested (CASA EPAAQ 2012)
- For now term reasonable & justifiable

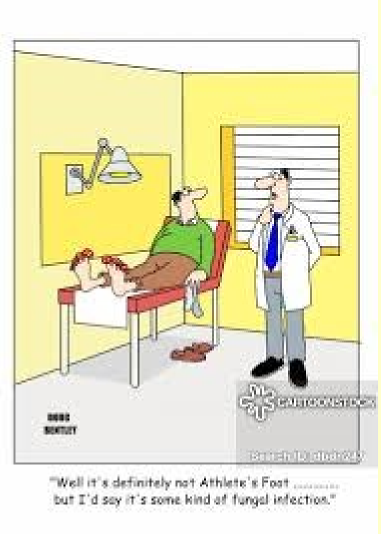
Background - Guidelines

- Some past Guidelines – none comprehensive
- Acknowledged that Guidelines will vary
- Comprehensive Guidelines
    - Consensus view of international experts
    - Nearing completion
    - Synopsis presented today
    - Pocket Guidelines planned

Scope of Presentation

- We are addressing
  - Bleed air contaminants/substances
    - Oils, hydraulic, de-icing fluids

- Not other pollutants
  - Pesticides
  - Infections



Technical Matters

- Medical need for understanding background of FE
- Outside air used to flush cabin & assist with pressurisation
- Pyrolysed oil in bleed air (design) - not Boeing 787 Dreamliner
  - No engine ‘bleed’ air filtration
- Good data assists in medical investigation/management
- Air exchange rates > than other indoor sites (sealed buildings)

Time of Presentation / Injury

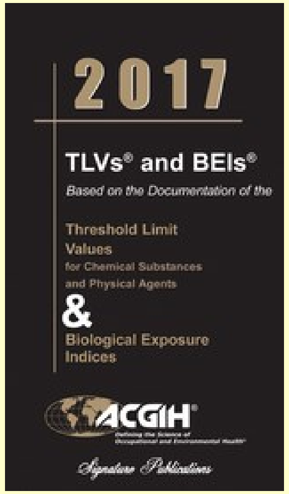
- Time of presentation with illness after FE important
  - In-Flight
  - Immediate Post Flight
  - Late / Subsequent
- Most report symptoms in-flight or immediately after
- Fume event / Smoke / Long-term low dose exposure (months / years)
- Industry set standards – PROTECT MOST - NOT EVERYONE !

Time of Presentation / Injury

- Industry set standards

PROTECT MOST - NOT EVERYONE !

- Set for ground level
- Not applicable to cabin environment
    - Altitude / complex pyrolysed mixtures



Presenting Symptoms

- Presenting symptoms - described elsewhere
- May involve all organ systems
- Duration
  - Hours, days, weeks, months
  - Sometimes, full recovery never occurs

Symptoms Experienced after FE - Summary

Neurotoxic

Neuropsychological

Gastrointestinal

Respiratory

Cardiovascular

Mucosal irritation

Table 2 Aerotoxic syndrome: short- and long-term symptoms

Short term exposure	Long term exposure
Neurotoxic symptoms: blurred or tunnel vision, nystagmus, disorientation, shaking and tremors, loss of balance and vertigo, seizures, loss of consciousness, parathesias;	*Neurotoxic symptoms*: numbness (fingers, lips, limbs), parathesias;
Neuropsychological or Psychotoxic symptoms: memory impairment, headache, light-headedness, dizziness, confusion and feeling intoxicated;	*Neuropsychological or Psychotoxic symptoms*: memory impairment forgetfulness, lack of coordination, severe headaches, dizziness balance, sleep disorders;
Gastro-intestinal symptoms: nausea, vomiting;	*Gastro-intestinal symptoms*: salivation, nausea, vomiting, diarrhoea;
Respiratory symptoms: cough, breathing difficulties (shortness of breath), tightness in chest, respiratory failure requiring oxygen;	*Respiratory symptoms*: breathing difficulties (shortness of breath), tightness in chest, respiratory failure, susceptibility to upper respiratory tract infections;
Cardiovascular symptoms: increased heart rate and palpitations;	*Cardiovascular symptoms*: chest pain, increased heart rate and palpitations;
	Skin symptoms: skin itching and rashes, skin blisters (on uncovered body parts), hair loss;
Irritation of eyes, nose and upper airways.	*Irritation* of eyes, nose and upper airways;
	Sensitivity: signs of immunosuppression, chemical sensitivity leading to acquired or multiple chemical sensitivity
	General: weakness and fatigue (leading to chronic fatigue), exhaustion, hot flashes, joint pain, muscle weakness and pain.

Winder et al 2005

In-Flight Investigation of Fume Event: Environmental

Record

- Type of aircraft
- When did event occur (stage of flight)?
- Where in the aircraft?
- What happened (smell, fumes, smoke)?
- How long did the event continue?
- Describe type of smell
- Who and how many (x out of y) affected?
- Record air quality monitor recordings (if available)

Medical Investigation of Fume Event: In-Flight

- Detailed careful history of FE including severity
- Record
  - Previous FE exposure and frequency, length of service
  - Symptoms and progression of symptoms
  - Observations of others
  - Any treatment given/used
  - Oxygen use (when/duration) including flow rate
  - Unusual behaviour
  - Pre-existing medical conditions
  - Trained medical personnel may record more
  - Treatment given

Medical Investigation of FE: Post Flight

- Medical, occupational and FE event history as before
- Will be more detailed – doctors involved !
- History of career flying time
- Detailed clinical examination
  - All organ systems
  - Emphasis on presenting complaints, neurological and respiratory systems
  - Mental and cognitive state important
- Special investigations - appropriate for presenting complaints

Medical Investigation of FE: Post Flight

- Special Investigations
  - Collect blood as soon as possible (record time from exposure)
  - Cholinesterases (record collection time) – activity assay v Mass spec
  - Routine biochemistry, haematology, muscle enzymes
  - Others, as clinically indicated
  - Carboxyhaemoglobin - HbCO (within 2 hrs post flight, maximum 4 hrs)
  - Methaemoglobin
  - Collection time should be recorded as well as time from exposure.

Medical Investigation of FE: Ongoing Biomonitoring

- After immediate post flight assessment
  - Investigations based on clinical indication
  - Commonly blood and urine
  - Noting need for repeat cholinesterase measurements
  - Unlikely pre-exposure levels measured
  - Measure again at week 1, 4, 12 weeks or symptom stability
  - Number agents / VOCs causing symptoms – probably not just TCP
  - Ongoing biomonitoring allows toxicological assessment relative to symptoms

Medical Investigation of FE: Ongoing Investigations

- Investigations based on clinical indication
- In particular
  - Neuronal and glial autoantibodies – indicate neuronal injury and gliosis
  - Detailed lung function testing may be needed to detect respiratory injury
  - Neurological defects – MRI scans, MRI/PET scans more sensitive
  - Neurobehavioural – Tests include Coding test (Processing speed), Problem solving, Learning, Memory, Sleep studies and others
  - Malignancy – Emerging reports of some cancers

Medical Investigation of FE: Emerging Areas

- Long recognised that fine particulates affect health
- Underscores issue of air quality standards
- Low level recurrent exposures may be cumulative in effect
- More recently ultrafine (nanoparticles) noted more toxic

Conclusions

- Preparation of medical protocol publication
- Long journey by many
- Some previous Guidelines and Protocols
- None as comprehensive as present
- Consensus document - Internationally expert authors
- Pocket Booklet being prepared for Guidance (What to do) for
    - In-Flight event
    - Medical personnel
- Be patient – we are almost there !

Cabin Air Contamination

An Accident Investigator's Perspective

My Background

- **Tony Cable:**
  - **UK AAIB:**
    - **Accident Investigator for 32 years, until 2009, concentrating on Engineering aspects.**
  - **AFTA:**
    - **Advisor on analysing technical failures for 20 years.**
  - **Specialisations:**
    - **Investigation.**
    - **Making effective Safety Recommendations.**

AAIB – Air Accidents Investigation Branch
AFTA – Accident & Failure Technical Analysis Ltd

ICAO Annex 13

- **Annex 13:**
  - **Standards & Recommended Practices:**
    - **For inquiries into aircraft accidents and incidents with international involvements.**
- **Many accident investigation bodies operate under regulations that generally reflect Annex 13.**

ICAO – UN International Civil Aviation Organisation

In the following the term “accident Investigation body” refers to official governmental investigation bodies

Accidents & Incidents – Annex 13

- **‘Accident’ definition:**
  - **An event where the result is:**
    - **Serious injury (defined), and/or**
    - **Significant aircraft damage (certain exclusions).**
- **‘Incident’ definition:**
  - **An event where:**
    - **No injury or damage, but safety was, or could be, affected.**

In the following the term “Accident” includes an Incident

Serious Incident

- **Annex 13 definition:**
  - **'*Circumstances with a high probability of an accident*':**
  - **"*The difference between an accident and a serious incident lies only in the result*".**
- **Annex 13 lists examples, including:**
  - **'*Fires and smoke in the cabin*'.**
  - **'*Flight crew emergency use of oxygen*'.**
- **Pilot impairment would qualify.**

Purpose of Investigating

- **Annex 13 defines the objective of investigation as:**
  - ***'Solely to prevent accidents or incidents*.'**
  - ***'It is not the purpose to apportion blame or liability*.'**

Contamination Events

- **Frequency of airliner cabin air contamination:**
  - **Aviation Safety websites suggest to me that there tend to be around 2-3 reported cases/day:**
    - **Smoke.**
    - **Fumes/Mist.**
    - **Odour.**
- **Result:**
  - **Generally a flight abort and landing.**
    - **Possibly with pilot(s) impaired.**
    - **Certainly costly.**

Incident Investigation

- **Investigation of Incidents:**
  - **Official investigation resources are often limited.**
  - **Most accident investigation bodies only investigate incidents designated as a 'Serious Incident'.**
  - **The decision to make this designation:**
    - **Is generally by the responsible accident investigation body.**
    - **Tends to be subjective.**

Air Contamination Investigation

- **Irrespective of Annex 13:**
  - **Possible that many contamination events are not subject to official investigation.**

Account of One Event

- "*During the descent both crew members began to feel disorientated and found that they had to concentrate hard to carry out their normal duties. At this point the commander began to feel 'confused'.*
- *The flight crew expressed concern that neither had detected the slow degradation in their performance as this only became fully apparent after they had donned oxygen masks and began to recover.*"

Sources of Contamination

- **Principal possible sources:**
  - **Electrical system malfunction.**
  - **Hydraulic system malfunction.**
  - **Oven overheat.**
  - **Consumer electronics battery overheat.**
  - **APU oil.**
  - **Engine oil.**

APU – Auxiliary Power Unit

Cabin Air Source

- **Typical source of pressurised conditioned air for an airliner cabin:**
  - **Air bled from the compressors of the gas turbine engines (and/or from an APU).**

Engine Oil Containment

- **Engine shaft bearings:**
  - **Multiple bearings:**
    - **Contained in bearing chambers inside the engine.**
    - **Lubricated and cooled by engine oil.**
- **Separation of oil from bleed air:**
  - **Labyrinth or carbon seal at each end of the bearing chamber (where penetrated by a rotating shaft).**

Seals

- **Seal pressurisation:**
  - **Pressurised air is applied to the outside of the seal.**
    - **The aim is to regulate the pressures so as to maintain an airflow into the bearing chamber.**
    - **This <u>should</u> prevent oil escape from the chamber.**
  - **The pressure must be limited to avoid:**
    - **Wastage of compressed air.**
    - **Excessive airflow into the oil system.**

Oil Seal Performance

- **Seal performance:**
  - **Generally highly effective at preventing much oil from escaping from bearing chambers.**
  - **The oil consumption of gas turbine engines typically is normally very low.**
  - **But – this does not mean that either:**
    - **Cabin air is free of all oil/oil products.**
    - **Even small traces of oil in the air is necessarily safe.**

Oil Leakage Across a Seal

- **Seal leakage control:**
  - **Control of air pressures within engine compartments aims to maintain the correct pressure gradient across each bearing chamber:**
    - **Appears to be a complex design issue.**
    - **It appears that the correct pressures might not be maintained:**
      - **During variation in the engine power level.**
      - **If an oil seal malfunctions.**
  - **Oil could escape into the compressor airflow, producing oil mist in the cabin.**

Seal Malfunction

- Malfunctions possibly allowing oil escape into the compressor air (and hence the bleed air):
  - Deterioration of bearing.
  - Damage to oil seal component.
  - Obstruction of oil and/or air pipes in the engine.
  - Inadequate scavenging of oil, allowing it to pool in:
    - Engine
    - APU
    - Air ducts
    - Airconditioning units.

Safety Recommendations

Country	Number of Reports Making Recommendation	Number of Recommendations
Australia	2	7
Sweden	1	4
UK	5	13
Ireland	1	1
Iceland	1	1
Germany	2	5
Spain	1	1
Austria	1	5
UAE	1	8
Total	15	45

Additional Contamination Investigations

- **Other contamination events:**
  - **Investigated, and reported on, by nine national accident investigation bodies.**
  - **Without Recommendations being made.**

Types of Recommendation Made - 1

Recommendation	Number
Airworthiness/Maintenance/Certification	9
Data analysis	3
Reporting	3
Education & training	3
Checklist/mandatory oxygen use, at 100%	5
Mandatory use of Personal Breathing Equipment	1
Crew & Passenger protocol during and/or after event	5
International database	2

Types of Recommendation Made - 2

Recommendation	Number
Research - oils and effect on health	8
Develop treatment protocol	1
Research – identify oil contaminants in cabin air	1
Detection/Warning systems	7
Filtration	1
Emergency evacuation procedures	1
Safety risk assessment	2

Sample Recommendation - 1

- **UK AAIB Safety Recommendation 2007-002 (paraphrased):**
  - ***'It is recommended that the EASA and the FAA consider requiring a system to provide a <u>flight deck warning</u> of smoke or oil mist in the air delivered from each air conditioning unit.'***

Sample Recommendation - 2

- **Germany BFU - Safety Recommendation 07/2014 (paraphrased):**
  - ***'EASA should implement a <u>demonstration of compliance of cabin air quality during type certificatio</u>n of aircraft, engines and APU such that . . . . permanent adverse health effects resulting from contaminated cabin air are precluded.'***

Investigation Output

- **Output – aimed at preventing recurrence:**
  - **Published information:**
    - **From which others can learn.**
  - **Safety Recommendations:**
    - **Principal output.**
    - **Generally addressed to:**
      - **Airworthiness Regulators.**
      - **Manufacturers.**
      - **Operators.**

Response to Recommendations

- **Are Recommendations likely to be effective at preventing recurrence?:**
  - **Only if the recipients take effective action.**
- **Do recipients tend to take effective action?:**
  - **Very frequently not, in my experience.**

Experience of Recommendations

- **In my experience:**
  - **The aim of many recipients appears to be to avoid taking action:**
    - **Often apparently on the grounds of cost:**
      - **but short-term vs much larger potential long-term cost.**
  - **It seems that large aircraft manufacturers can and do have appreciable influence on their regulator.**

Wording of Recommendations

- **The wording can influence the effectiveness:**
  - **Wording along the lines of:**
    - ***"The regulator shall require . . . . ."***
  - **Is much better than:**
    - ***"The regulator shall consider requiring . . . . ."***
  - **The "*consider*" Recommendation commonly seems to be a waste of time.**

"Procedures Not Followed"

- **A common response to a Recommendation:**
  - '***Ground/flight crew didn't follow correct procedure***.'
  - '***<u>This caused the accident</u>***.'
  - '***Thus corrective action is not required***.'
- **This ignores the fact that crew might not always follow procedures, because of:**
  - **Accidental omission – an inevitable Human Factor.**
  - **Task overload in a very highly confusing situation.**
  - **Consequent sheer inability to identify the situation, and thus the necessary procedure.**

Cabin Air Recommendations

- **Known investigations of incidents:**
  - **45 Safety Recommendations:**
    - **From over 15 published reports.**
    - **Carried out by over 13 investigation bodies.**
- **Response to Recommendations:**
  - **Often difficult to assess in detail over an extended period if a Recommendation has prompted action.**
  - **Information suggests few signs that <u>effective action</u> has been taken on most of the Recommendations.**

Accident Recurrence

- **Investigation experience shows:**
  - **Accidents where a previous similar event(s) did not provide a clear warning are rare.**
  - **Many cases where repeat accident(s) result from lack of effective action on Recommendations.**

Current Situation

- It appears that much remains to be done on:
  - Determining the levels of oil products in cabin air:
    - During normal operation.
    - During smoke/fume events.
  - The possible chronic & acute effects of the levels.
  - Means to warn of unacceptable oil levels.
  - Means to prevent oil entering the cabin.

Thank you

Occupational Health Problems among Flight Attendants

Presented by James Cone, MD, MPH
Aircraft Cabin Air Conference
9/18/2019

Newspaper Reports

- William Carley, *Wall Street Journal* 1977:

"Airline crew members and passengers may face a new hazard: ozone sickness, which has apparently struck hundreds of people during recent flights."

Wash Post 6 May 197

Coughs, Headaches, Bloody Noses Experienced

A New Flight Hazard: Ozone Sickness

By William M. Carley

NEW YORK—Airline crew members and passengers may face a new hazard: ozone sickness, which has apparently struck hundreds of people during recent flights.

Ozone gas is in a layer of the earth's atmosphere; normally it has been far too high to cause any problems for airline trips. But now it has apparently been causing illness because airplanes are flying higher to conserve fuel and because the ozone has dipped closer to earth.

Whether low doses of ozones cause any long-term effects isn't known, doctors say. But in the short run, enough ozone in the air can trigger a racking cough that may last for hours, severe shortness of breath, headaches, fatigue, eye irritations and sometimes bloody noses. Describing one recent flight, a Pan American World Airways stewardess says, "Almost everybody in the cabin was coughing and wheezing—the place looked like a turberculosis sanitarium."

When the ozone sickness first struck, apparently a few months ago, no one knew what it was. The symptoms, however, are setting off myriad repercussions:

• Squabbles between pilots and stewardesses over what has been happening and what to do about it have been brewing on planes.

• A scientific detective hunt has been under way to track down and confirm the cause.

• A series of hurried tests has been started, mainly by Boeing Co. and Pan American, to try to remedy the problem.

The airlines haven't made public announcements about the ozone sickness, apparently fearing that they might scare passengers away. (Crew

See EXPOSURE, A16, Col. 1

EXPOSURE, From A1

members interviewed generally asked that their names not be used for fear their comments would upset management.) When asked about the problem, company executives emphasize that they are working hard on remedies. "We think we're on the road to a solutitn," says William Waltrip, Pan Am's executive vice president for operations.

The normal oxygen molecule consists of two txygen atoms, while the ozone molecule consists of three. The airline ozone problem isn't restricted to a particular type of aircraft. United Airlines, for example, says scores of people on 35 of its coast-to-coast flights have been hit by the ozone sickness. The flights were in Boeing 747 jumbo jets and McDonnell Douglas DC-8s and DC-10s.

Man recent cases of the illness, however, appear to be on board Pan Am flights from New York, San Francisco and Los Angeles to Tokyo. These flights use the Boeing 747 SP (the initials stand for "special purpose"). The SP flies farther and higher than most other planes. For example, a medium-size jet such as the 727 typically flies for two hours at 35,000 feet on a New York-Chicago run. On a New York-Tokyo nonstop run, a Pan Am SP flies nearly 14 hours at around 45,000 feet. The high altitude, which conserves fuel, and the long distance combine to increase exposure to the ozone high in the earth's atmosphere.

Last year, when Pan Am became the first airline in the world to introduce the SP on its routes, stewardesses were the first to begin complaining. At first, ozone wasn't even suspected as a cause. "It's a long flight to Tokyo, through numerous time zones and your body gets all out of sync so you expect some minor problems," says William Lindner, director of safety at the Transport Workers Union, which represents Pan Am stewardesses. Pan Am's initial reaction to the complaints, Lindner adds, was that "well, some people are hung over." And he says, "I think management also suspected some union tactics may have been involved."

The stewardesses weren't sure what was happening. "The girls don't like the SP anyway because the flight is so long and the air is so dry you become dehydrated," one Pan Am stewardess says. "At first even I thought it must be psychosomatic."

But the number of complaints began rising—and in strange ways. "People seemed to have trouble going out to Tokyo, but not coming back," Waltrip says. "We couldn't figure it out." Pan Am then began monitoring temperature and humidity in the cabin, correlated with latitude and longitude, to seek clues to what was happening. Ozone, not being suspected, wasn't measured.

FLYING: RESPIRATORY HAZARD?

- Studies have suggested that flight attendants may experience increased rates of respiratory symptoms, particularly associated with exposures to long-haul flights.
- This association is plausible because flight attendants are known to experience exposures to respiratory irritants: Ozone, specific chemicals including hydraulic fluids, engine oils, jet fuel and pesticides, cigarette smoke (prior to ban), and viral infectious diseases.

OFFICIAL PRONOUNCEMENTS AT THE TIME

- J. Donald Collier, Director, Environmental Affairs, Air Transport Association: "The record and experience of over 20 years of jet operations is conspicuously quiet on health problems related to air quality".
- FAA: "Standards for air quality are satisfactory".
- John P. Reese, Aerospace Industries Association: "Air quality in aircraft cabins is equal to or better than the air quality in other environments".

DISSENTING VIEWS

- Xenix Corporation: Made ventilation systems for aircraft. Petitioned FAA in 1980's for aircraft cabin air quality standards. They accused the FAA of "a premeditated effort to stonewall and obstruct the efforts to establish meaningful health and safety standards".

FLIGHT ATTENDANT HEALTH STUDIES COMPLETED

- UC Berkeley/CA Department of Public Health Study – IUFA – Reed (1980)
- NIOSH Study – IUFA – Malignant melanoma (1981-82)
- APFA Study #1 – Cone and Cameron (1983)
- APFA Study #2 – Cone and Cameron (1983-4)
- IUFA study – Cone and Earle (1983-4)
- AFA study – Reproductive hazards (1994)
- CA Department of Public Health-AFA Study – Reynolds and Cone – Breast cancer and malignant melanoma (1999)

PHASE 1 STUDY: APFA 1983

- Study initiated by IUFA representing American Airlines flight attendants.
- Symptoms reported particularly on SFO-HNL turnaround flights.

PHASE I STUDY: HYPOTHESES

- Symptoms of respiratory distress, sinus congestion, nasal pain, blocked eustacian tubes and nosebleeds are associated with exposure to airborne contaminants while flying.
- Specific types of aircraft are associated with increased frequency of symptoms.
- Mobil Jet II oil is the cause of the increased symptoms.

PHASE I STUDY METHODS

- Individual flight attendants were examined at the SF General Hospital Occupational Health Clinic
- Questionnaire survey distributed to all flight attendants on the SFO-HNL turnarounds, total of 5 flights each.
- Additional group of flight attendants flying turnarounds from LAX-HNL were surveyed.
- Investigation into the chemicals contained in Mobil II oil

“DIRTY SOCKS” ODOR

- Four flight attendants were examined. All identified “dirty socks odor” associated with symptoms. Symptoms sometimes occurred even without the odor, however.
- Odor and symptoms were most frequently reported on DC-10-10 aircraft. Odor was strongest in over-wing section and galleys. Also in cockpit.
- Odor strongest on taxi, take-off and landing.

"DIRTY SOCKS" ODOR

- Odor more pronounced when Mobil II jet oil was used.
- Odor was reduced when water separator bags were changed.
- American Airlines correspondence indicated that management also suspected Mobil II jet oil to be culprit. They suspected contamination of the Auxiliary Power Unit (APU) door or inlet duct by oil from the #2 engine. Contamination of heat exchangers and insufficient cabin ventilation were also suspected.

POTENTIAL EXPOSURES

- Turbine oils: Mobil Jet II oil is a synthetic oil containing tri-cresyl phosphates: known eye, skin and mucous membrane irritants.
- Hydraulic fluids: Also contained phosphate esters.
- Other potential chemical exposures: NOX, O3, cigarette smoke, formaldehyde, pyrolysis products of engine oils, jet fuel and hydraulic fluid.

MEDICAL EXAMINATION RESULTS

- Clinical evaluation: Symptoms of nasal burning, headache, eye tearing, nasal discharge, sneezing, sore throat, hoarseness, cough and hearing difficulties after beginning to fly SFO-HNL turnarounds.
- Symptoms lasted 1-5 days.

QUESTIONNAIRE RESULTS

- 58 questionnaires received from flight attendants on SFO-HNL turnarounds over 3 day period, 8/15/83-8/17/83. Participation rate 100%
- Age: 34-44, mean = 37 years.
- All were female. 17 were smokers. 42 reported prior allergies.
- Unusual odors noted by 14/20 flight attendants working on one particular aircraft, on taxi and descent.
- Odors described as "dirty socks", musty or "petroleum burning".

SYMPTOMS REPORTED

Symptom	#	%
Eye	38	66
Nose	35	60
Sinus	14	24
Chest	12	21
Ear	11	19
Central Nervous System	10	17

PHASE I STUDY CONCLUSIONS

- Symptoms are caused by one or more air contaminants. At least one of these contaminants is the probable cause of the "Dirty Socks" odor.
- Concentrations very by aircraft type, location within aircraft, and phase of flight.
- Mobil II jet oil implicated as a possible causative agent.

PHASE I STUDY RECOMMENDATIONS

- Identification of all likely cabin air contaminants
- Industrial hygiene sampling of likely contaminants during each phase of flight
- Eliminate causes of exposure, improve maintenance procedures, or engineering changes to aircraft: e.g., more frequent changes of water bags, burn out contaminants from A/C systems, clean APU door/inlet, change to different engine oil, increase fresh air flow.
- Respiratory protection for flight attendants in the meantime.
- Medical / Epidemiologic Surveillance of airline crew for symptoms reported.

PHASE II STUDY

- Meetings with medical department, American Airlines
- Expansion of symptom survey to include other bases and airlines using other equipment.
- Industrial Hygiene Survey onboard flight, SFO-HNL turnaround, on a DC-10 aircraft. Sampling for O3, NOX, SO2, phosphoric acid esters, organic vapors.

RESULTS – PHASE II STUDY

- Sampling results: Nitrous oxide detected on 3 segments of the flight, at concentration of 1 ppm. One segment with nitrous oxide also had "dirty socks" odor noted. No other contaminants detected.
- A total of 683 questionnaires were received out of 720 distributed (95%)
- Age: Mean of 36 years.
- 88% female.
- Allergy history: 36%
- Dates of survey: August 1983-March 1984.
- 68% were non-smokers.
- Aircraft: N (%)
  - 747 170 (26%)
  - DC-10-10 275 (39%)
  - DC-10-30 237 (35%)

PHASE II SURVEY RESULTS

- Symptoms: Statistically significant associations seen with type of aircraft and eye, nose, throat and sinus irritation, eye dryness, watery eyes, redness, burning eyes, nose itching, nasal discharge and dryness, and sinus burning, congestion and pressure/pain.
- Shortness of breath, dizziness and lightheadedness associated with type of aircraft.
- Boeing 747 and DC-10-10 both associated with increased risk of symptoms
- Base: Oakland (World Airways) flight attendants had lower risk of symptoms.
- Dirty Socks Odor: Significantly associated with eye, nose and sinus irritation symptoms.

PHASE II STUDY CONCLUSIONS

- Flight attendants flying DC-10-10 or Boeing 747 aircraft are at significantly higher risk of developing irritant/allergic rhinitis, particularly after exposure to "Dirty Socks" odor.
- Symptoms suggest a powerful mucous membrane and respiratory irritant.
- Nitrous oxide was measured on one flight. It is a known respiratory irritant. Levels were lower than usually associated with such symptoms.
- Prime suspect agents: Vaporization, combustion / pyrolysis products of aircraft fluids, particularly engine oils.

PHASE II STUDY RECOMMENDATIONS

- Flight attendants who have developed symptoms of rhinitis or upper respiratory / eye irritation should be removed immediately from further exposure. Make O2, cartridge respirators available.
- All air packs should be operating at all times.
- Destructive analysis of Mobil II jet oil.
- Further study by FAA or others to determine, cause of the problem, and institution of engineering controls to eliminate the source.

PHASE III STUDY - IUFA

- 1000 members of the Independent Union of Flight Attendants based in SFO and London were surveyed regarding symptoms and exposures, March 1983-April 1984.
- Prospective study of peak expiratory flow rates using a miniature hand-held device to measure lung function before, during and after flights.

PHASE III STUDY RESULTS

- A total of 280 questionnaires were returned. (28%).
- Age: Predominantly 40-49 years of age.
- 90% female.
- Chest pain or tightness reported by 65% of participants. Cough 57%; 38% said they usually had symptoms of shortness of breath or chest tightness while flying.
- Equipment: Boeing 747 SP associated most frequently with symptoms (62%).

PHASE III RESULTS – PEAK EXPIRATORY FLOW

- 8 out of 20 selected to participate in this phase completed testing.
- 2 of 8 had evidence on PEFR of >20% drop over a 24 hour period. Both were associated with long-haul flights. All 8 had small but measurable drop in mean PEFR comparing pre-flight to post-flight measurements. 7/8 had a statistically-significant drop in PEFR.

DISCUSSION

- Results of our studies of flight attendants in the early 1980's demonstrated consistent symptoms and some evidence of decreased pulmonary function associated with certain aircraft / flights.
- Symptoms are similar to those reported in the study performed in 1978 by CA Department of Public Health.
- Contamination of the Auxiliary Power Unit by engine oil was recognized over 35 years ago as a likely cause of symptoms among flight crews.

CURRENT EVENTS

THE NEW YORK TIMES **INTERNATIONAL** WEDNESDAY, AUGUST 7, 2019

British Airways Evacuates Smoky Plane

By ILIANA MAGRA

LONDON — The cabin of a British Airways flight filled with what appeared to be white smoke as it prepared for landing in Spain on Monday afternoon, prompting the airline to evacuate more than 170 passengers, with three taken to the hospital.

In an emailed statement on Tuesday, the airline acknowledged that its flight BA422 from Heathrow Airport near London had experienced a technical issue on its landing approach into Valencia, Spain's third-largest city.

The statement added that three passengers had been taken to a hospital as a precaution and had since been discharged, and that the airline was investigating the details of what had happened.

That came as little comfort to many of those onboard the flight, some of whom posted on social media about their experience.

Most passengers were barely discernible through the white smoke or vapor in a video shared on Twitter by Gayle Fitzpatrick, one of the passengers on the flight.

Neither the crew — some of whom, according to passengers, put on oxygen masks and protective fire gear — nor the airline said anything to the passengers about what happened, Ms. Fitzpatrick, a corporate governance manager at Audit Scotland, said in a message on Tuesday.

"We are still waiting to hear what happened," she said. "It was very scary."

Emergency slides were deployed after landing in Valencia, Spain.

Thomas Budd, a lecturer in airport planning and management at Cranfield University in Britain, said potential causes of smoke in a plane cabin included electrical failures, overheating equipment, galley spillages and hot-air leaks from pneumatic ducts.

In this case, the flight was nearing its finish when the plane started descending rapidly, and "a horrible white acrid smoke" began to fill the cabin, Ms. Fitzpatrick said.

"A detector was going off," she added.

There was a smell of metal and chemicals, Lucy Brown, another passenger, said in a message on Tuesday. "We covered our mouths with our clothes," she said. "We don't know why oxygen masks didn't deploy."

Passengers shouted they couldn't breathe, she added.

Others were crying and hyperventilating, Ms. Fitzpatrick said, but eventually everyone was evacuated — 175 passengers were onboard, along with six cabin crew members and two pilots, British Airways said — by going down chutes after the crew opened the emergency doors.

Ms. Fitzpatrick said on Tuesday that she was still in shock, adding that both she and her husband still had sore chests.

Ms. Brown, who said that she had to wait seven hours after landing to get her luggage, wrote on Twitter on Monday that the experience was terrifying.

"Felt like a horror film," she said. "Hopefully we'll find out what went wrong on the plane soon so it never happens again."

RECENT OCCUPATIONAL HEALTH STUDIES

- 1. Janet Wei, MD, Chrisandra Shufelt, MD, MS, Eveline Oestreicher Stock, MD, Claire Mills, RDMS, RVT, Shivani Dhawan, MS, Riya Jacob, BASc, Tina Torbati, BS, Galen Cook-Wiens, MS, Neal Benowitz, MD, et al. Vascular aging is accelerated in flight attendants with occupational secondhand smoke exposure. JOEM 2019.
- McNeeley E. Estimating the health consequences of flight attendant work: comparing flight attendant health to the general population in a cross-sectional study. BMC Public Health 2018.
- McNeeley E. Symptoms related to new flight attendant uniforms. BMC Public Health 2019

AIRCRAFT CABIN AIR CONFERENCE 2019

Legal Summary

THIS PRESENTATION IS ONLY A SNAPSHOT, OF SOME OF THE LEGAL CASES FROM AROUND THE WORLD, THAT ARE AVAILABLE IN THE PUBLIC ARENA.

IN PROVIDING CASES FROM AROUND THE WORLD, I AM NOT PROVIDING LEGAL ADVICE IN ANY FORM.

ANY OPINIONS EXPRESSED, ARE MY PERSONAL OPINIONS, BASED ON EXPERIENCE AND OR KNOWLEDGE AND NOT THOSE OF OTHERS.

JUDY CULLINANE

Covering Snapshot

- Key Messages
- OHS Tribunals Canada
- British Columbia WCAT
  From Workers Compensation Appeal Canada
- Labour Court Germany
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- Amsterdam Court
- France Court
- Workers Compensation & Appeal Board Pennsylvania USA
- Department of Labor and Industry Pennsylvania USA
- Virginia Court USA
- Latest Fume Events
- Workers Compensation Court Australia
- Australian Senate Inquiry 2000
- Australia Dust Diseases Tribunal
- Workers Compensation Court Australia - Perth
- How did Ansett Australia stop Workcover Claims
- Dismissing Claims
- Discontinued or Filed for Bankruptcy Australia
- Civil Cases Awarded/Settlements
- What Emergency Landing?
- Pilots Loss of License
- Coroners Findings
- Still Going
- Court Trial Dates for 2020
- Common Threads
- Takeaway
- Thank You ☺

Key Messages

Airlines consider operational and financial risk, **but why not the health risk?**

Airlines are not expected to ground fleets, **but they are excepted to maintain - maintenance schedules, act on reports, adhere to regulations - cabin airflow and uphold Occupational Health and Safety.**

Airlines (most airlines)require a full medical assessment, including a chest x-ray – you must have 100% health….to be employed…**so what happened in your working environment…?**

While industry work to find solutions, please don't forget the people, who have lost their health and careers through no fault of their own.

Occupational Health and Safety Tribunal Canada

Air Canada* v. *Canadian Union of Public Employees 14 **Date:** 2015-08-27. **Case No.**: 2011-62 and 2012-06 **Citation:** 2015 OHSTC

Claudia Martinez Flight Attendant

- Ms. Martinez was employed by Air Canada as a flight attendant and a member of the flight attendant bargaining unit represented by the Canadian Union of Public Employees (CUPE). On November 29, 2011, she operated flight AC 460 from Toronto to Ottawa aboard an Airbus A319 identified as Fin 277.
- According to HSO Pollock, during that flight Ms. Martinez noticed an odour in the cabin which she described as "dirty wet sock smell" to which she attributed nausea and headache. She thus refused to operate the return flight to Toronto (AC 465) on the basis that the odour constituted a danger.
- A joint report from the flight deck crew (G. Mongrain and M. Lefebvre) indicates that Captain Mongrain advised the Service Director prior to departure of flight AC 460 of a defect log entry concerning an inoperative Auxiliary Power Unit (APU) valve which would result in no air conditioning from the APU, require the first engine to be started at the gate prior to pushback and a second engine cross bleed start after pushback.
- **The HSO report indicates that during the pre-flight safety briefing for AC 460, the Service Director advised the cabin crew, including Ms. Martinez, that Fin 277 had a history of a "dirty, wet sock" odour in the cabin.**

https://www.canada.ca/en/occupational-health-and-safety-tribunal-canada/programs/decisions/2015/ohstc-2015-014

Occupational Health and Safety Tribunal Canada

Diaz Delgado et al. v. Air Canada **Date:** 2015-08-27 **Case No.:** 2011-38 and 2012-22 **Citation:** 2015 OHSTC 15

Between: Francisco Diaz Delgado, Meng Liang and Hadin Blaize, Appellants and Air Canada, Respondent

Matter: Appeals under subsection 129(7) of the *Canada Labour Code* of directions issued by a health and safety officer.

Decision: The decisions **that a danger does not exist is confirmed**.

Reasons

- [1] These cases concern appeals brought under subsection 129(7) of the Canada Labour Code (the Code) by the appellant employees of Air Canada, of decisions that a danger does not exist rendered under subsection 129(4) of the Code by Health and Safety Officers (HSOs) Mary Pollock and Rochelle Blain on March 26, 2012, and July 18, 2011, following their investigations into work refusals by the appellant Air Canada employees Diaz Delgado, Liang and Blaize.
- Given the commonality of documentary evidence and testimony, **these two appeals were heard together with two other appeals which were brought under subsection 146(1) of the Code by employer Air Canada concerning directions issued under subsection 145(1) of the Code on November 4 and December 23, 2011, by HSO Mary Pollock pursuant to her investigation into work refusals by Air Canada employees Claudia Martinez and Jerome LaPorte (Air Canada appeals).** The circumstances of the latter appeals are very similar to the appeals dealt with in the present decision. A separate decision will deal with these Air Canada appeals.

https://www.canada.ca/en/occupational-health-and-safety-tribunal-canada/programs/decisions/2015/ohstc-2015-015.html%5B04/11/2017

Occupational Health and Safety Tribunal Canada

Delgado v. Air Canada **Date:** 2019-02-07 **Case No.:** 2011-38 2012-22 **Citation:** 2019 OHSTC 3

Appeals under subsection 129(7) of the *Canada Labour Code* of two decisions rendered by a health and safety officer

Decision The two decisions are rescinded.

Reasons

- [1] This decision concerns the redetermination **of two appeals brought under subsection** 129(7) of the *Canada Labour Code* (*Code*) against two decisions that a danger does not exist rendered under subsection 129(4) of the *Code*.
- [2] Health and Safety Officer (HSO) Rochelle Blain rendered the **first decision that a danger does not exist** on July 18, 2011, following an investigation prompted by the work refusal of five of the respondent's employees. Mr. Francisco Diaz Delgado and Mr. Meng Liang, two of the employees who had filed a work refusal, filed an appeal of HSO Blain's decision on July 28, 2011.
- [3] HSO Mary Pollock **rendered the second decision that a danger does not exist on March 12, 2012, following an investigation prompted by the work refusal of Ms. Hadin Blaize, another of the respondent's employee**. Ms. Blaize filed an appeal of HSO Pollock's decision on April 13, 2012.

Decision

- [115] For all of the reasons stated above, I conclude that the refusing employees in the present appeals were well founded in claiming danger when they exercised their right to refuse to work**. Following redetermination of the decision, I rescind the original decisions of absence of danger rendered by HSOs Pollock and Blain.** **(*Smell, history of reported problems Person suffered accident at work – had the right*)**

Francisco Diaz Delgado, Meng Liang and Hadin Blaize and Air Canada

Occupational Health and Safety Tribunal Canada

Air Canada* v. *Canadian Union of Public Employees **Date:** 2015-08-27. **Case No.:** 2011-62 and 2012-06 **Citation:** 2015 OHSTC 14

Matter: Appeal under subsection 146(1) of the *Canada Labour Code* of directions issued by a health and safety officer.

Decision

- The direction under subsection 125.2(1) of the Code **is rescinded.**
  The direction under paragraph 125(1)(*s*) **is confirmed.**
  The direction under paragraph 125.1(*f*) **of the Code and section 5.4 of the *Aviation Occupational Health and Safety Regulations* is confirmed.**

Reasons

- [1] **These cases concern appeals** brought under subsection 146(1) of the *Canada Labour Code* (the Code) of directions issued by Health and Safety Officer (HSO) Mary Pollock on November 4, 2011 and December 23, 2011.
- [2**] In both cases, the issuance of these directions was preceded by a finding of "danger"** by said HSO at the conclusion of her investigation into the work refusals registered by the two refusing employees. In both instances, the appellant formulated its appeal by stating that it was appealing "the finding of danger" in the directions issued by HSO Pollock. For the purpose of hearing and determination on the merits and given the great facts and circumstances similarity as well as the commonality of documentary evidence and testimony, these two appeals were heard simultaneously with two other appeal cases, those having been brought under subsection 129(7) by employees of the present appellant against the decisions that a danger does not exist rendered pursuant to subsection 129(4) of the Code respectively by Health and Safety Officers Mary Pollock and Rochelle Blain on March 26, 2012 and July 18, 2011. A separate decision will deal with those appeals.

British Columbia WCAT
From Workers Compensation Appeal Canada

Tracey Morey Flight Attendant **WCAT Decision Number**: WCAT-2006-02748-AD. **WCAT Decision Date: June 30, 2006**

Original decision

By a claims adjudicator at the Workers' Compensation Board (Board), **disallowing her claim in relation to symptoms** experienced during and after her shift as a flight attendant on November 10, 1999. Dissatisfied with the Review Board findings, the worker brings this further appeal.

- Under section 239 of the *Workers Compensation Act* (Act), WCAT is authorized to consider and decide appeals such as this one. Section 254 of the Act gives WCAT the exclusive jurisdiction to inquire into, hear and determine all questions of fact and law which may arise or need to be determined in an appeal.
- In *WCAT Decision #2006-02747-AD*. Both the cited findings, draw on analysis of section 5 of the Act and item #13.00 of RSCM…to show the alleged toxic exposure experienced by the worker was a compensable injury.
- "In view of all the evidence, **I find the worker did suffer a personal injury on November 10, 1999 which arose out of and in the course of her employment**. She was disabled by the initial acute symptoms and by the lingering dizziness and vertigo described in the medical reports here considered."

Conclusion

- **For the reasons indicated, the worker's appeal is allowed and the October 19, 2001** Review Board findings are varied accordingly. At the Review Board level, the worker's representative requested reimbursement for the medical-legal report from Dr. Chin. **This was denied by the Review Board, however I now allow it.**

Labour Court Germany

Oliver Birk and KHigerin **– In its judgment, the Labour Court (Sozialgericht) assumes** that the applicant was with **high certainty a victim of a work injury**. The following factors were decisive: Since the fifties of the last century, there has been a large number of cases in which health problems have been reported by aircraft personnel or passengers, without warning odours. After reviewing and evaluating all individual points of view, **the Freiburg Court concluded that an accident had occurred.**

The applicant has thus become a victim of a work injury. https://www.aerotoxicteam.com/uploads/6/0/3/8/6038702/english_version_german_court_-_aerotoxic_team.pdf

The First Chamber of the Sozialgerichts Gießen **dismissed the action**.

- It could not be established that a toxic effect had taken place on the flight. The prerequisite for the determination of an occupational accident is that the insured activity, the harmful effects as well as the illness, because of which compensation is claimed, are proven. On the other hand, the probability of the causal link is sufficient for the recognition of a health disorder as a result of harmful effects.

The full proof is provided if the fact requiring proof is **proved with certainty - was lacking.**

- The Court did not overlook the fact that numerous aspects of this complex issue, such as the possibility that the occurrence of so-called fume events are related to the procedure for obtaining cabin air, had so far not been clarified or were disputed. However, this does not lead to an easing of the burden of proof or even a reversal of the burden of proof for all subjectively or objectively perceived changes in smell during a flight. This would only be conceivable if a large number of passengers and insured persons were demonstrably ill on such a flight, which was not the case here. It was only certain that an unpleasant smell had been perceived by the plaintiff and other crew members. **A chemical (toxic) load was neither secured during the flight nor afterwards.**

https://www.aerotoxicteam.com/uploads/6/0/3/8/6038702/nerve_poison_in_cabin_air_and_statutory_accident_insurance.pdf

Social Court Germany

FREIBURG ARBEITSGERICHT - SOCIAL LAW COURT – Considered

The Chamber has no doubt that on 20.6.2014, the KHigerin - suffered health damage in the form of inhalation trauma and thus an accident at work external effect, namely the inhalation of contaminated cabin air. (Statutory Accident Insurance – Nerve Poison in Cabin Air) Incident worked for Lufthansa AG fume event 9 October 2011

- *A stewardess has been having considerable health problems which occurred after a flight, due to the fact that poisonous chemicals floated around the aircraft. Together with Oliver Birk of the Stuttgart office of the DGB Rechtsschutz GmbH, she fought at the labour/industrial court Freiburg/Germany to determine the existence of an accident.*
- *After reviewing and evaluating all the individual aspects, **the Freiburg Social Court came to the conclusion that an accident had occurred. The applicant has thus become a victim of a workplace injury.***
- *The judgment of the Sozialgericht Freiburg is not yet final. If the employers' association (BG=Berufsgenossenschaft) appeals to the National Social Court, we will continue to report. (the case number is given at the bottom of the article)*

https://www.dgbrechtsschutz.de/fileadmin/media/0_2015_Media_Neu/PDF/Urteile/Berufs_krankheiten__Unfallrente/SG_Freiburg_S9U1210-15_13-06.pdf

GIESSEN SOCIAL LAW / LABOUR COURT Germany (worker's comp) – Dismissed the Action 9 May 2019

https://www.aerotoxicteam.com/uploads/6/0/3/8/6038702/nerve_poison_in_cabin_air_and_statutory_acciden___t_insurance.pdf

Amsterdam Court

ECLI:NL:RBAMS:2013:5980 Rechtbank Amsterdam.

Case number C/13/547894 / KG ZA 13-1016 HJ/PV Authority. **Date of judgment** 18-09-2013 Date of publication 18-09-2013

Areas of law. Civil Justice. Special features - **Applications for interim measures**

Case Kort geding. Eiser is Pilot for KLM

Decision - **The judge in preliminary relief proceedings**

- 5.1.Condemns KLM to commission a research institute, or a researcher, to investigate the presence and concentration of TCPs in the cabin air of its Boeing 737s within fourteen days of the notification of this judgment;
- Study was undertaken: TCP identified in 46% of flights at low levels- no fume events identified.

http://uitspraken.rechtspraak.nl/inziendocument?id=ECLI:NL:RBAMS:2013:5980&keyword=ECLI:NL:RBAMS:2013:5980

France Court

Air France V CHSCT (Health and safety workers committee (2010))

Grand Instance of BOBIGNY - **Order applied to prevent cabin air monitoring**

- In support of its claims, AIR FRANCE submits firstly that there is no justification for any serious risk within the meaning of Article L 4614-12 of the Labor Code.
- AIR FRANCE notes finally that the risk of inhalation of polluted air in cabin is old and known, that it is rare and already taken into account by the employer so that it can not be qualified as a serious risk.
- AIR FRANCE submits, secondly, that the expert measure decided by the CHSCT PNT and PNC is in any case useless.
- The defendants – there was knowledge of 29 incident reports for the first quarter of 2008, company reports 22 reports for the full 2008 year.

Judgement 10/5/18 - **CHSCT successful** - Court of Appeal (2010) violated the article L. 4614-12 of the Labour Code.

Supreme Court of Appeal (2012) - Cour de cassation.

France Court

Easyjet V CHSCT (Health and Safety Workers Committee (2016))

Tribunal de grand Instance de Bobigny (2018)

Order applied to prevent monitoring studies requested by CHSCT

- **Outcome**: annul the decision of the 2016 CHSCT for air monitoring studies.
- **Verdict against CHSCT/ not appealed**

2 pilots in France have lodged an action in the Tribunal de Grand instance (High court). No third party

Asking magistrate to investigate if a case can be lodged with the French criminal prosecutor

Workers Compensation & Appeal Board Pennsylvania USA

Macon Fowler v US Airways Inc. Dsp: 3630624-1 Filed and Heard in Harrisburg Pennsylvania 17102

Termination and Review Petition Circulated Date: 01/21/2015. Injury Date: 01/16/2010

Decision: 15 Jan 2015 **(was delayed due to numerous attempts to resolve through mediation**)

Claimants Review Partition Granted in part and the description of his injury in the NCP is amended to include the addition of **"reactive airways disease due to inhalation exposure."**

Defendant's Termination Petition is Granted that the claimant fully revered from his injuries suffered as of January 16, 2010 effective June 17, 2010.

- "In the case at bar, very skilled counsel for Employer/Defendant Kimberly A. Zabroski, Esquire "saved" the Employer's termination petition by, making sure Dr. Greenberg acknowledged that US Airways accepted respiratory irritation due to an episode of exposure as acknowledged on the NCP (Dr. Greenberg's Dep. at pp. 14-15, 36). Under ' *To* and *Jackson,* supra, the Judge believes Dr. Greenberg's testimony was competent. However, if this case is appealed, the Judge would believe the WCAB may took a second look at this issue, including whether D r. Greenberg failed to accept the diagnosis of "reactive airway disease." However, this WCJ believes his testimony meets the legal standard of proving a termination of benefits under *Jackson* and *To.*"

https://www.dli.pa.gov/Pages/default.aspx.

I believe Macon Fowler has never fully recovered…not 100%

Department of Labor and Industry Pennsylvania USA

DAVID HILL v. US AIRWAYS

Appeal Case: A13-0157 Opinion Mailing Date: 04/15/2015 **Determination:** **Affirmed**

Opinion from the Workers' Compensation Appeal Board file. **An appeal to the Commonwealth Court of Pennsylvania** may be taken by any party aggrieved by the Board's decision – the denied claim on the basis of an error of law.

Decision

- "Because Dr. Greenberg credibly testified that Claimant fully recovered from his accepted work injury of single acute episode of exposure to non-toxic odour resulting in transient respiratory irritation, and testified that he can return to unrestricted work and requires no further treatment, the WCJ did not err in granting Defendant relief".
- "However, the WCJ did not accept the Claimant's evidence regarding the extent of the work-related injury or disability, appeal denied, 563 Pa. 622 757 A.2d 936 (2000)(**determining that an employer can meet its burden by presenting unequivocal medical evidence of a claimant's full recovery)".**
- "We note that Dr. Harrison even acknowledged that while exposure can cause respiratory problems, there is no evidence that Claimant has reactive airway disease or a chronic problem. **As such, the WCJ did not err".**

History of fumes prior to event & after Fumes entered cabin on return flight - start up, cruise, descent, Oil & Hydraulic fluid identified.

Aviation career 1972 to January 16, 2010 as a Boeing 767 Captain Workers Compensation & Appeal Board Pennsylvania USA denied.

Virginia Court USA

Kamyszek v. Delta Airlines, Inc. et al Federal Civil Lawsuit Virginia Eastern District Court

Case No. 1:14-cv-01377. Citation 28 U.S.C. 1441. Nature of Suit 315 Personal Injury; airplane Product Liability

Case Christopher Kamyszek, a passenger on board Delta Airlines flight from Salt Lake City to Minneapolis -16 Dec 2011.

- Seeking USD $5 million compensation for alleged loss of enjoyment of life, ability to earn a living and employment, as well as damages for mental pain and suffering and permanent, debilitating physical injury. He claims he was injured by a fume event on board the aircraft, approximately fifteen minutes after take-off.
- It appears this case is not continuing.

21 May 2015 - So Ordered re 27 Stipulation of **Dismissal filed** by Christopher Kamyszek. Signed by District Judge Liam O'Grady on 5/21/15. (gwalk,)

30 April 2015 ORDER that the **25 Unopposed Motion to Dismiss Airbus with Prejudice is GRANTED**. Signed by District Judge Liam O'Grady on 04/30/15. (pmil,)

28 April 2015 **MOTION to Dismiss With Prejudice** by Christopher Kamyszek. (Barks, Daniel)

Latest Fume Events…Yes…July and August 2019

- **6 August 2019** British Airways flight to Valencia – smoke filled the cabin – emergency with smoke – 200 evacuated
- **28 July 2019** American Airlines Flight AA728 Philadelphia to London Heathrow - odour "call it a dirty socks smell. We need to turn this around…we are not declaring an emergency…" "Cabin…row 22…" Diverted to Boston.
  - Sick Flight attendants (9)and passengers
- **19 July 2019** British Airways Airbus A380 Flight BA286 San Francisco to London Heathrow – diverted to Vancouver – most crew crew incapacitated

https://news.sky.com/video/smoke-filled-plane-makes-emergency-landing-in-valencia-11778282. https://www.wsoctv.com/news/9-investigates/9-investigates-toxic-fumes-on-planes-and-a-new-push-for-safety-changes/970961923

https://www.change.org/p/stop-contaminated-cabin-air-in-aircraft/u/24901209?fbclid=IwAR2Nin-Urdeiwcm236waKl9dhD1AEeEFA9heE50A8pAxVOqZh-mxgsKY-Pc

Workers Compensation Court Australia

Alysia Chew v Eastwest Airlines Ltd & Ansett Australia Ltd, Compensation Court of New South Wales, (Matter 19652 of NSW),

Judgement 28 April 1999

Ms Chew suffered injury January 1992 to 30 October 1993; and Section 47 of the *Workers Compensation Act* applies and that the applicant as a result of the injury, ***"is unable without substantial risk of further injury to engage in employment of a certain kind because of the nature of that employment shall be deemed to be incapacitated for her employment at that kind."*** pp 12-13.

- The basis of Ms Chew's claim was that between January 1992 and 30 October 1993, when a flight attendant with Eastwest Airlines, she was exposed to fumes, toxic substances and other irritants whilst carrying out duties as a flight attendant on BAe 146 aircraft. Ms Chew also claimed that fumes within the aircraft to which she was exposed contained Mobil Jet Oil II which contained the substance triorthocresyl phosphate (TOCP).

"We are and will remain ahead of the game" Ansett Dr Dai Lewis

Claims 1985 - 1998	Claims Accepted	Claims Denied	Accepted without Prejudice	Pending	Resigned on Medical Grounds
29	13	5	4	7	3

Workers Compensation Court Australia

Carter v Ansett Australia Ltd [2000] QDC 049 District Court of Queensland

- June 2000 - **Was granted an extension of time** to 31 August 1999 to commence action – due to material not being available at the time.

Carter v Ansett Aust Ltd [2000] QCA 333 Supreme Court of Queensland

Appeal No 5414 of 2000 DC No 1227 of 2000

- 18 August 2000 **Successful i**n the District Court in extending the period of limitation in an action for damages for personal injuries against the applicant – the applicant sought leave to appeal against the decision – suffered injuries as a result of exposure to toxic chemicals whilst in the employ of Ansett Australia – was exposed to fumes in the cabin of a BAE146- 200 aircraft between 1993 and 1994 – where there was a discerned the existence of a causative relationship between the ingestion of the fumes and the symptoms suffered at a time outside the period of limitation – whether that material fact of decisive character relating to the right of action was not within her means of knowledge until 31 August 1999.
- [18] "In our opinion the decision of the learned District Court judge was correct. Moreover we think he reached that decision by correctly applying the provisions of s 30 and s 31 of the Limitation of Actions Act. Accordingly we would refuse leave to appeal with costs".
- Believe the case was **discontinued…funding.** http://archive.sclqld.org.au/qjudgment/2000/QCA00-333.pdf
- Resigned on medical ground in 1995 as did the three flight attendants on the same flight all requiring oxygen 14 Nov 1994

Australia Dust Diseases - Tribunal

1992 Incident - Joanne Turner – BAe146 Flight Sydney to Brisbane – thick cloud of smoke - oil leak

***Turner v Eastwest Airlines Limited* [2009]New South Wales Dust Diseases Tribunal 10 (5 May 2009)**

Court of Appeal – Supreme Court of New South Wales

- In April 2010, The Supreme Court of NSW **dismissed an application by East West Airlines for leave to appeal** ("East West Airlines Limited v Turner [2010]," 2010).

East West Airlines Ltd v Turner [2010] HCATrans 238 (3 September 2010)

- Cabin smells from oil were noted to be an ongoing problem acknowledged by the defendant, with numerous complaints about the cabin air prior to the incident on 4 March 1992, including an entry 10 days prior to the incident stating: ˜APU AIR NOT FIT FOR HUMAN CONSUMPTION. **Ms Turner was found to have been exposed to Mobil Jet Oil II on 4 March 1992 with the court finding that ˜pyrolysed effects of Mobil Jet Oil II are harmful to the lungs.** As such Ms Turner suffered from a pathological condition to the lungs caused by exposure to the smoke and that condition has continued for more than eighteen years and is expected to be life-long.

The High Court of Australia subsequently dismissed the appeal by East West Airlines in August 2010

http://www6.austlii.edu.au/cgi-bin/viewdoc/au/cases/nsw/NSWDDT/2009/10.html Turner v Eastwest Airlines Limited [2009] NSWDDT 10

Workers Compensation/Civil Perth Australia

Judith Anne Cullinane and Ansett Australia Limited WC93D No 962 of 1998

Flight 6-8 November 1997 BAe146 JJW 3 Days incapacitated

*Flight Attendant Pauline Guy on same flight 6-8 November 1998 Workcover claim advised **12 January 1998 excepted** "Tiredness, Dizziness, nausea etc due to Environmental Factors*

Flew as passenger mid November 1998 on A320, collapsed exiting aircraft-wheelchair. On return flight came off-wheel chair with oxygen. **Test Flight Jan 1998** on 737 as passenger, off in a wheelchair with oxygen. (Required oxygen on flight soon after takeoff – tingling extremities, nausea, tiredness, loss of control of limbs

District Court Western Australia No. 4296 of 1998 summons served 6 November 1998.

Judith Anne Cullinane – District Court of Appeal

- **The Commissioner noted that the Defendant sought to dispute the Plaintiff's claim on the causation issue, but he adopted the submissions on the "material contribution" being the relevant test, accepting Dr Barnes and Professor Winder, concluding that there was a "real and not remote chance that the exposure to fumes in the workplace caused the plaintiff's symptoms". (Limit of claim over threshold – proceeds to District Court)**

Decision On the capacity issue, the Commissioner accepted that there was evidence that the Plaintiff may very well never return to work as a flight attendant".

- **Court Appeal 25 February 1999 – J Cullinane won** and awarded costs
- **Court Case 2000 Judith Anne Cullinane won the right to review** all Ansett Australia and other documents with the defendants claiming "Sensitive information" but this was disapproved with some were in the public domain, some were internet articles, some were duplicates etc.

Nov 2001 – tender as evidence BAe AGREEMENTS $. **Settlement at Mediation pre trial July 2002 (10 hour mediation)**

How did Ansett Australia stop Workcover Claims

Oct 1995 Ansett Dr Dai Lewis in an email – "Discussion with Dr Patrick Carrol, Consultant adviser to the Queensland Workers Compensation Board confirms that his report to the Board states in his opinion there is not a "Toxic Chemical" involvement her. He is also to talk to Hickson's treating Specialist, hoping to put him right".

"…I will continue to try and reverse the certifying Doctors opinions….and continue to provide the analyses to Dr Carrol who by the way will in the end be examining each of our Flight Attendants."

April 1995 Ansett Dr Lewis email ….."Queensland Workcover confirm they don't require any further sampling…information…as a result they are denying Flight attendant Workcover claims. "…Less specific test, one simply for oil mists. We could do this **but it would only be of use an identifier of trouble and would not in itself prove of any great use in court action….Tedlar Bag".**

Oct 1995 Dr Affleck calls Dr Lewis about 3 crew…"knows him so limited testing to carbon monoxide"… Flight attendants had asked for Cholinesterase

April 1997 Ansett Dr Dai Lewis to Cpt Jenson "…offer ground duties…threat of loss of flying duties worked well before East West was absorbed."

November 1997 Richard Fox – "Testing Tedlar Bags….not designed to measure semi volatile compounds…will not detect TCP… Sample taken then tested 3 weeks later…" "Richard Fox report refers to design and to test within 24 hours no more than 72 hours. Method of testing at Ansett allows the potential loss of compounds, meaning…exposure probably greater than reported". "AGAL analysis is for volatile compounds only. Semi volatile compounds that were collected would still be adhered to the inside of the tedlar bag". "Many fuel, oil, hydraulic fluid decomposition products fall into the semi volatile category, including triorthocresylphosphate isomers….writes about refence the WHO EHC 110 on Tricresyl phosphate: Triortho cresyl phosphate….mixed o-cresyl isomers".

(Report from R Fox regarding Judy Cullinane's flight and flight reports)

How did Ansett Australia stop Workcover Claims

March 1998 Consensus – "Independent Panel" ..Westermann, Carroll Rob Loblay and others signed…Dr Dai Lewis drafted the consensus for the BAe146 …to be signed off by all…**March 1998.**

The "Independent Panel" were also the Work Cover Doctors !

The consensuses statement was attached to a letter was sent to Flight Attendant and Workers Compensation Doctors

The "Independent Panel" reviewed selected and incorrect reports…." The following R Fox's report **had changes from the draft to the published report.**

Air Quality and Comfort Measurement Aboard a Commuter Aircraft and Solutions to improve Perceived Occupant Comfort Levels

Paper ID 8199 Draft a by Richard Fox …different to the published version. 1998

- 'Findings from the bleed air contamination monitor indicated that full hydrocarbon clean out of the ECS systems on the three aircraft tested never occurred"….System contamination was not only in the filters, but in other areas of the system as well". "Air flow…flows in the aisle…head height…generally well below 0.1 meter/second"
- States carbon monoxide never detected in flight…method used summa cannister....which is not designed to detect carbon monoxide. Semi-volatile contaminants were analyzed from samples removed from the aircraft filters. A search referenced against a calibrated standard was made for the isomers of Tricresylphosphate. No isomers of tricresylphosphatre were detected, However, **Triethylphosphate was detected. Triorthocresylphopshate is of concern since is is considered to be a neurotoxin. (Ansett has crossed out and written "no need to write this")**
- Unsafe levels of formaldehyde measured during pack burnouts.

Ansett Australia had in its possession…

Dec 84 21/7 British Aerospace Service Information Leaflet – " The following is offered should oil contamination of the air conditioning system be experience.

Jan 24. 1983 Mobil Oil Corporation J Aveni – " Mobile Jet Oil has been used for many years by many commercial airlines with no incidents of adverse health affect. Obviously if cabin air becomes contaminated with any lubricant and /or its decomposition products in sufficient quantities, some degree of discomfort due to ye, nose and throat…generally traced to improper design, improper maintenance or malfunction of the aircraft."

April 92 Dan Air - confirming oil leakage, shaft seal APU and problems for over 1 year.

May 1992 Dr Vasak report 16 in the case of justified medical concern following a continuing inhalation exposure to the contaminated air...some biological tests may be of help (eg: inhibition of cholinesterase in a case of proven exposure of a toxic organophosphate)

1995 Ansett Engineer "…taking up directly with Allied Signal…filtration can only handle day to day leakage".

Nov 1996 Ansett K Currie to Dr Dai Lewis ' latest summary information, lack of approx. 50% of incidents don't find there way into the logs".

August 1997 Richard Fox to Ansett Dr Dai Lewis…"Pack Burns didn't appear to remove all organic matter… in fact TCP is being detected by health and safety measures during and after Pac Burns…levels measured on bleed air contamination monitor during Pack Burn were 4 times greater than we allow in our engine except in our APU facilities..". R Fox used Suma Cannisters which do not detect TCP but Dr Van Nettan used catalytic converters - detected TCP.

Sept 1997 Ansett Greg Vaugh spoke to Ansett Dai Lewis 'Spoken to Air BC – 1 case neuro poisoning' 'triorthercresyl phosphate (TOCP) – neurotoxic to humans, sufficient evidence, additionally QLD health found TCP."

December 1997 George Lee report to Dr Lewis…use cryogenic trap…small amount of tricresyl phosphate found …pack burn then …altered a pack burn to 70 C…then not detected.

Jan 2000 Ansett Dr Dai Lewis email to Rod Westermann "…interested in seeing any …flight attendants…following BAE 146 return to work program…sent via our insurer QBE…interest/ Also mentions pilots and depression…".

Dismissing Claims

Patricia Forames, et al. v. ST Aerospace Mobile, Inc., Case No. 1111434 (Ala. Sup. Ct.)

Date: August 30, 2013 **Court:** Alabama Supreme Court

Decision: **affirmed** the Mobile County Circuit Court's **summary judgment dismissal of eleven claims of "Areotoxic Syndrome"** exposure by US Airways crew members.

- **B767 (2010) - US AIRWAYS Tail N 251AY (had suffered fumes over many months)**
- First Officer Mick Fowler (June 2010) reported, fatigue, wooziness and grogginess, during a fume event while landing a Boeing 767 – after landing he was taken off the plane on a stretcher to an emergency room.
- **Captain David Hill medical's failed - neurological**
- 2 Pilots had medical certificates withdrawn by FAA and denied workers comp on appeal
- Cabin Crew workers compensation accepted
- **Captain David Hill – took his own life 2016 (RIP)**

https://condonlaw.com/2013/09/alabama-supreme-court-affirms-summary-judgment-dismissing-aerotoxic-syndrome-claims/

Discontinued or Filed for Bankruptcy Australia

Incident late 1999 - Melissa Dray

- June 2015 - BAe Systems – Western Australia District Court registrar George Kingsley ruled Bae Systems had a case to answer.
- Melissa filed for bankruptcy in Perth…unable to continue against BAe Systems

Welcome Melissa ☺… Melissa is here today and will be speaking later…

Civil Cases: Awarded/Settlements

- **Filed in 1998** **Debra Bradford & 24 other Flight Attendants v Alaska Airlines and others**. Alaska Airlines settled with the flight attendants earlier in 2000, agreeing to pay $725,000 without admitting any wrongdoing.
- **June 2001** **Debra Bradford & 24 other Flight Attendants v Alaska Airlines, Inc., an Alaska Corporation, Allied Signal, Inc., a Delware corporation, McDonnell Douglas Corporate Boeing** NO. 98-2-15033-5 SEA *Lost the case– Motion for Partial Summary Judgement against defendant Allied Signal Inc. (pursuant to Civil Rule 56) in the The Superior Court for the State of Washington in and for the County of King.*
- **2002** **Judith Cullinane v Ansett Australia Limited** – BAe146 Incident 6-8 November 1997 Settled out of Court.
- **2007** **Stewarts Law V Excel Airways** – settled ?...: B767/passengers
- **2011** **Terry Williams v Boeing– American Airlines MD-82 Aircraft**
  - Incident 2007 Single exposure, when toxic smoke and oil fumes leaked into aircraft cabin Settled out of court. https://www.law360.com/articles/276817

What Emergency Landing ! Civil Case

Ridgell v. Frontier Airlines, Inc. et al   Case Number 2 :18-CV-04916 Filed 1 June 2018 California

The plaintiff claims Frontier Airlines has so far refused to acknowledge a dangerous 'fume event' during which the air in cabin of a flight became contaminated.

Frontier Airlines, Inc.; Airbus S.A.S.; and Airbus Group HQ Inc.

- Alleged "fume events" resulting from the possible defective design and manufacture of the companies' Airbus fleet of aircraft. Passenger cabin becomes contaminated with "**pyrolised compounds**".
- Flight made an emergency landing in Phoenix – Frontier refused to acknowledge the event, with scheduling posted as landing on time in Orlando without incident.
- Lawsuit passengers "experienced physical distress," including "passing out, choking, coughing and eye irritation".

- **The Court denied class certification and the case settled individually but on a confidential basis.**

Pilot loss of licence…..

Pilot Leanne Harper - Ansett - November 1998

First Officer Susan Michaelis - National Jet - August 1999

12 November 1999 during a flight between Bromma and Sturup in Sweden - Captain on a BAe 146 operated by Braathen's Malmo Aviation had to use oxygen when effected by fumes. Captain handed over to the First Officer to land the plane.

- Investigation the airline had come to the conclusion that, "the oil leak was the reason for the air in the cabin being made toxic."
- **Loss of license** – **Neils Gomer** - Fumes, dizzy, groggy, drunkenness, disorientated

- Numerous more known to be awarded around the world and some known to be denied.

Still Going…

22 June 2015 - Five Crew filed to sue The Boeing Company in the Cook County Circuit Court Illinois – alleging breaches of duty of care " negligent acts or omissions" Incident - Alaska Airlines unscheduled landing in Chicago July 2013.

Due to court early 2020

https://www.bloomberglaw.com/public/desktop/document/Woods_v_Boeing_Co_Docket_No_2015L006324_Ill_Cir_Ct_June_22_2015_C?1555077893

2019 Unite Union Legal notices served - 51 cases against: (Comprising 4 Pilots, 47 Cabin Crew)

- British Airways.
- EasyJet
- EasyJet
- Thomas Cook
- Jet2
- Virgin Atlantic

Coroners Findings

Westgate (Died 2012)

2015: Regulation 28- Prevent future deaths: airline & CAA - (withdrawn)

2017: Final findings

- Accidental death: (accidental) pentobarbital overdose:
- Suffering from
- Dorsal root ganglioneuropathy affecting spinal nerves and possibly cranial nerves
- Myocarditis…..
- Depression and anxiety (caused in part by ganglioneuropathy & that condition remained undiagnosed

Bass (Died 2018)

- Death by misadventure

"The senior coroner wrote the letter of concern to the chief coroner asking him to advise all coroners of the need for the additional tests in cases where toxic cabin air is a suspected cause of death. Significantly the senior coroner in his letter recognised that exposure to toxic cabin air may lead to a clinical impact on the body."

https://unitetheunion.org/news-events/news/2018/october/unite-calls-for-public-inquiry-after-coroner-warning-on-toxic-cabin-air/

Court Trial Dates for 2020

Vashti Escobedo V Boeing Illinois Circuit Court Cook County Law Division

- Filed Apr 15, 2016 later Vashti Escobedo, Ray C Escobedo and Lara K Lane as Plaintiffs
- 29 Aug 2019 the case was set down for focussed case management for 3 October 2019 at 9:30am

2013. An Alaska Airlines flight took off from Boston for San Diego. The plane had to be diverted to Chicago after all four flight attendants became violently ill. Two passed out.

Escobedo V Boeing goes to court – **February 2020 in Chicago (expected to be 4-5 weeks)**

Involves 4 Flight Attendants injured in the same event and a Flight Attendant from a separate event.

Woods V Boeing goes to court – **February 2020**

https://www.bloomberglaw.com/exp_blp/eyJjdHh0IjoiRE9DIiwiaWQiOiJYMVE2TkxDSVU0ODIiLCJ1dWlkIjoiTlFycjR6YUFydVptdnBmRlgrYTBnUT09S0ZIekpzenBJSkpSaEdMc21BeXNRdz09IiwidiI6MSwidGltZSI6IjE1NTUwNzc2MDYwMDAiLCJzaWciOiJZSHhQODRQVnVWd05jdWFpNXhKVlBqK0ptSVE9In0=

Common Threads

Failure of Cases

- Couldn't prove exposure
- Method of testing and or results
- Different countries, courts, rules, regulations
- Prove the fact or threshold of injury
- Lack of understanding

Success of Cases

- Precedent set
- Doctors diagnosis with supporting specialist reports
- Evidence of fume event and that others were sick, including passengers
- The wording of the statements, reports
- **A good understanding of the issue and how to explain and argue it……ESSENTIAL**

Turbo Oil 219 Oil can says: "Do not breathe mist or vapor from heated material" (Worth remembering….for Court)

British Aerospace Regional Aircraft Limited and Eastwest Airlines (Operations) Limited and Ansett Transport Industries (Operations) Pty Limited

Agreement British Aerospace Regional Aircraft Limited and Ansett Transport Industries (Operations) Pty Limited East west Airlines (Operations) Limited **signed by All**

Signed 3 September 1993

"…Pursuant to the Aircraft Purchase Agreements, BAE warranted that relevant parts of the Aircraft (as therein defined) would conform to applicable specifications supplied by BAe and would be free from defects due to defective material and or defective workmanship or defective design on the part of the BAe in accordance with and subject to the terms, conditions and limitations contained in the Aircraft Purchase Agreements".

"Ansett have EWA have made certain written claims against BAe alleging defective design of the Aircraft resulting in the obnoxious oil and other (the "cabin environment problem") fumes affecting the passenger cabins of some or all of the Aircraft".

"BAe herby agrees with Ansett and EWA that it shall pay EWA the sum of Australian $750,000"

Eastwest Airlines (Operations) Limited and Ansett Transport industries (Operations) Pty Limited and Allied Signal Incorporated and another with AVCO Corporation

Agreement 1993 "Allied Signal to provide EWA and Ansett a total Parts and Labour Credit of US$1,235,000 as financial consideration associated with the operation of Allied Signal APUs on the BAe146 aircraft. The applicability of the credit will be limited to APUs and APU parts including kits to convert 85-129(E) APUs to A-129(K) configuration...labour and parts..".

"After detailed and protracted investigations, it was determined that a source of the smell was oil leakage from Allied Signal APUs which entered the bleed air system through the air conditioning packs".

- "Credit is to be used against any account receivable due from EWA or Ansett…purchase of APUs and APU parts including kits to convert 85-129(E) APUs to A-129(K)
- (Not dated…has 1993 and not signed by Allied Signal – Signed By Ansett and East West with Common Seal)

Similar Agreement 1993 with AVCO Corporation claiming engine bleed air problems since the purchase in 1989 until 1993…various deficiencies and inadequacies. Seeking US$150,000 cash and US$100,000 parts credit to be used in full by 31 Dec 1994. (Only signed by Ansett and EWA with Common Seal)

- Both of these remained **unsigned.**

TAKE AWAY

It could happen to you, your loved one, your family or friends.
It's not about money…**its about your health…your career…your lifestyle.**

Airlines (most airlines) require a full medical assessment, including a chest x-ray – you must have 100% health….to be employed…**so your health should not be degraded by your workplace.**

While industry tries to work out a solution, <u>don't forget the people who have lost their health and careers</u>.

Times up…. billable hours…$$$$$$$$$$
Your Legal Bill to Date $182,000…..NEXT Court date…..COST $$$$$$$$$…..

What does it matter to a company… it's tax deductible…it is not out of their own pocket…

Thank YOU

Thank you to my late husband Tim Cullinane who supported me when I became ill in November 1997 with my court case and the Australian Senate.

(We met on a flight – Tim passed away with multiple myeloma Dec 2008) (RIP)

Thank you to my son Joel who was 7 when I got sick in November 1997, and who then looked after us both. When we had to sell everything and live in a tent, while I continued to fight the airlines for compensation you never complained.

We regrouped and had to re-enter the workforce. I completed an MBA 2012 and together Joel and I we were admitted into the Queensland Law Courts as Lawyers.

…We made it…I am definitely slower.... And it was and still is a struggle.

Picture – Joel and I – My proudest day.

AUSTRALIAN FEDERATION
OF AIR PILOTS

CABIN AIR QUALITY MONITORING //

Organophosphates sampling during fume events in Australia

Aircraft Cabin Air Conference 2019

Cpt Marcus Diamond

PROTECTING AUSTRALIA'S PILOTS//

The Australian Federation of Air Pilots' mission:

To represent and promotes the interests of Australian professional flight crew and champions the highest possible standards of aviation safety

AFAP
1938

WHY SAMPLE? //

Dozens of concerned and affected pilots

There are unanswered questions

Unactioned findings from Gov't reviews & enquiry

Refutable statements in other sampling studies

Adding to the data

Our industry needs to acknowledge the problem and improve

2000 AUSTRALIAN SENATE ENQUIRY //

Recommendation 3

The Committee believes that development of an appropriate and accurate test for the presence of any chemical fumes in aircraft cabins is essential. The Committee accordingly recommends that CASA liaise with operators to develop a standardised, compulsory monitoring program which provides for testing cabin aircraft air during fume events.

Recommendation 8

The Committee recommends that CASA assess how quickly fitting appropriate high-grade air filters can be made mandatory for all commercial airliners flying in Australia to minimise any deleterious health effects arising from poor aircraft cabin air on crew and passengers. In view of proposed standards currently under consideration in the United States of America and elsewhere, such a system should ideally be designed to remove at least 99% of particles 0.3 micron or larger from recirculated cabin air.

The committee received considerable evidence criticizing aspects of the regulatory regime for the aircraft and focusing on issues that should be taken up by regulators, such as:

- Oil leaks & exposure to oil fumes
- Responses to crew complaints
- Testing procedures for cabin air
- Modification measures necessary to remedy fume contamination

RECOMMENDATIONS //

Domestic and international laws and standards for the quality of air in aircraft

2.21 Australia has adopted design standards and requirements for all aircraft which are certified to operate in Australian airspace. As noted above, these include United States Federal Aviation Regulations (FAR's) (section 25) and joint European Aviation Regulations (section 25). Both standards have requirements dealing with cabin ventilation and contamination in an aircraft. FAR 25.831 requires:

> (a) Under normal operating conditions and in the event of any probable failure conditions of any system which would adversely affect the ventilating air, the ventilation system must be designed to provide a sufficient amount of uncontaminated air to enable the crewmembers to perform their duties without undue discomfort or fatigue and to provide reasonable passenger comfort….

CASA confirmed to the Committee:

> Perhaps an important section is a statement under section 25.831 of FAR 25, which says that: 'Crew and passenger compartment air must be free from harmful or hazardous concentrations of gasses and vapours.' That is the only statement that is in there at present. What constitutes 'harmful' or 'hazardous' is left up to other standards, and generally they are getting into the health standards.[22]

(b) Crew and passenger compartment air must be free from harmful or hazardous concentrations of gases or vapours …

(c) There must be provisions made to ensure that the conditions described in para B … are met after reasonably probable failure or malfunctioning of the ventilating, heating, pressurization or other systems and equipment.

AFAP
— 1938 —

CASA'S VIEW //

CASA outlined in a submission its views on air quality on the Bae 146 aircraft. According to the authority:

> A team of Australian medical experts reviewed the test methods and results and has declared that there is no contaminant present in the cabin environment that will induce any long term or permanent effects on the passengers or crews.
>
> In particular, **at no time was tricresylphosphate (TCP) ever identified in any sample gathered in an Australian aircraft.**

Action Recommended:

It is believed the quality of the air to meet certification standards for this type of aircraft should be tested by Gas Liquid Chromatography to determine levels of organophosphates and their interaction with hydrocarbons/volatile organic compounds in the ambient cabin air.

EPAAQ FORMED 2007 //

EPAAQ was unable to reach definitive conclusions saying it is an area of research where "reasonable people's views can differ".

CASA considered it wouldn't propose any major policy or regulatory decisions based on that evidence. It also noted many of the EPAAQ's recommendations fell outside the ambit of CASA's functions set out in the *Civil Aviation Act* 1988 (Cth)

Civil Aviation Advisory Publication (CAAP) advises:

(c) smoke, toxic or noxious fumes inside the aircraft is considered a major defect

FAA response to 2002 CAQPCCA report acknowledges:

"FAA rulemaking has not kept pace with public expectation and concern about air quality and does not afford explicit protection from particulate matter and other chemical and biological hazards. No present airplane design fulfills the intent of 25.831 because no airplane design incorporates an air contaminant monitoring system to ensure the air provided is free of hazardous contaminants."
(Federal Aviation Administration, 2005)

REGULATOR RESPONSES //

EPAAQ report, CASA said:

Contamination of aircraft cabin air by bleed air – a review of the evidence (up to September 2009)

The panel's inability to reach definitive conclusions highlights the fact that this is an area of research where reasonable people's views can differ. In the circumstances, **it would not be prudent for CASA to make major policy and regulatory decisions on the basis of inconclusive evidence.**

EASA found:

- a causal relationship between the reported health symptoms and oil/hydraulic fluid contamination has not been established. **As there is no conclusive scientific evidence available, the Agency is not able to justify a rulemaking task to change the existing design or certification specifications.**

OTHER REPORTS //

Cranfield University: Are there organophoshates in cabin air?

- In over 95% of the cabin air samples, no detectable amounts or ToCP or TCP were found. TBP was detected more routinely, but not in the majority of samples.

EASA study 2017: Final Report Preliminary Cabin Air Quality Measurement Campaign

- Study results indicate that under routine aircraft operations, contaminant level in aircraft cabins are mostly similar to those in residential and office buildings

- In more than 95% of all cabin air samples, no detectable amounts or ToCP or other TCP's were found.

- In conclusion: "... A continuation of the previous measurement series is also not considered as constructive, since encountering a real TCAC-event, which needs to be investigated in order to answer some of the questions, remains very unlikely ..."

Is this a "pretended" problem?
Do we know the isomers to look for?

SENATE'S FINDINGS - ATTITUDE OF AIRLINES TO STAFF'S REACTIONS TO FUMES //

The response to employees showing symptoms of toxicity showed a **lack of understanding of duty of care.**

Information issued to staff on the issue has attempted to **minimize the problem using language of public relations.**

The basic approach to injured staff appears to be **adversarial.**

Staff have been **bullied and have been victimized**.

Workers have been **forced to keep working** in conditions that continue to **aggravate their health, in some cases to permanent incapacity.**

Staff have been **offered demeaning duties**, and genuine attempts at rehabilitation have been lacking.

ATSB – 323 REPORTED EVENTS IN 2018//

Australian Government
Australian Transport Safety Bureau

Date range: From 16 Jan 2018 to 15 Jan 2019
Location: All
Occurrence Category: All
Occurrence Type: Fumes
Aircraft and Airspace: All

Row	Date	ATSB Reference Number	Category	ATSB Investigation	Location	Latitude	Longitude	State	Aircraft Manufacturer	Model	Operation Type	Operation Sub Type	Airspace Type	Airspace Class	Summary
37	12/02/2018	201800507	Incident		Perth Aerodrome	31° 56.418' S	115° 58.02' E	WA	Airbus	A320	Air Transport High Capacity	Passenger	CTR	C	During pre-flight preparations, fumes were detected in the cockpit and cabin.
38	12/04/2018	201801808	Incident		abeam Mooliabeenie (ALA)	31° 19.998' S	116° 1.002' E	WA	The Boeing Company	737	Air Transport High Capacity	Passenger	CTA	A	During cruise, the cabin crew observed smoke emanating from an in-flight entertainment screen. Engineers replaced the in-flight entertainment screen.
39	12/06/2018	201802812	Incident		near Perth Aerodrome	31° 56.418' S	115° 58.02' E	WA	Fokker Aircraft B.V.	F28	Air Transport High Capacity	Passenger	CTA	A	During climb, cabin crew detected fumes emanating from an oven.
40	12/09/2018	201805646	Incident		abeam Geraldton Aerodrome	28° 47.772' S	114° 42.45' E	WA	Fokker Aircraft B.V.	F28	Air Transport High Capacity	Passenger	CTA	A	During climb, fumes were detected in the cabin. The engineering inspection did not determine the source of the fumes.
41	12/10/2018	201807271	Incident		Perth Aerodrome	31° 56.418' S	115° 58.02' E	WA	Embraer-Empresa Brasileira De	EMB-120	Air Transport Low Capacity	Passenger	CTR	C	During pre-flight procedures, fumes were detected in the cockpit and cabin. The engineering inspection revealed the left hand pressure regulating shutoff valve was
42	12/10/2018	201807267	Incident		near Perth Aerodrome	31° 56.418' S	115° 58.02' E	WA	Fokker Aircraft B.V.	F28	Air Transport High Capacity	Passenger	CTR	C	During descent, fumes were detected in the cabin. The engineering inspection did not determine the source of the fumes.
43	12/10/2018	201807304	Incident		near Perth Aerodrome	31° 56.418' S	115° 58.02' E	WA	Fokker Aircraft B.V.	F28	Air Transport High Capacity	Passenger	CTA	C	During descent, fumes were detected in the forward galley. The engineering inspection did not determine the source of the fumes.
44	12/12/2018	201808958	Incident		near West Angelas Aerodrome	23° 8.1' S	118° 42.402' E	WA	Fokker Aircraft B.V.	F28	Air Transport High Capacity	Passenger	CTA	A	During cruise and again in the next sector, fumes were detected in the cabin. The engineering inspection revealed the left and right hand water separator drains were
45	13/02/2018	201800486	Incident		near Broome Aerodrome	17° 56.982' S	122° 13.668' E	WA	Fokker Aircraft B.V.	F28	Air Transport High Capacity	Passenger	CTA	A	During descent, fumes were detected in the cockpit and cabin. The engineering inspection could not determine the source of the fumes.
46	13/03/2018	201801168	Incident		Gold Coast Aerodrome	28° 9.87' S	153° 30.282' E	QLD	The Boeing Company	737	Air Transport High Capacity	Passenger	CTR	C	During engine shut-down, fumes were detected in the cockpit and cabin. The engieering inspection did not reveal the source of the fumes.
47	13/06/2018	201802840	Incident		Perth Aerodrome	31° 56.418' S	115° 58.02' E	WA	S.A.A.B. Aircraft Co	340	Air Transport Low Capacity	Passenger	CTR	C	During preparation for flight, fumes were detected in the cockpit emanating from the avionics.
48	13/06/2018	201802835	Incident		near Perth Aerodrome	31° 56.418' S	115° 58.02' E	WA	Fokker Aircraft B.V.	F28	Air Transport High Capacity	Passenger	CTA	C	During descent, fumes were detected in the cockpit and cabin.
49	13/07/2018	201803619	Incident		near Perth Aerodrome	31° 56.418' S	115° 58.02' E	WA	Fokker Aircraft B.V.	F28	Air Transport High Capacity	Passenger	CTR	C	During approach, fumes were detected in the cabin. The engineering inspection did not reveal the source of the fumes.
50	13/08/2018	201804823	Incident		Perth Aerodrome	31° 56.418' S	115° 58.02' E	WA	The Boeing Company	717	Air Transport High Capacity	Passenger	CTR	C	During push back, fumes were detected in the cabin. The source of the fumes was traced to APU exhaust air being taken in by an engine on start up and spreading
51	13/08/2018	201804647	Incident		near Perth Aerodrome	31° 56.418' S	115° 58.02' E	WA	Fokker Aircraft B.V.	F28	Air Transport High Capacity	Passenger	CTA	C	During descent, fumes were detected in the cabin. Engineers replaced the coalescer bags.
52	13/10/2018	201807344	Incident		near Darwin Aerodrome	12° 24.882' S	130° 52.602' E	NT	Airbus	A320	Air Transport High Capacity	Passenger	CTA	A	During descent, fumes were detected in the cockpit.
53	13/10/2018	201807307	Incident		near Broome Aerodrome	17° 56.982' S	122° 13.668' E	WA	Fokker Aircraft B.V.	F28	Air Transport High Capacity	Passenger	CTR	D	During approach, fumes were detected in the cabin. The engineering inspection did not reveal the source of the fumes.
54	13/11/2018	201808138	Incident		Avalon Aerodrome	38° 2.37' S	144° 28.17' E	VIC	Airbus	A320	Air Transport High Capacity	Passenger	CTR	D	During cruise, fumes were detected in the cabin. The engineering inspection did not determine the source of the fumes.
55	13/11/2018	201808135	Incident		Nifty Aerodrome, 195Â° M 111Km	22° 38.022' S	121° 16.83' E	WA	Fokker Aircraft B.V.	F28	Air Transport High Capacity	Passenger	CTA	A	During cruise, fumes were detected in the cabin. Engineering replaced the right air-conditioner coalescer bag.
56	13/12/2018	201808961	Incident		near Gold Coast Aerodrome	28° 9.87' S	153° 30.282' E	QLD	Airbus	A320	Air Transport High Capacity	Passenger	CTA	C	During cruise, fumes were detected in the cabin. The engineering inspection revealed a leak in the APU.
57	14/02/2018	201800510	Incident		Coondewanna Aerodrome, 225Â° M 74Km	23° 25.68' S	118° 17.352' E	WA	Airbus	A320	Air Transport High Capacity	Passenger	CTA	A	During descent, fumes were detected in the cockpit and cabin. Engineers replaced the oil pump.

WHY SAMPLE FOR TCP? //

Because the engine oil manufacturers appear to report the TCP content of their products unevenly, **Professor Chris van Netten of the University of British Columbia** analysed the actual TCP content – both total TCPs and the relative amounts of four TCP isomers – in samples of eight aviation engine oils and three aviation hydraulic fluids.

The total TCP content of the eight oils ranged from 2.2 to 5.2% (by weight), and the total TCP content of each hydraulic fluid was zero.

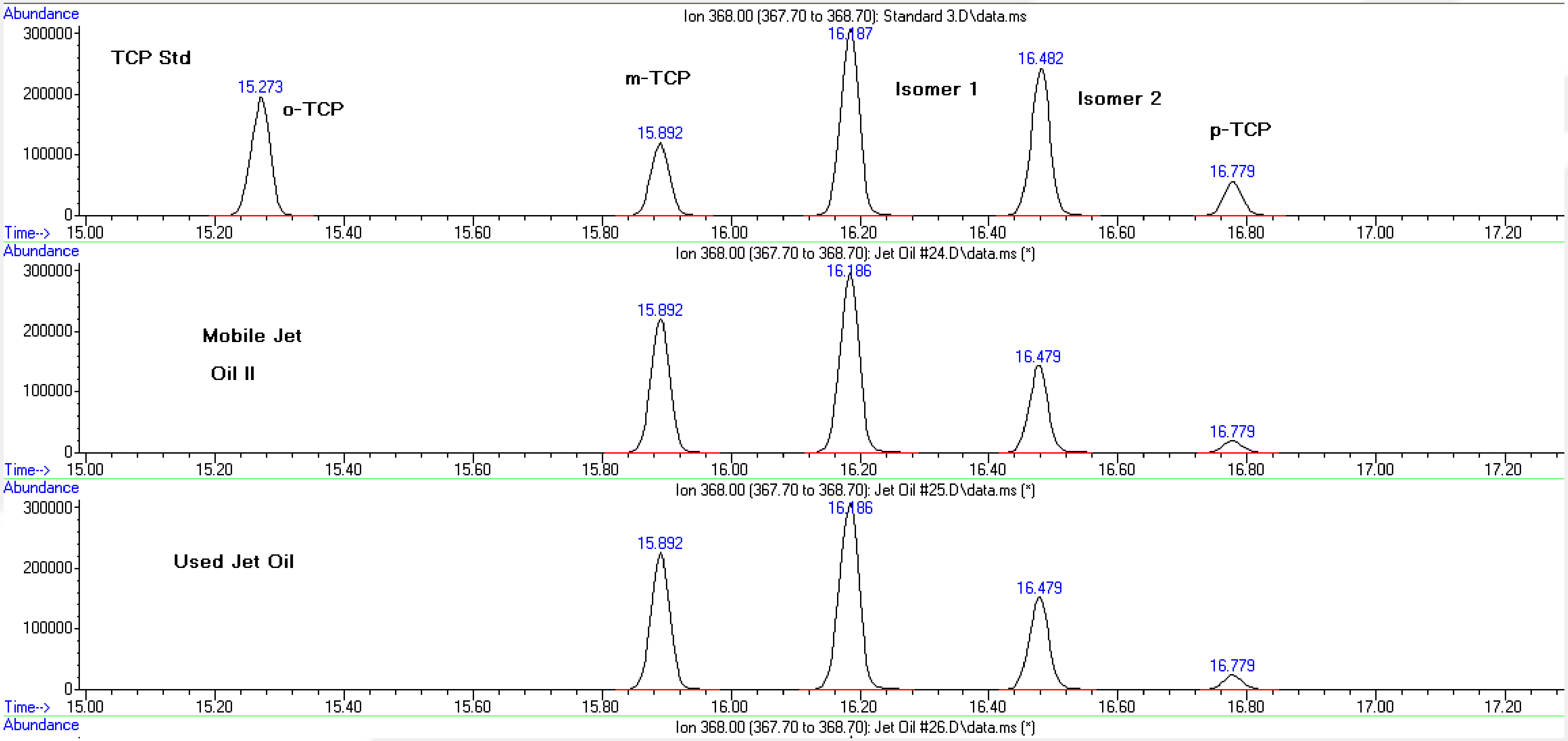
Tricresyl Phosphate ((TCP) is an indicator of bleed air contamination of aircraft air

- Highly specific to most jet turbine oils

To assess risk, need to measure the level of exposure to bleed air components

- TCP and its isomers are known neurotoxins
- Important indicator of the presence of all other pyrolysis products

TCP ISOMER PATTERNS FROM JET TURBINE OILS //



available at www.sciencedirect.com

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ELSEVIER

Science of the Total Environment

Short communication

Design of a small personal air monitor and its application in aircraft

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ABSTRACT

A small air sampling system using standard air filter sampling technology has been used to monitor the air in aircraft. The device is a small ABS constructed cylinder 5 cm in diameter and 9 cm tall and can be operated by non technical individuals at an instant notice. It is completely self contained with a 4 AAA cell power supply, DC motor, a centrifugal fan, and accommodates standard 37 mm filters and backup pads. The monitor is totally enclosed and pre assembled in the laboratory. A 45° twist of the cap switches on the motor and

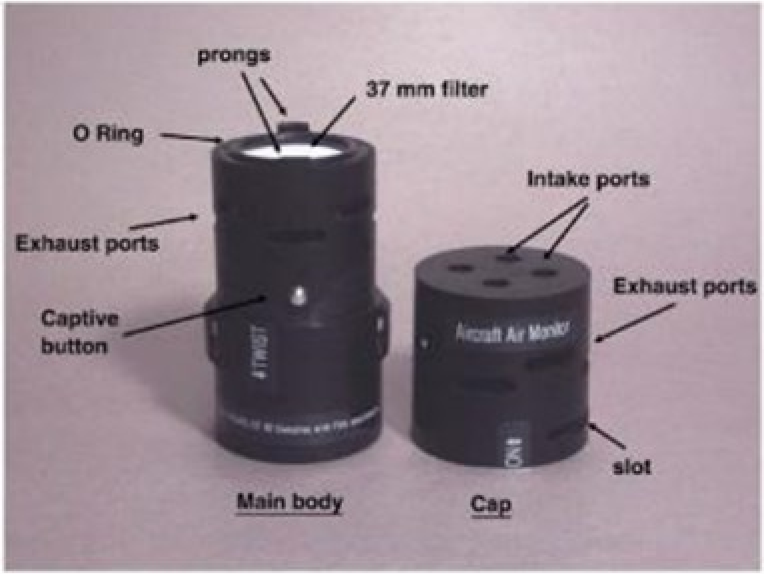


Fig. 2 – VN sampler with cap removed showing details and filter housing.

Protocols for the use of the VN Sampler for fume events in engine bleed pressurised aircraft cabins.

Rules for activating the VN sampler

- Prepare the sampler when there is a persistent presence of abnormal air quality[1] and the PIC is planning to submit a company pilot report or maintenance entry[2]
- Remove the sampler from the plastic bag and "twist ON" to activate. The sampler may be placed in any convenient position on the flight deck; it does not need to be next an air vent
- Once activated, run the sampler for as long as the flight lasts or until the batteries run out (approximately 1 hour), whichever occurs first. Continue to run the sampler even if the abnormality has disappeared. **Make sure you annotate the time on/off.**
- Keep track of the exposure time and any of the details. i.e. aircraft, date, location and duration of sampling, phase of flight, describe the type of abnormality etc. See attached fume event form
- Close the sampler (twist OFF) and place inside a self-sealing plastic bag that was provided.

The AFAP has provided a stamped return address package for you to post the sampler and this report to the Safety and Technical department

[1] for the purposes of this trial, abnormal air quality or contamination includes the presence of odours, fumes, haze and smoke that may be associated with engine or APU bleed air

[2] remember that under the Australian Transport Safety Investigation Act 2003 section 18 smoke and fumes are an immediately reportable matter. An event must be reported to a nominated official as soon as is reasonably practicable, and a written report submitted within 72 hours

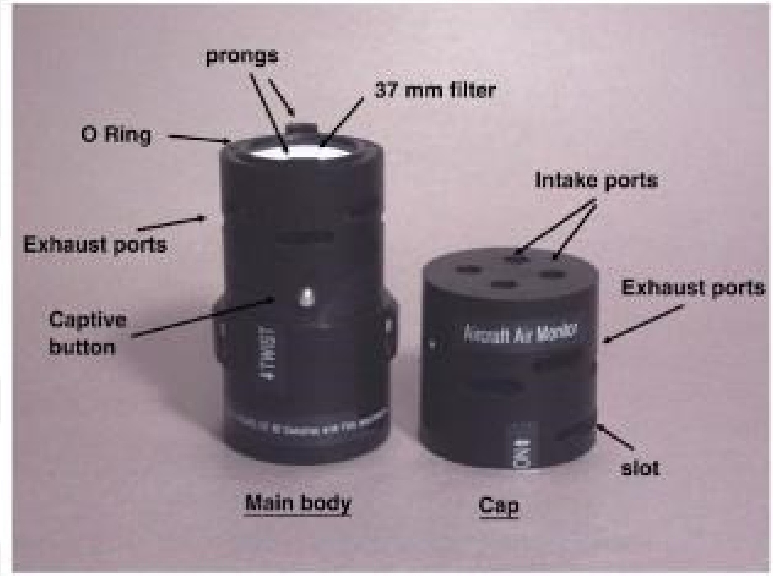


Fig. 2 – VN sampler with cap removed showing details and filter housing.

Please fill in this report if you have activated the VN Sampler device within an aircraft cabin/flight deck.

Name or Sampler #		Approx' monthly crew hours flown		Approx' monthly aircraft cycles flown	
107B		60		37	
Date LCL	2018	**A/C type**	NB Jet	Route or FLT No	x[redacted]
Time of activation LCL	50 min	**A/C Reg**	VH - [redacted]		
Company report reference, e.g Maint log, safety report	[redacted]	Phase of flight e.g GND, Eng start, taxi, climb, cze, dsc, app/ldg	Cruise & descent	Bleeds On or Off	On
				APU, On or Off	Off
Odour comments Oil, skydrol, fuel, dirty socks, gym bag, electrical etc	Oil/dry heated dust	Fume comments e.g visible, haze, not visible etc	Not visible	Contamination comments Likely bleed air? IFE/equipment ? Ovens? etc	Likely bleed air or ECS oil contamination
Short report:	This A/C has exhibited oily odours late on descent recently, including on both sectors today. Not noticed by crew other than the Captain. These mild odours are generally treated as normal. This A/C has had recent fume events involving oil found leaking from the APU. Air sample taken based on reasonable suspicion of the presence of oil in the air conditioning. Request confirmation of oil presence in this sample. Post flight, Capt' had an aggravated chest & dry cough which persisted through the night. Sampling commenced in cruise................				

AFAP
— 1938 —

CABIN AIR SAMPLING RESULTS //

October 2018 Australian samples

nanograms (ng) per filter analyzed

sample#	TBP	m-TCP	mmp-TCP	mpp-TCP	p-TCP	Total TCP	Flow rate Liters/min	Sampling time minutes	Volume Liters of air	TCP/m3 ng	TBP/m3 ng
83 SIM	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	1	54	54	LOD	
107 SIM	9.20	<LOD	<LOD	<LOD	<LOD	<LOD	1.2	20.00	24	LOD	383.3
114 SIM	68.00	<LOD	<LOD	<LOD	1.19	1.19	1	35	35.00	34.00	1085.7
115 SIM	31.00	<LOD	2.59	2.06	1.23	5.88	1.00	55.00	55.00	106.90	563.60
119 SIM	89.00	69.95	126.05	80.12	34.73	247.85	1.00	64.00	64.00	3872.60	1390.60
125 SIM	74.00	14.55	26.38	15.46	6.41	62.80	1.10	45.00	49.00	1281.60	1510.20
161 SIM	5.00	4.86	9.78	6.21	2.93	23.78	1.20	40.00	48.00	495.40	104.10
Blank 1	<LOD	<LOD	<LOD	<LOD	<LOD						
Blank 2	<LOD	<LOD	<LOD	<LOD	<LOD						
Blank 3	<LOD	<LOD	<LOD	<LOD	<LOD						
Blank 4	<LOD	<LOD	<LOD	<LOD	<LOD						
LOD	2.08	0.92	2.36	1.83	0.43						

LOD: Limit of detection
SIM: Single Ion Monitoring for Tributyl Phosphate (TBP) and Tricresyl Phosphate (TCP)

Sample #119.
The exposure was calculated on the basis of 64 minutes. It appears however, from the pilot's notes, that the bulk of the TCP and TBP might have been collected during the last segment of sampling. If this was indeed the case, and using the 35-minute sampling period, the exposure could have been as high as **7081.4 nanogram of TCP/m3** and **2542.9 nanograms of TBP/m3.**

Van Netten: Given levels of TBP & TCP in normal flights are usually close to or below our detection limit, **almost all samples, except #83, identify a problem.**

STUDIES MEASURING TCP //

Showing maximum total TCP levels detected						
Study	**Year**	**Country / Region**	**Max. level TCP µg / m3**	**Number of samples**	**number of aircraft**	**number of events**
Denola	2011	Australia	51.3	78	46 individual a/c	9 incidents smoke odour
Fox (PhD)	2012	US	100	?	Single engine study	
Cranfield	2011	UK	37.7	100	5 a/c types	'minor' fumes in 25 flights
Hanhela	2005	Australia	49	80	3 a/c types	no correlation, but some samples taken with canopy open
Fox / Malmo	1999	Sweden	20.3	1	1	(1) engine test
AFAP	2018/19	Australia	**3.872**	**19**	7 a/c, 1 type	**19**

300 different substances – cabin and bleed air studies
Pyrolysed oil 127 + (EASA 2017)

Van Netten: TCP makes up only 3% of jet turbine oil - the reported values should be multiplied by 33 to obtain exposure to all engine oil components

PILOT EXPANDED REPORTS //

October 2018 Australian samples

nanograms (ng) per filter analyzed

sample#	TBP	m-TCP	mmp-TCP	mpp-TCP	p-TCP	Total TCP	Flow rate Liters/ min	Sampling time minutes	Volume Liters of air	TCP/m3 ng	TBP/m3 ng
115 SIM	31.00	<LOD	2.59	2.06	1.23	5.88	1.00	55.00	55.00	106.90	563.60
119 SIM	89.00	69.95	126.05	80.12	34.73	247.85	1.00	64.00	64.00	3872.60	1390.60

Sample 119 - This sample shows one of the higher results for TBP and TCP yet there was barely a detectable odour during the sampled flight. None of the cabin crew detected an odour at all and the pilots detected it only mildly.

This aircraft had a leaking hydraulic pressure line, with extensive hydraulic oil evident on the belly of the aircraft, as shown in the images. Note that the aircraft had been cleaned only 2 weeks earlier. Post incident this aircraft was designated for a further wash "at company convenience". On further investigation, engine oil was found to be present in the APU compartment drain and fumes were noted by the engineers when the APU inlet door was opened.

5 days later a **significant oil fumes event occurred which involved an air return**. No cause was found and **it was suggested that the odour may have been due to "smelly passengers"**. One crew member showed a slightly elevated carboxy haemoglobin level (carbon monoxide) when tested several hours after the event.

This aircraft had also been reported for a strong oily odour on 2 previous recent occasions. After one of the events, engineers assessed the odour to be due to atmospheric ozone in accordance with the Trouble Shooting Manual.

Sample 115 - This sample was taken on reasonable suspicion of a problem due to recent occasional sporadic oily smells. Only one crew member detected a very mild "dusty" or "dry musty" smell during the sampling period. No other crew members detected any odour. This aircraft subsequently had a fumes event 6 weeks later with the crew describing a mild "heated dust-like" odour and then a moderate "sweaty socks" odour. Upon investigation engineers discovered oil leaking from the APU into the APU air intake

AFAP 1938

nanograms (ng) per filter analyzed

sample#	TBP	m-TCP	mmp-TCP	mpp-TCP	p-TCP	Total TCP	Flow rate Liters/ min	Sampling time minutes	Volume Liters of air	TCP/m3 ng	TBP/m3 ng
114 SIM	68.00	<LOD	<LOD	<LOD	1.19	1.19	1	35	35.00	34.00	1085.7

Contaminated cabin air sampling report (VN Sampler):

Please fill in this report if you have activated the VN Sampler device within an aircraft cabin/flight deck.

Name or Sampler #		Approx' monthly crew hours flown		Approx' monthly aircraft cycles flown	
114		65		35	
Date LCL	Oct 2018	A/C type [redacted]	NB Jet	Route or FLT No	x [redacted] [redacted]
Time of activation LCL	34 min	A/C Reg	VH - [redacted]		
Company report reference, e.g Maint log, safety report	[redacted]	Phase of flight e.g GND, Eng start, taxi, climb, cze, dsc, app/ldg	Cruise & descent	Bleeds On or Off	On
				APU, On or Off	Off
Odour comments Oil, skydrol, fuel, dirty socks, gym bag, electrical etc	Bleach/chllrine like cleaning fluid	Fume comments e.g visible, haze, not visible etc	Not visible	Contamination comments Likely bleed air? IFE/equipment ? Ovens? etc	Possible cleaning agent, possible oil
Short report:	Cabin crew reported bleach or chlorine like odour in forward cabin.From row 5 forward. Not detected in the flight deck.........Odour detected in cruise and present until after landing. One cabin crew also detected a "sweaty socks smell" this cabin crew felt nauseous soon after t/off. Another cabin cew had a headache. Neither pilot could smell anything unusual. The VN sampler was startd approx' 10 min's before descent until arrival at the gate. The sampler was run for 34 min's. The cause was later attributed by engineering to mixing of twosoaps in the forward lavatory. However Captain suspects contaminated air.........				

Van Netten: Sample #114 Significant TBP was detected as well as a trace of TCP. Again, as above, a high acute exposure could have been present during the sampling time.

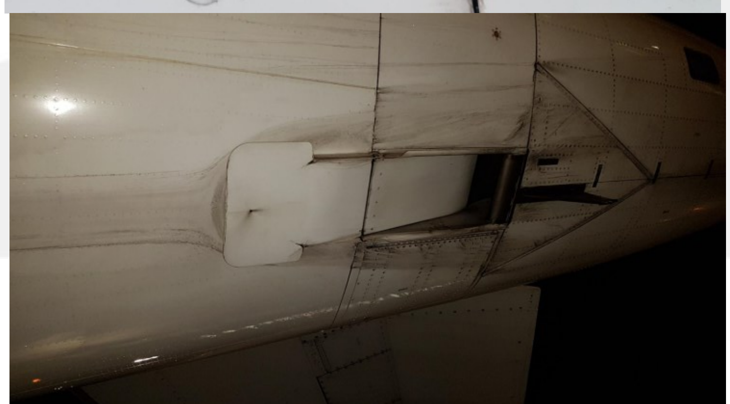
APU HYDRAULIC OIL INGESTION //

nanograms (ng) per filter analyzed

sample#	TBP	m-TCP	mmp-TCP	mpp-TCP	p-TCP	Total TCP	Flow rate Liters/ min	Sampling time minutes	Volume Liters of air	TCP/m3 ng	TBP/m3 ng
83 SIM	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	1	54	54	LOD	
107 SIM	9.20	<LOD	<LOD	<LOD	<LOD	<LOD	1.2	20.00	24	LOD	383.3
114 SIM	68.00	<LOD	<LOD	<LOD	1.19	1.19	1	35	35.00	34.00	1085.7
115 SIM	31.00	<LOD	2.59	2.06	1.23	5.88	1.00	55.00	55.00	106.90	563.60
119 SIM	89.00	69.95	126.05	80.12	34.73	247.85	1.00	64.00	64.00	3872.60	1390.60
125 SIM	74.00	14.55	26.38	15.46	6.41	62.80	1.10	45.00	49.00	1281.60	1510.20
161 SIM	5.00	4.86	9.78	6.21	2.93	23.78	1.20	40.00	48.00	495.40	104.10

APU hydraulic oil ingestion aligns with detected TBP

APU HYDRAULIC OIL INGESTION //



COMMON SYMPTOMS OF ILLNESS //

Single or short-term exposures:

- **Neurotoxic:** blurred or tunnel disorientation, shaking and tremors, loss or seizures, loss of consciousness
- **Psychotoxic:** memory impairment headache, light-headedness, dizziness, confusion and feeling intoxicated
- **Gastro-intestinal:** nausea, vomiting
- **Respiratory:** cough, breathing difficulties

Long term low-level exposure or residual exposure:

- **Neurotoxic:** numbness (fingers, lips, limbs), parathesias
- **Psychotoxic:** memory impairment, lack of coordination, forgetfulness, severe headaches, dizziness, sleep disorders
- **Gastro-intestinal:** salivation, nausea, vomiting, diarrhea

RAW DATA SECOND SAMPLE SET //

ng/filter					
	TBP	m-TCP	mmp-TCP	mpp-TCP	p-TCP
Sample 102 SIM	57.15	5.76	12.88	7.31	2.63
Sample 68 SIM	96.30	<LOD	<LOD	<LOD	<LOD
Sample 69 SIM	68.08	<LOD	<LOD	<LOD	<LOD
Sample 71 SIM	68.87	0.96	2.00	1.19	<LOD
Sample 81 SIM	83.17	<LOD	<LOD	<LOD	<LOD
Sample 163 SIM	112.84	1.87	7.09	7.62	3.87
Sample 112-1 SIM	165.19	<LOD	<LOD	<LOD	<LOD
1-Con(Process control) SIM	51.32	<LOD	<LOD	<LOD	<LOD
Blank 1	<LOD	<LOD	<LOD	<LOD	<LOD
Blank 2	<LOD	<LOD	<LOD	<LOD	<LOD
Blank 3	<LOD	<LOD	<LOD	<LOD	<LOD
Blank 4	<LOD	<LOD	<LOD	<LOD	<LOD
LOD:	2.08	0.92	2.36	1.83	0.43

LOSS OF MEDICAL – REPORT EXTRACTS //

MEDICAL PANEL

CONSTITUTED PURSUANT TO THE WORKPLACE INJURY REHABILITATION AND COMPENSATION ACT 2013

	[redacted]/9/17	"Shutdown fumes"
	[redacted]/2/18	"Strong oil fumes in cruise"
	[redacted]/2/18	"Dry dusty fumes in flight deck only"
	[redacted]/3/18	"Fumes PAN SYD MEL"

	[redacted]/4/18	"Hydraulic Leak. Severe Hyd residue"
	[redacted]/4/18	"Hydraulic Leak"
	[redacted]/6/18	"Fumes descent"
	[redacted]/6/18	"Fumes again Cabin crew report post flight"
	[redacted]7/18	"Hydraulic leak/Staining Fume Risk"
	[redacted]/7/18	"Cumulative Respiratory effects"
	[redacted]/2/19	"Smell on start"
	[redacted]/3/19	"Transient smell on start (oily)"

Hair sampling confirming a presence of chemicals including tri-cresyl phosphate (TOCP) in his system,

I found [redacted] offered history most compelling and could not exclude the possibility of a syndrome secondary to chronic airborne chemical exposure.

report by Dr [redacted] proposed a link between exposures derived from his employment and his subsequent symptoms, and concluded with the recommendation that [redacted] should not fly again in an aircraft in which fume events were possible,

Report: Opinion: Treating doctor correspondence, Serial consultations Enduring and fluctuating symptoms of cough and wheeze, but additional non-specific, systemic symptoms such as malaise and headache. …there was evidence of tri-cresyl phosphate exposure and organophosphate exposure in specialist pathology sampling..

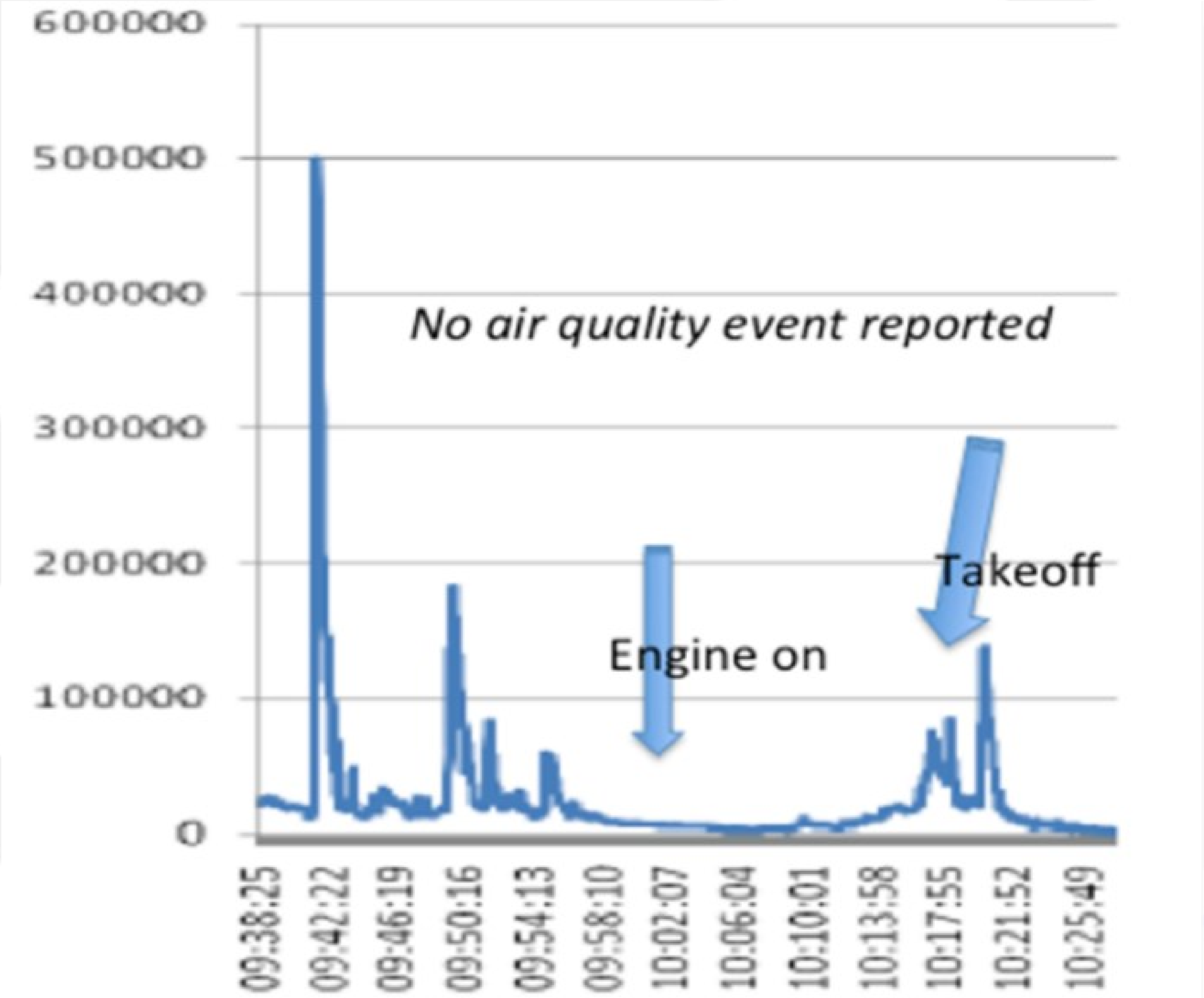
Although not a generally accepted term,…case is consistent the diagnosis of "aerotoxic syndrome".

There are ample grounds to surmise that [redacted] symptoms are consistent with airborne chemical fumes used in the aviation.

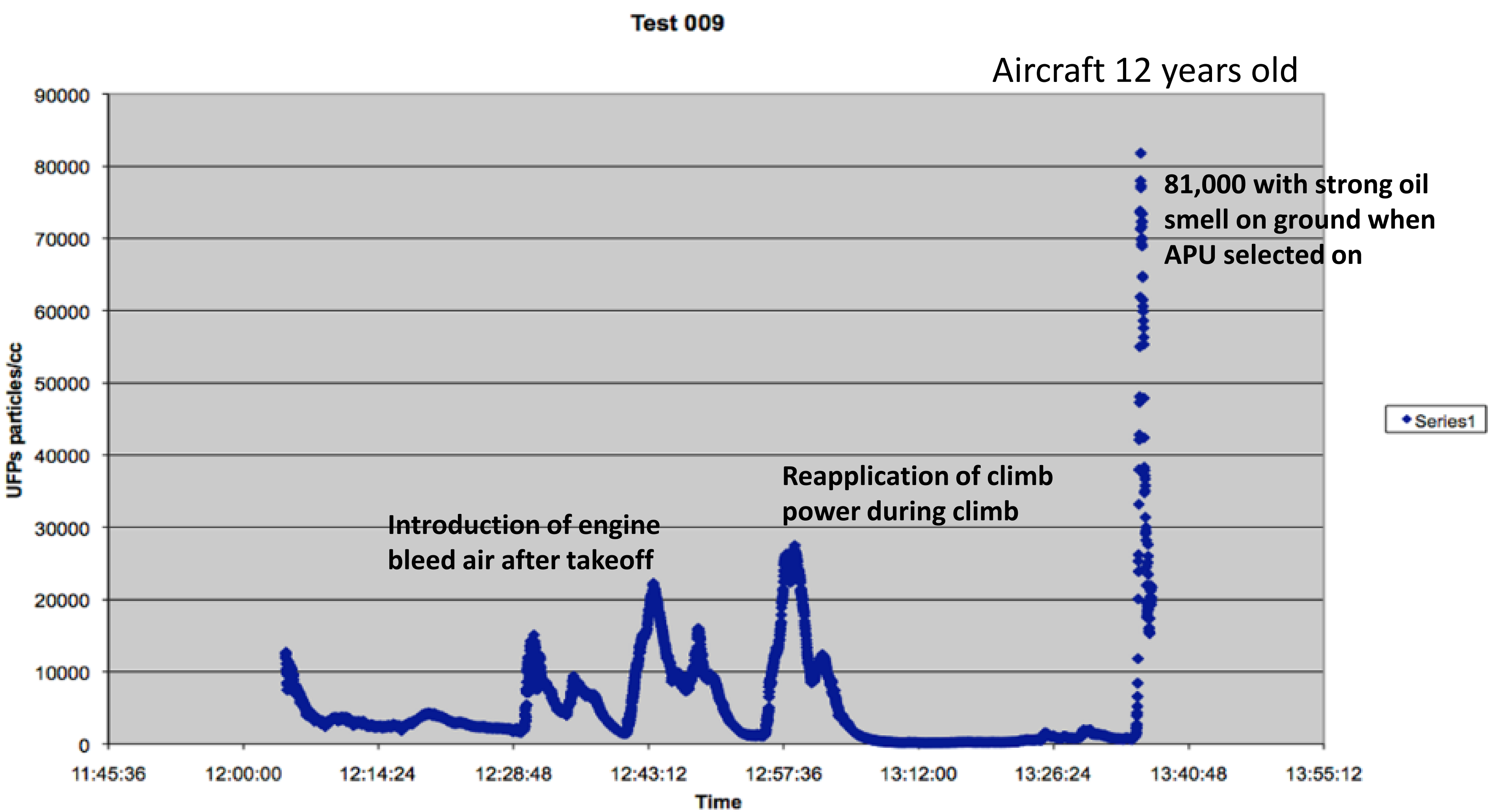
There is evidence that in some cases, symptoms can endure indefinitely.

Treatment is supportive.

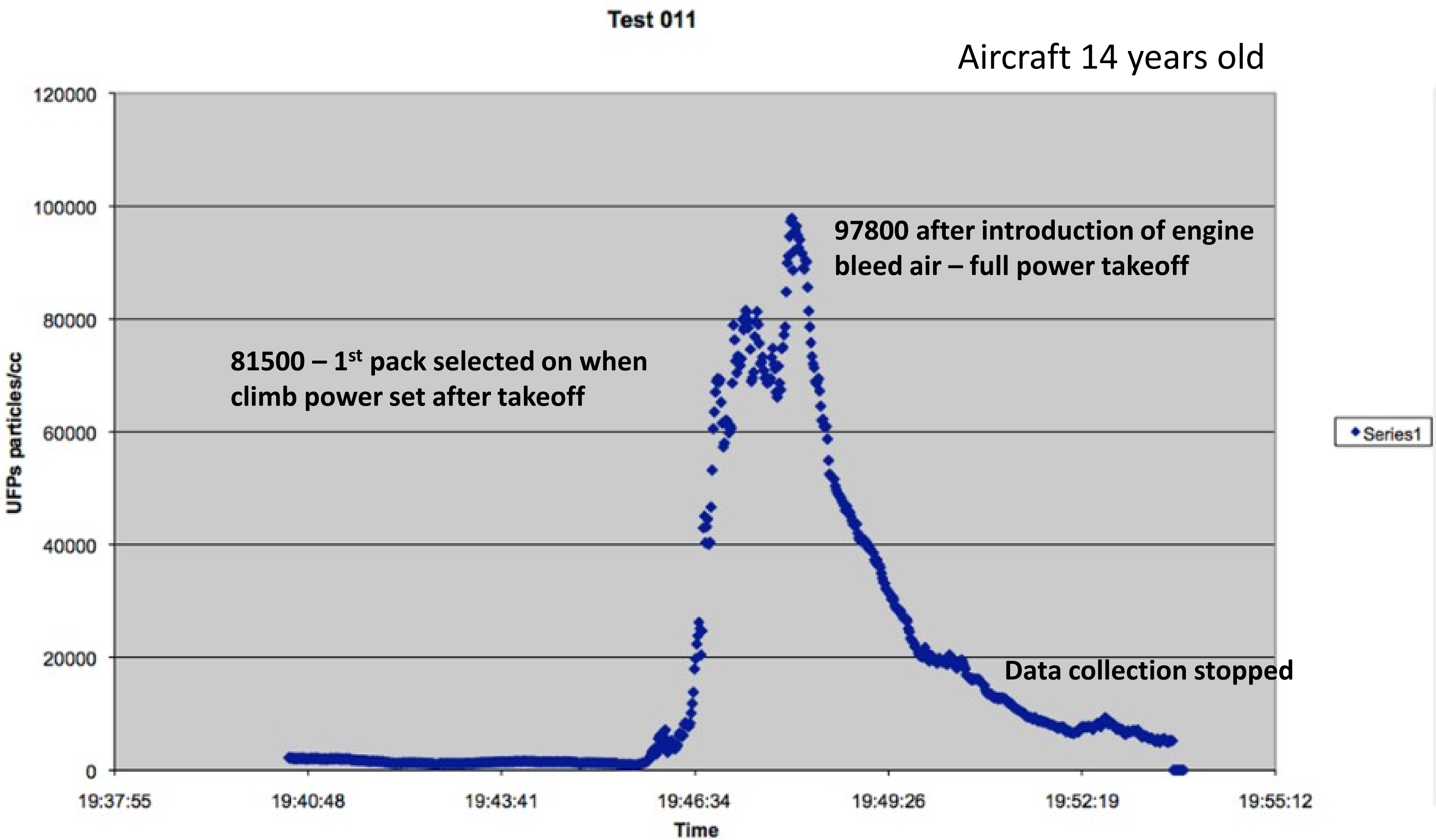
UFPs: CRANFIELD 2011 //



UFPs: GCAQE 2018 – FLIGHT 3 //



UFPs – GCAQE 2018 – FLIGHT 4 //



Captain Marcus Diamond

BSc *Melb*, ATPL *Aus, NZ, PNG*

Safety & Technical Manager

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Lab of Neurophysiology | qEEG – ERP

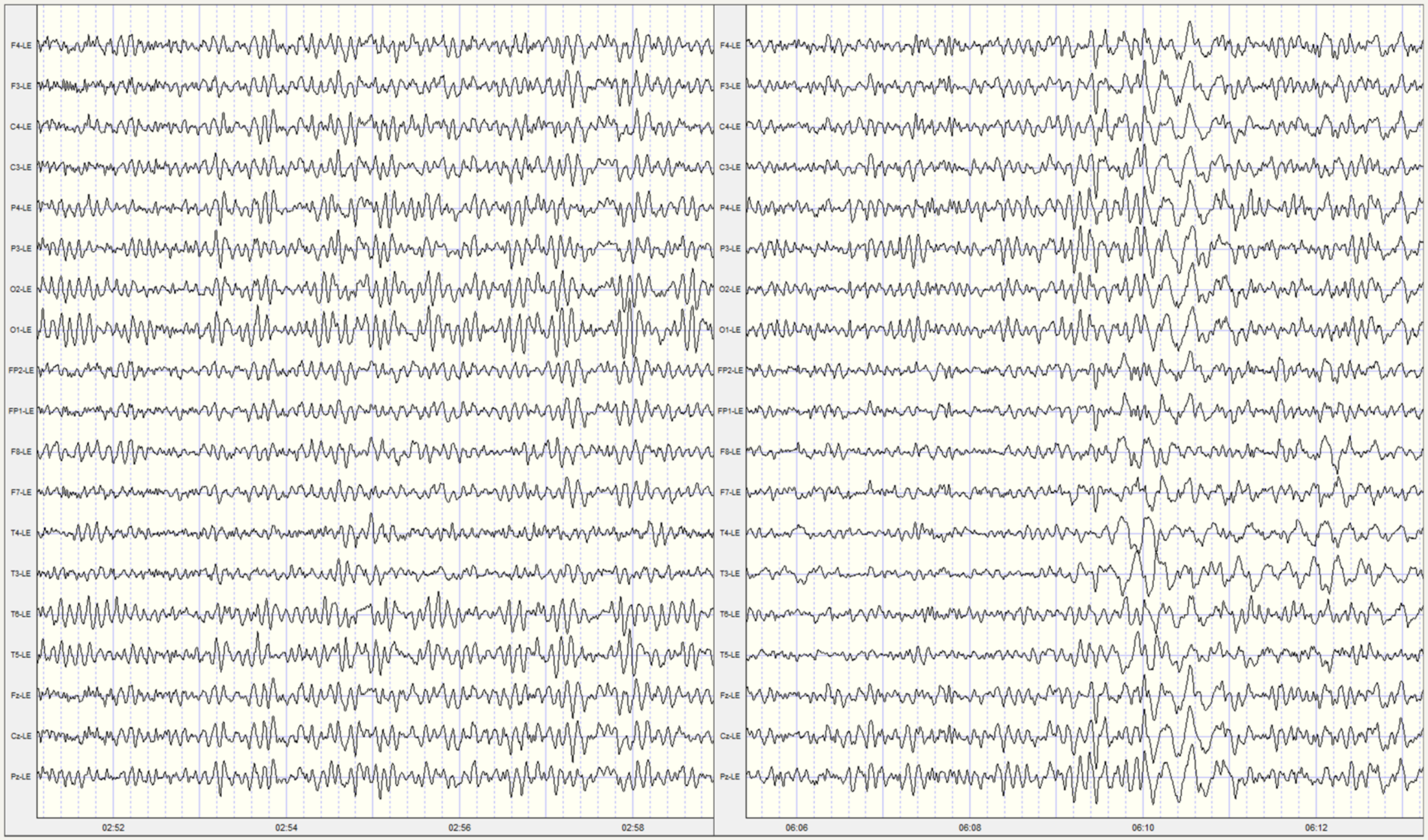
AerotoxBrain@proximus.be

Neurophysiology

qEEG – ERP - EP

Neurophysiology

- EEG



Neurophysiology

qEEG

2D Topography

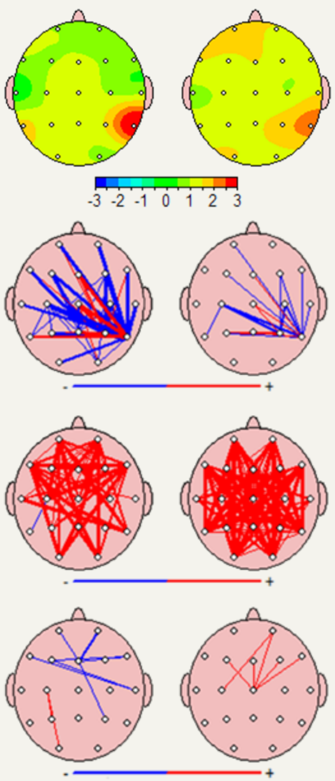
Theta Alpha

Absolute Power

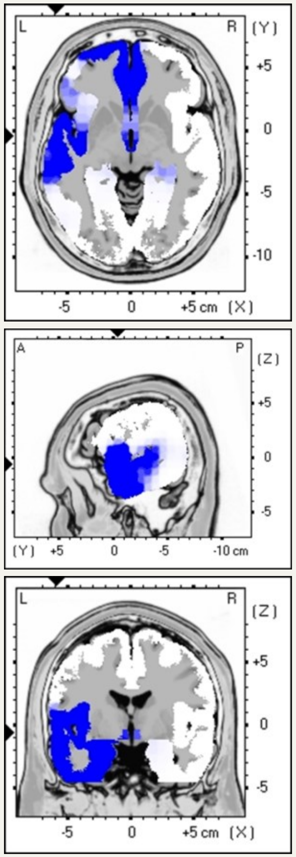
Amplitude Asymmetry

Coherence

Phase Lag



3D Source Analysis

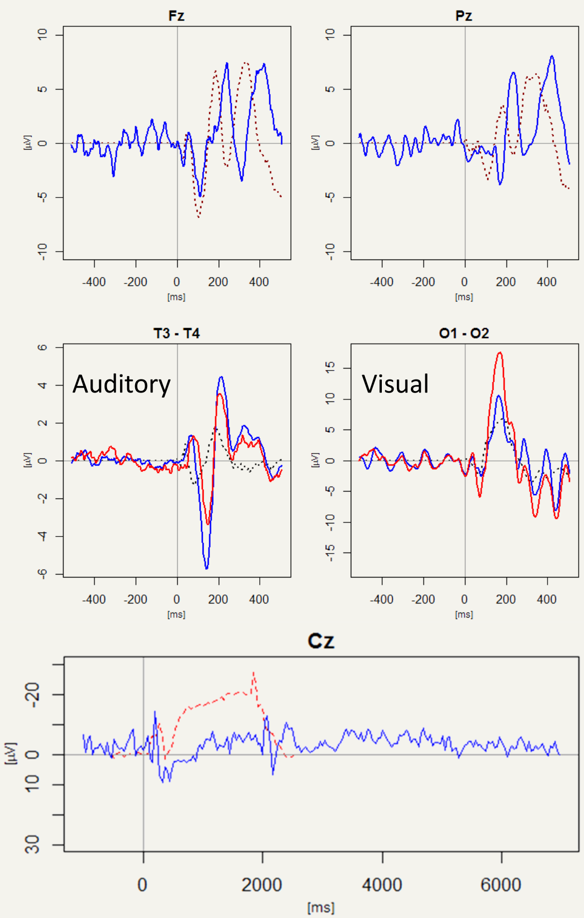


Event Related Potentials

P300

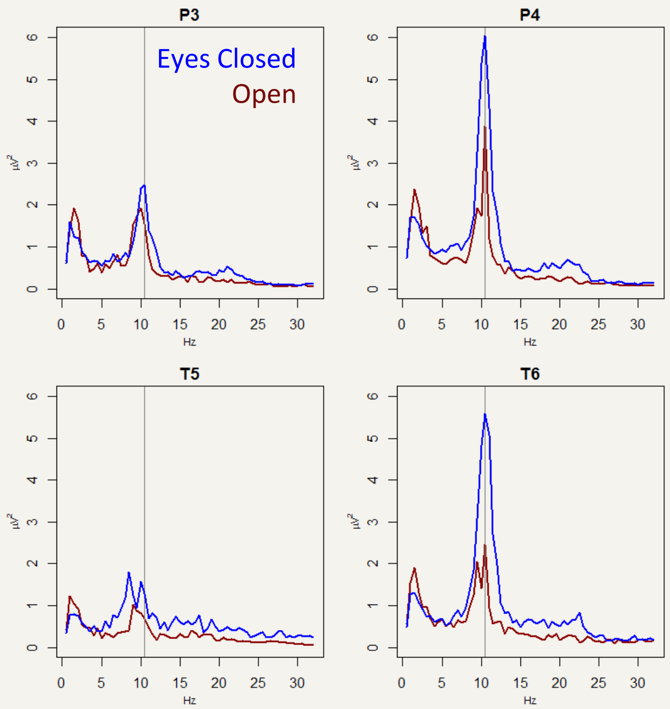
EP

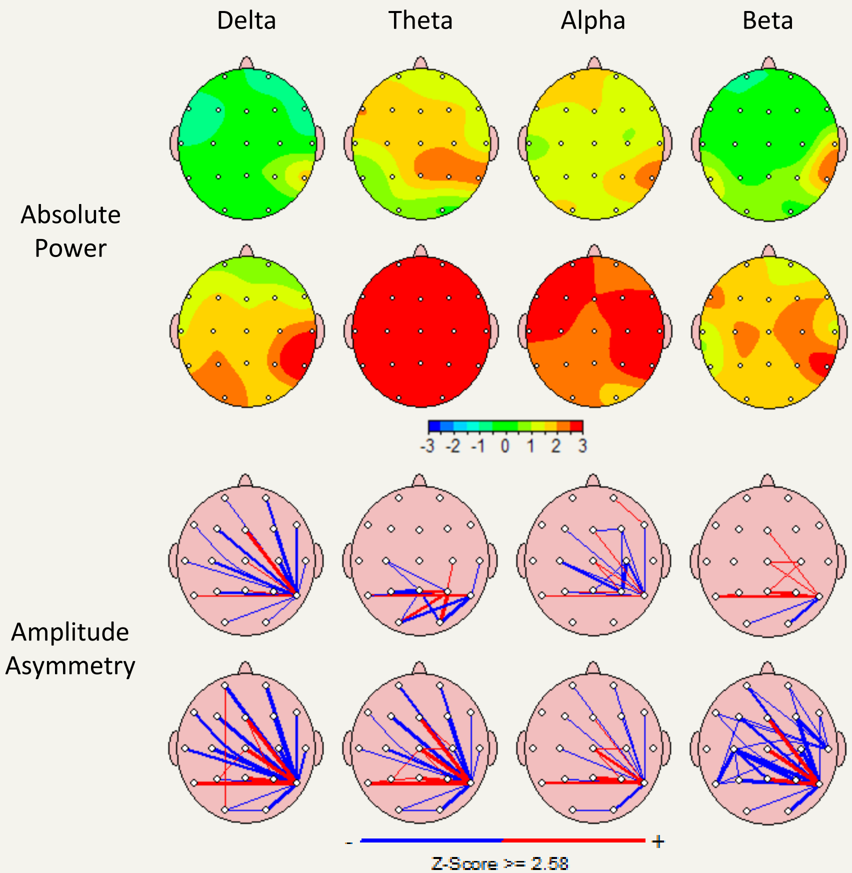
CNV



Neurophysiology

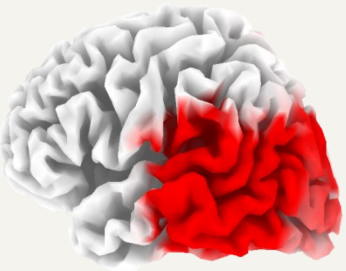
- qEEG
  - 2D topography

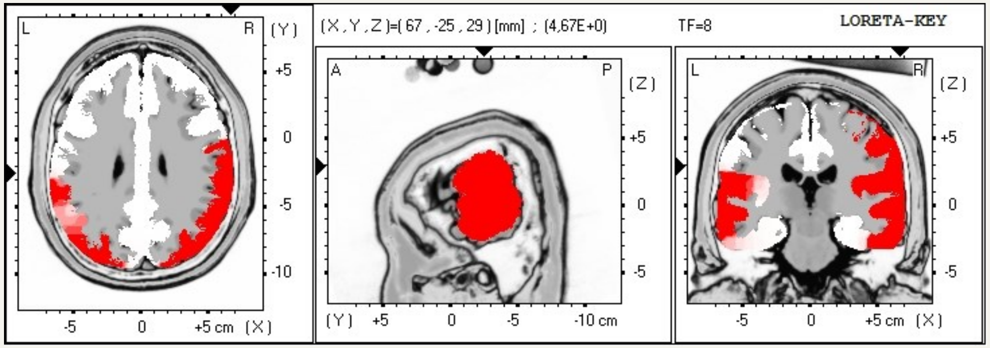




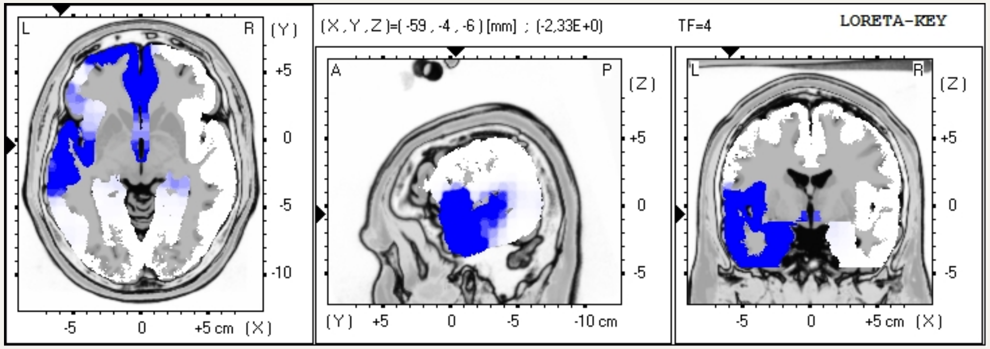
Neurophysiology

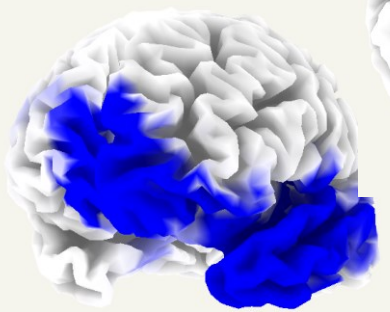
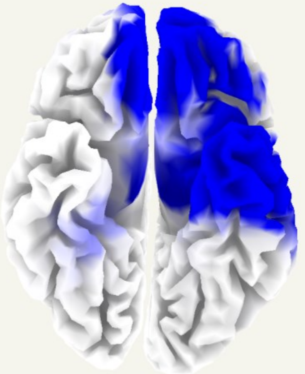
- qEEG





  - LORETA 3D Source Analysis



Preliminary Results

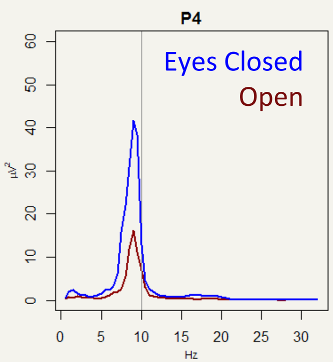
Total subjects: 30

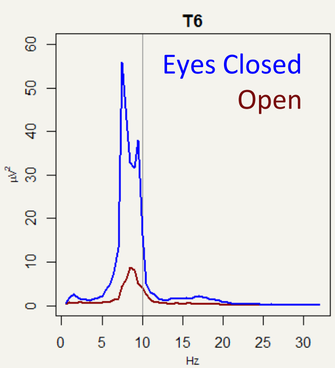
Neurophysiology

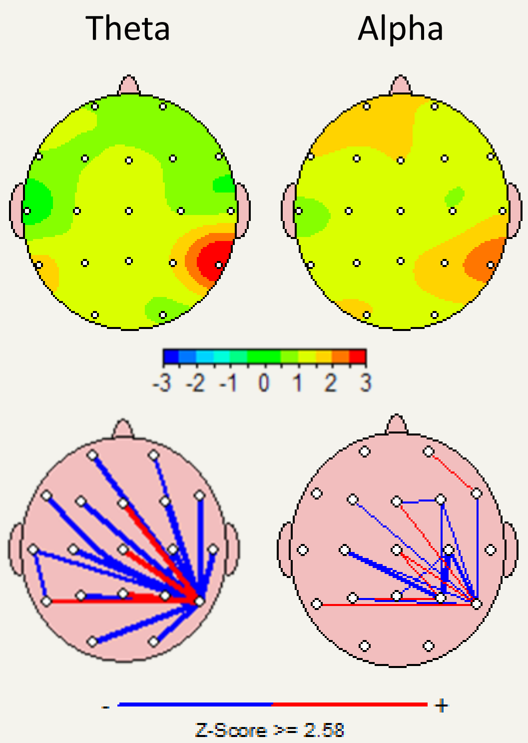
- Subjects
  - 30 (of 100+)
  - Pilots, Flight Attendants
    Frequent Flyers, Ground Crew
  - 25-67 years of age
  - 2-42 years of flying
  - Active or
    Non-active for 6 months – 22 years

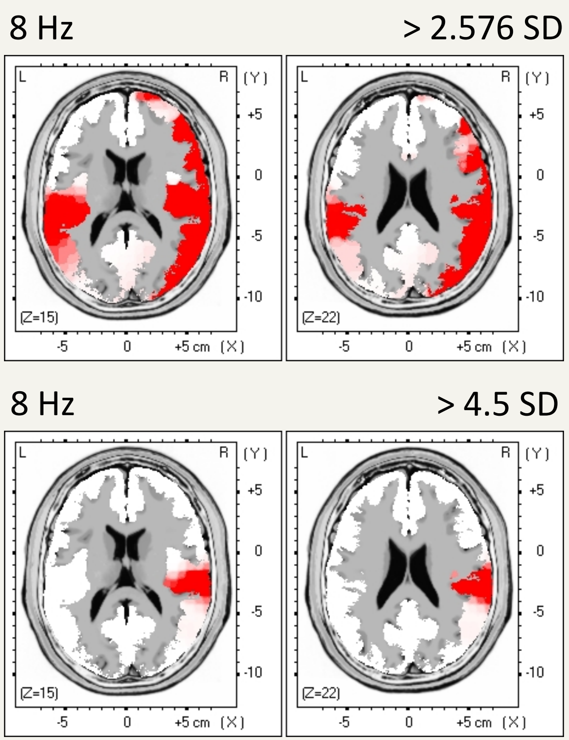
Group 1

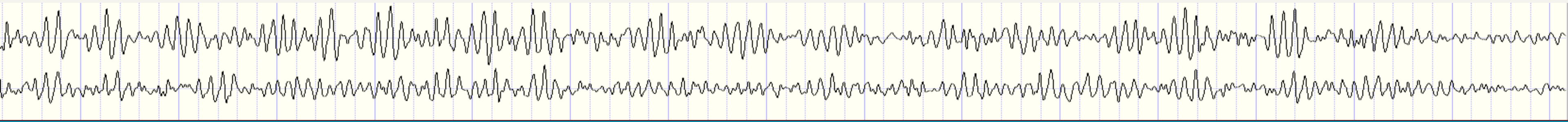
Total subjects: 25 of 30







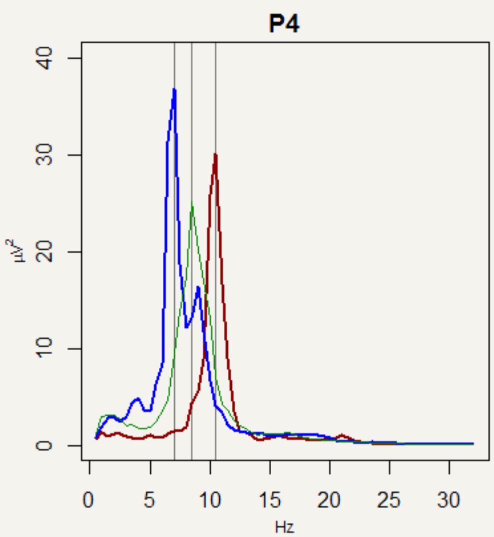


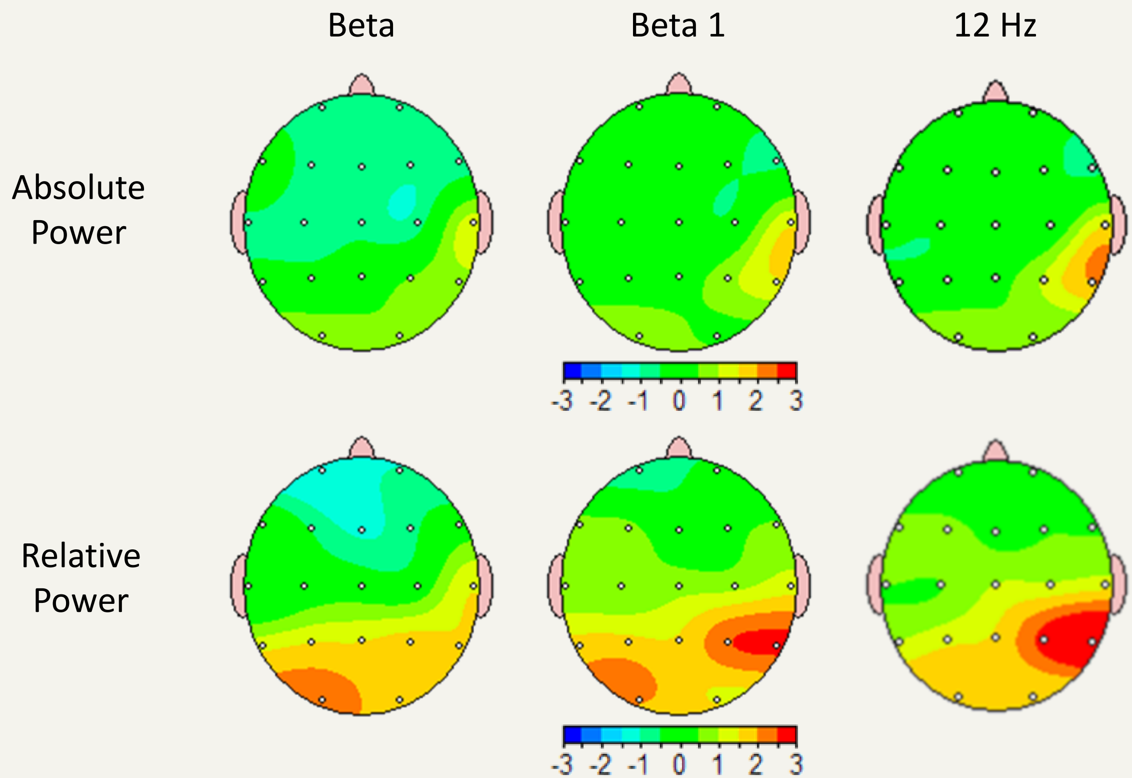


Group 1

Total subjects: 25 of 30

- 2D Topography

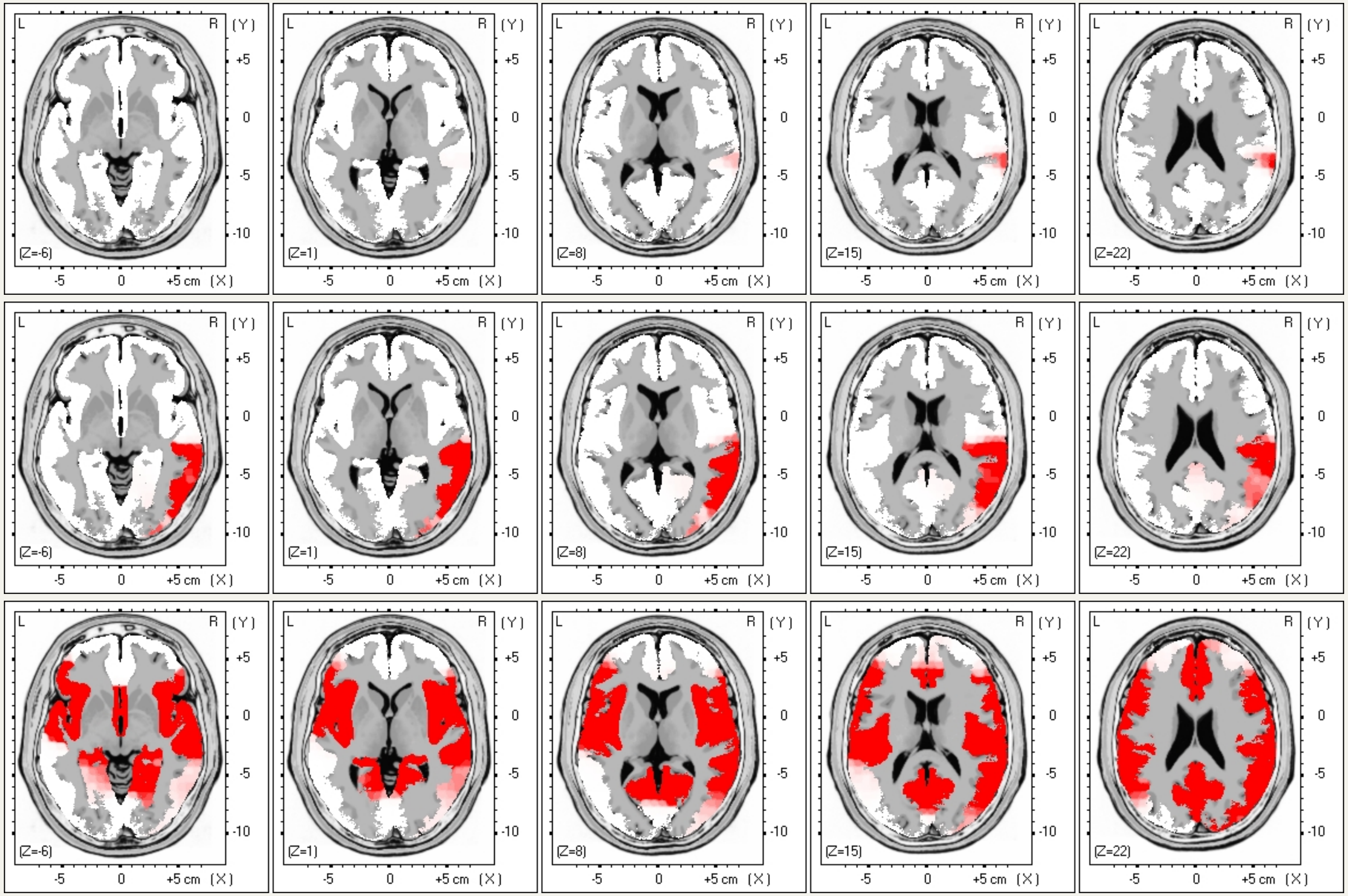




Group 1

Total subjects: 25 of 30

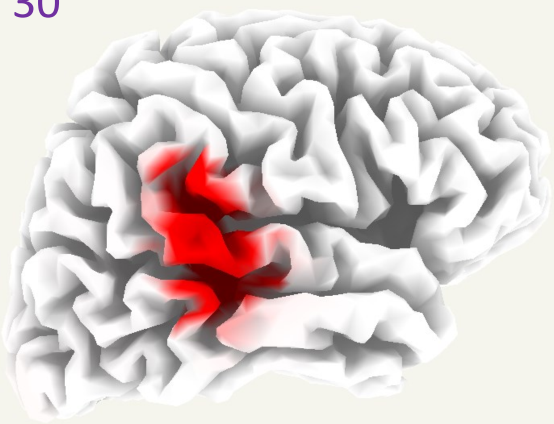
- LORETA



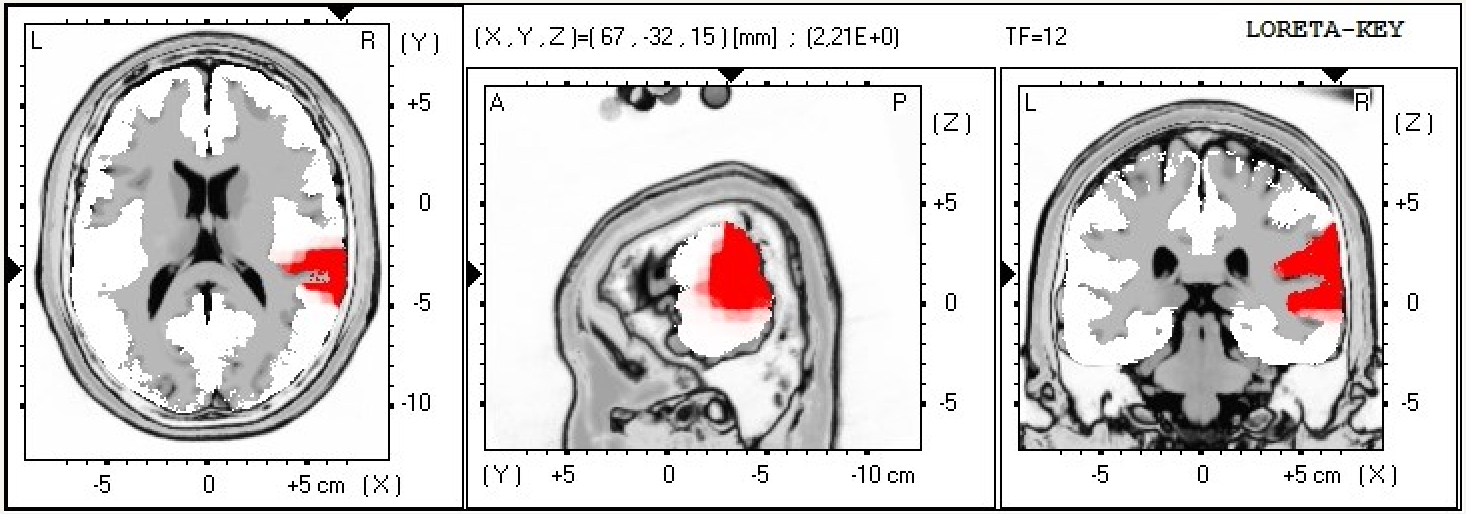
Group 1

Total subjects: 25 of 30

- qEEG
  - 3D LORETA

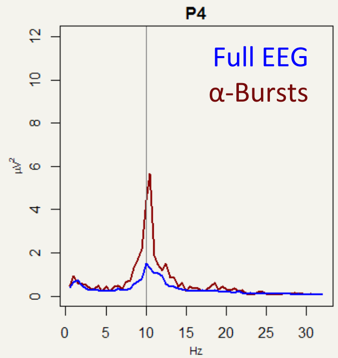


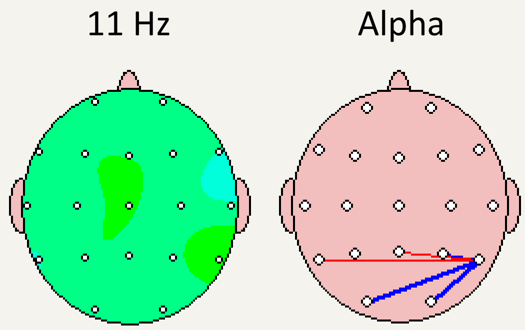
Right Hemisphere

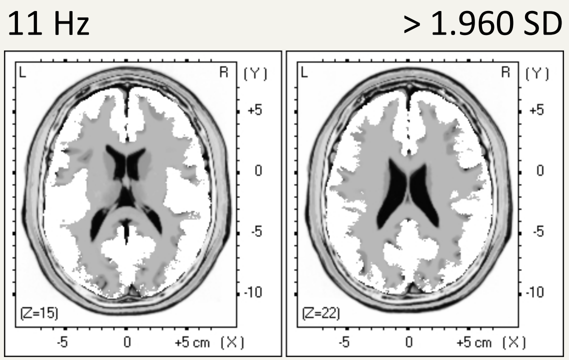


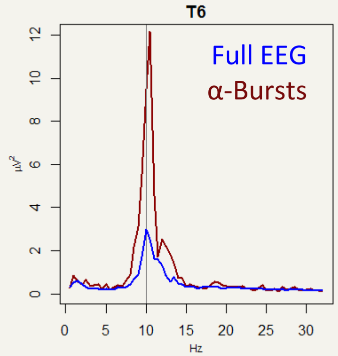
Group 2

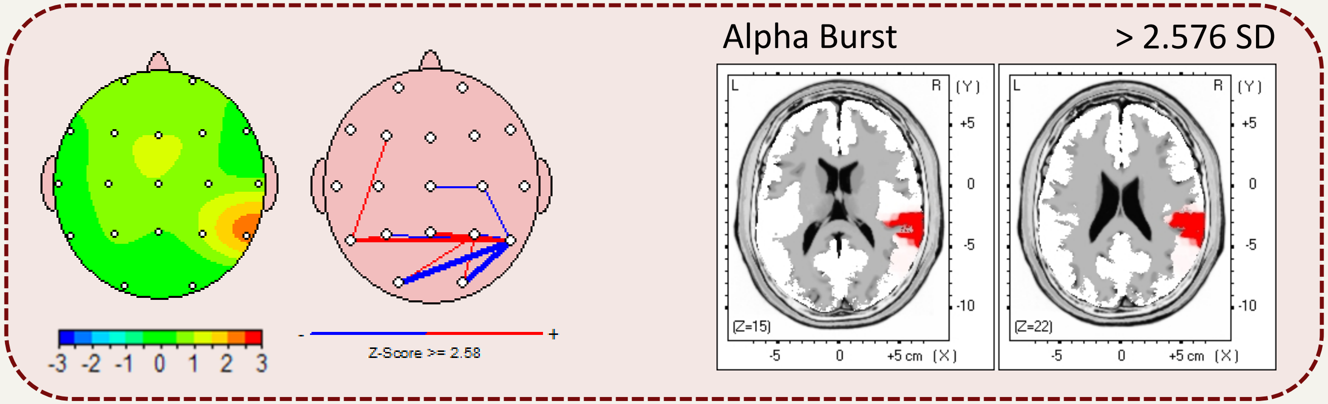
Total subjects: 4 of 30

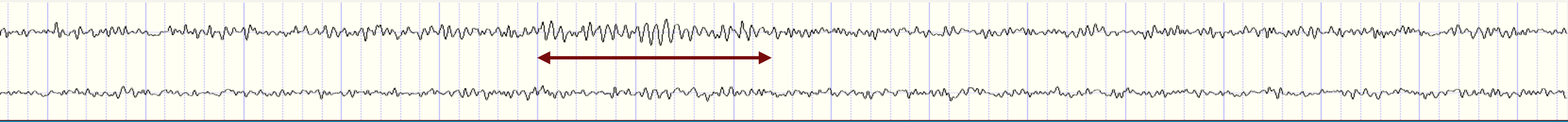






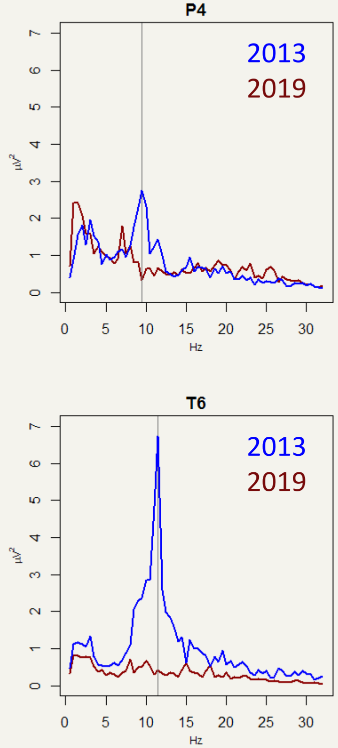


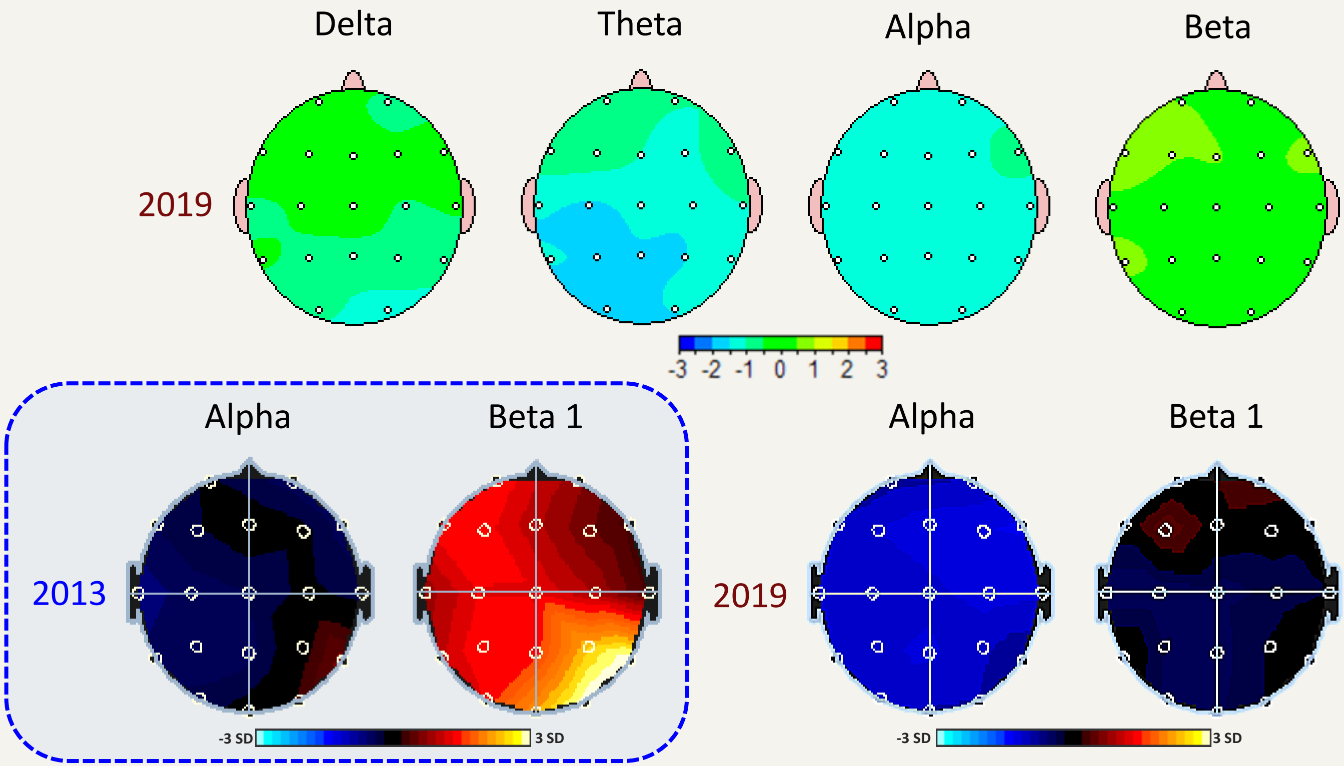


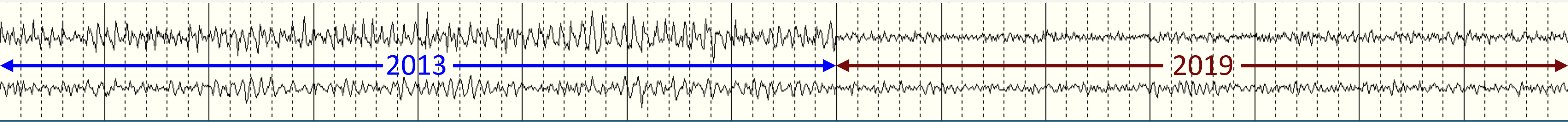


(Group 3)

Total subjects: 1 of 30







Pattern Distribution

Total subjects: 30

Group 1

- **Prominent** base rhythm
- R-Post-central, R-Superior Temporal
- Peak Frequency: 7-12 Hz
- Pilot, Flight Attendant
  Frequent Flyer, Ground Crew

Group 2

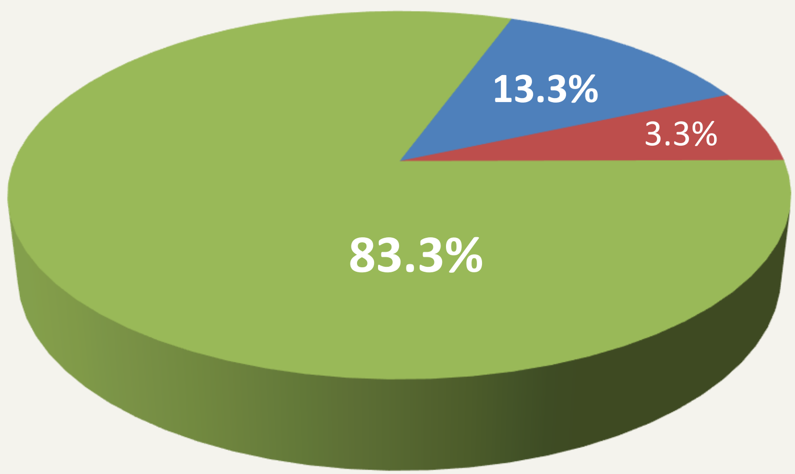
- **Minimal** base rhythm
- R-Post-central, R-Superior Temporal
- Peak Frequency: 9-12 Hz
- Pilot, Flight Attendant
  Frequent Flyer

83.3%

13.3%

96.7%

3.3%



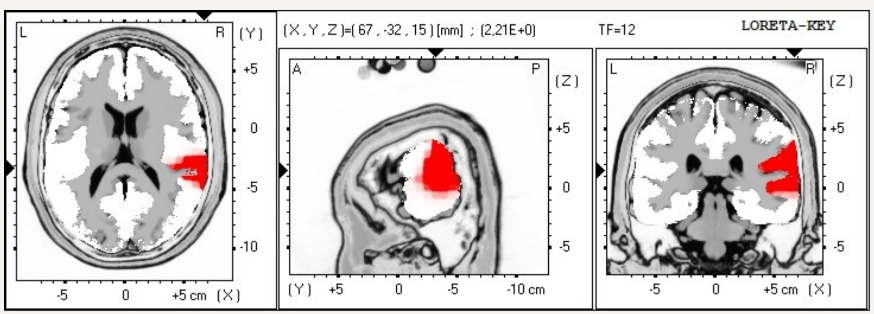
(Group 3)

- Absent base rhythm
- Frequent Flyer

Connecting the dots

Cognitive (dys)functions

- Functions
  - Sensory integration
  - Attention
  - Executive functions



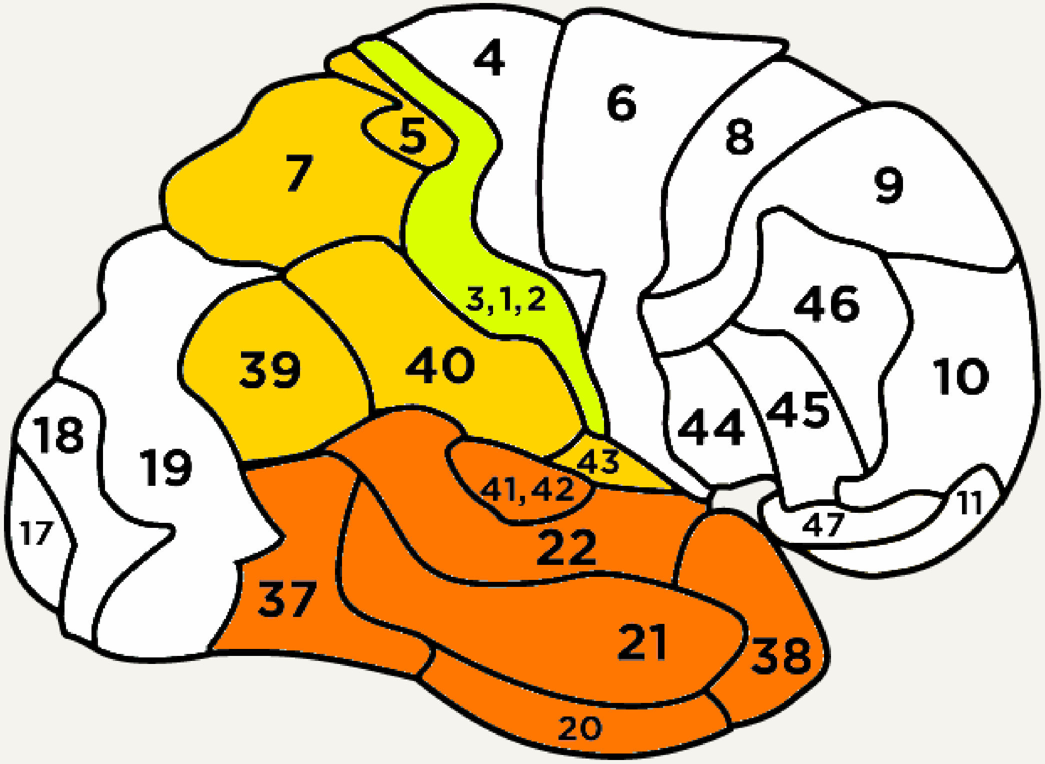
- Symptoms
  - Hypersensitivity
  - Attention problems
  - Losing train of thought
  - Unable to multitask
  - Trouble following conversations
  - Difficulty remembering steps in a multi-step process
  - Slow processing

Cholinergic System

- Organophoshates
  - Bleed Air - Tricresyl phosphate (TCP)
  - Desinsectants
  - Flame Retardants
- Carbamates
  - Desinsectants
- Metals
  - Aluminum

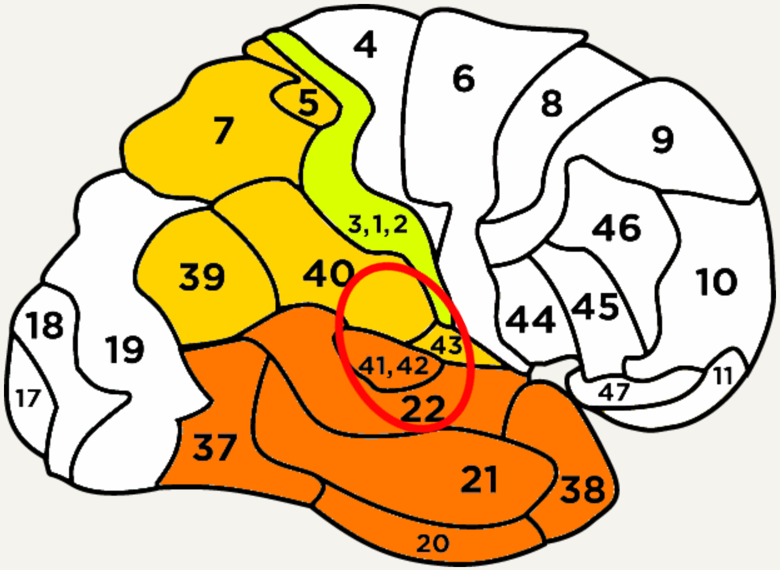
Cholinergic System

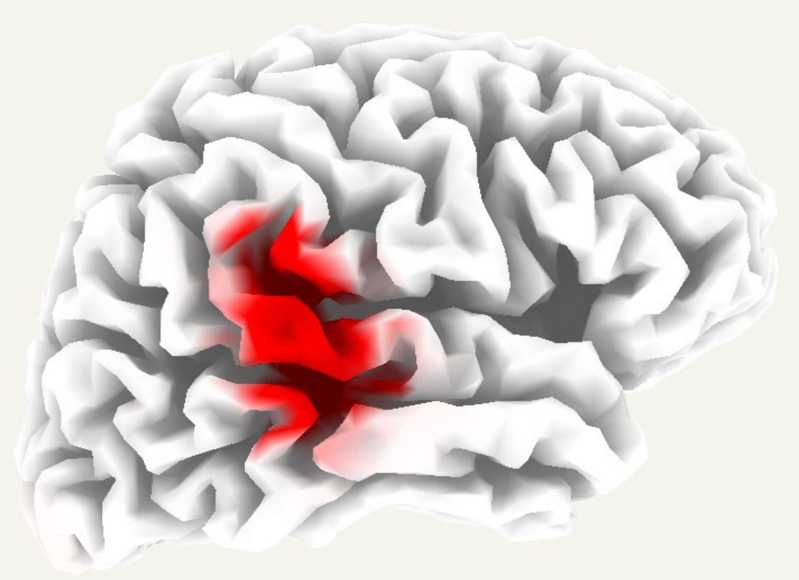
- Acetylcholinesterase (AChE)



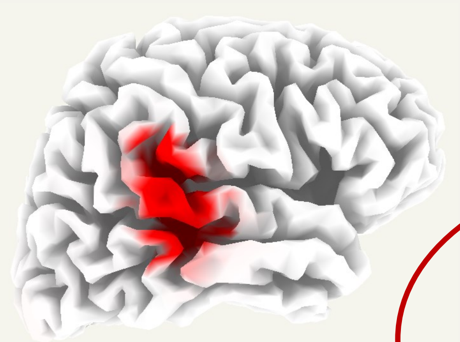
Cholinergic System

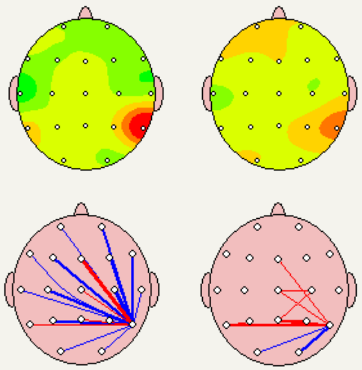
- Acetylcholinesterase (AChE)

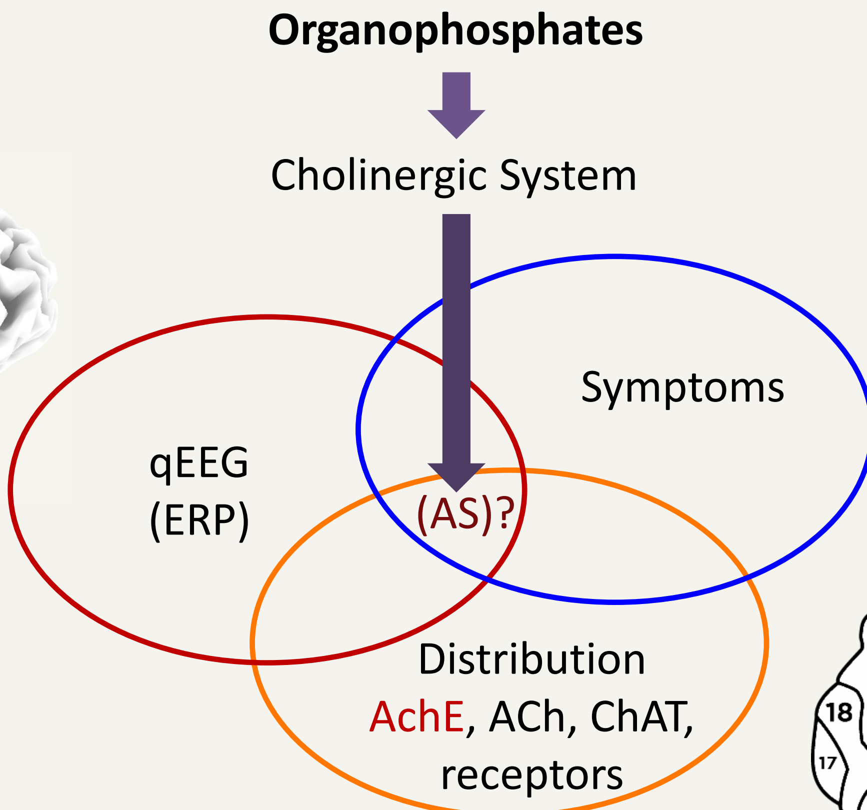




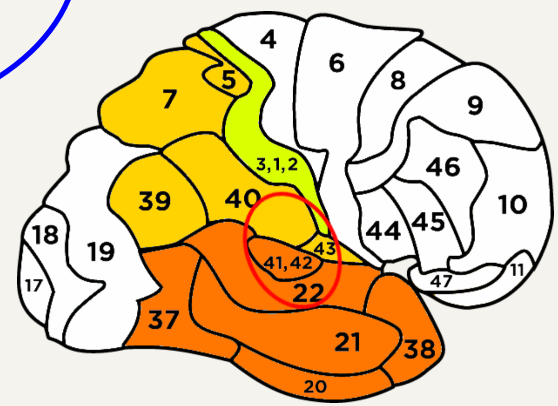
Aerotoxic Signature (AS)?







- Sound and Light hypersensitivity
- Attention problems
- Losing train of thought
- Unable to multitask
- Trouble following conversations
- Difficulty remembering steps in a multi-step process
- Slow processing



Acetylcholine (ACh), Choline Acetyltransferase (ChAT)

Thank you for your attention

Daniel Dumalin, az sint-jan brugge-oostende av – campus Henri Serruys, Belgium

Lab of Neurophysiology | qEEG – ERP

AerotoxBrain@proximus.be

Aircraft Cabin Air Conference 2019

Making the Safety Case for Aircraft Operators

(Fume Risk in the Cabin/Cockpit)

Cliff Edwards

Independent Aviation Risk
Management Consultant (Retd)

Background

- This presentation suggests arguments to aid the management of risks of fume contamination of the cockpit or passenger cabin during operational flights.
- The focus of this paper is commercial aircraft operations.
- Cliff has spent much of his career leading in developing aviation safety systems for aircraft operators.
- He has no specialist skills in aircraft design, or specialist knowledge in fume contamination, but he recognises the risks.

Managing Risk

- Risks exist in life, & largely we manage these,
  - if we know of the risks, and
  - understand how to control the level of risks we face.
- Technically "risk" is a calculated point to predict the probability x severity of the risk effecting the organisation.
- Public transport aircraft operators are required to manage their risks as a corporate responsibility, and this sits with the Accountable Manager.

Managing Risk

- Donald Rumsfelt made famous the statement that there are three classes related to Risks:
  - Known Knowns
  - **Known Unknowns,** and
  - Unknown Unknowns
- The former as we **know** these risks should be managed already.
- The latter can't be effectively managed as they are **unimagined**.
- The middle group which I believe includes fume contamination is an emerging risk needing to be effectively managed.
- It falls to **aircraft operators** to demonstrate management of this risk, or potentially face future litigation.

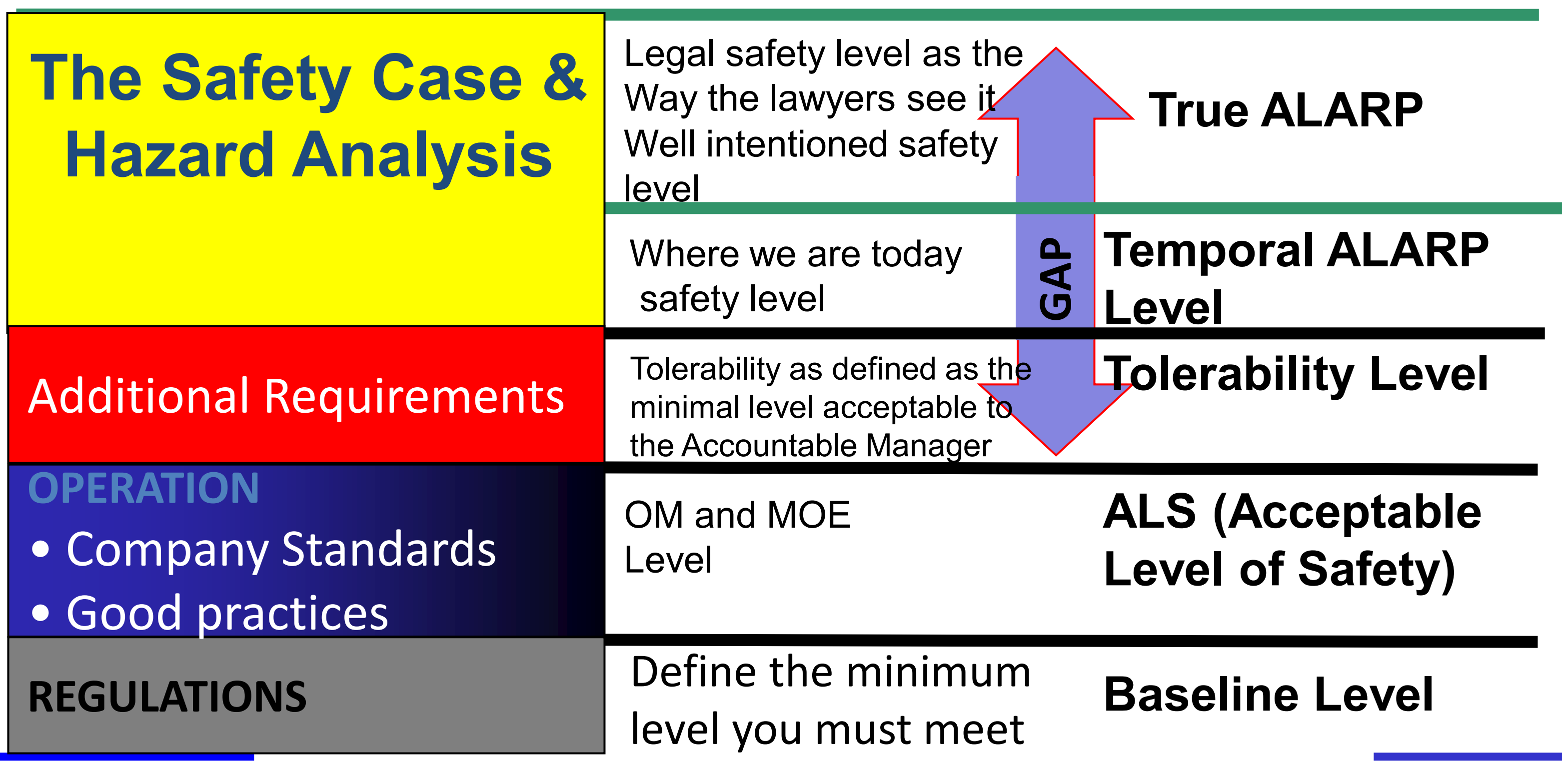
Demonstrating Risk Management

- Risk & Hazard Management is a core requirement of the operator's required SMS.
- Risk assessments are done using a structured approach, typically a matrix.
- Once risks are assessed, it is a corporate responsibility to demonstrate effective control.
- Risks should be managed effectively to levels of an acceptable level of safety, preferably ALARP (as low as reasonably practicable).

The Argument for ALARP?

What do we mean by achieving an acceptable level of safety:

- Is ALARP Achievable?
- What is Tolerable?
- What is an acceptable level of safety?



The Operational Safety Case

- The aircraft manufacturers and the regulators appear to be reluctant to aid operators in managing this laterly defined risk, we developed a bowtie hazard analysis and a draft Safety Case that can be used by the operators.
- These documents offer a modelled approach that is not specific to any aircraft type, or aircraft operator.
- However it is relevant to the fume contamination in the cabin and cockpit.
- And its free of charges and consultants!

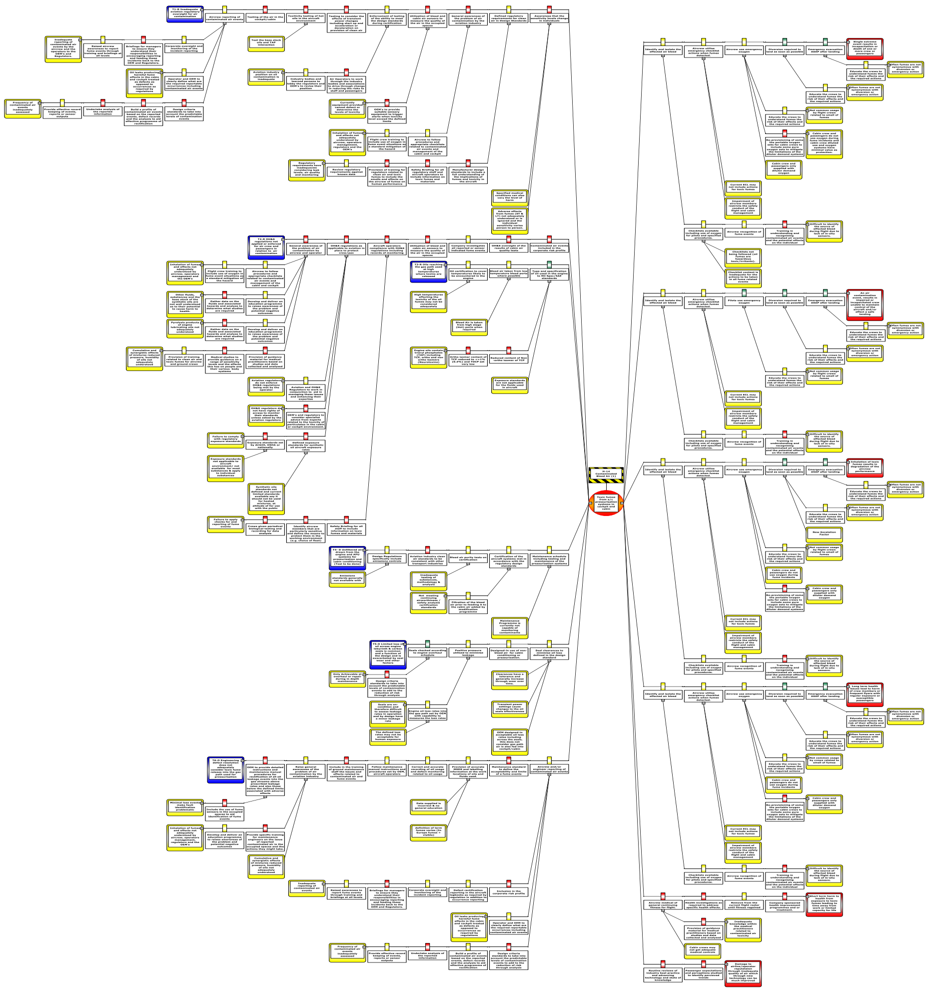
The Operational Safety Case

- Safety Case includes a generic Risk Assessment.
- Fume contamination is an emerging risk to the aircraft operator in their risk profile, it nonetheless exists.
- As a risk that can impair the health & performance of both flight crews and the operator’s clients it should not continue to be ignored.

The Operational Safety Case

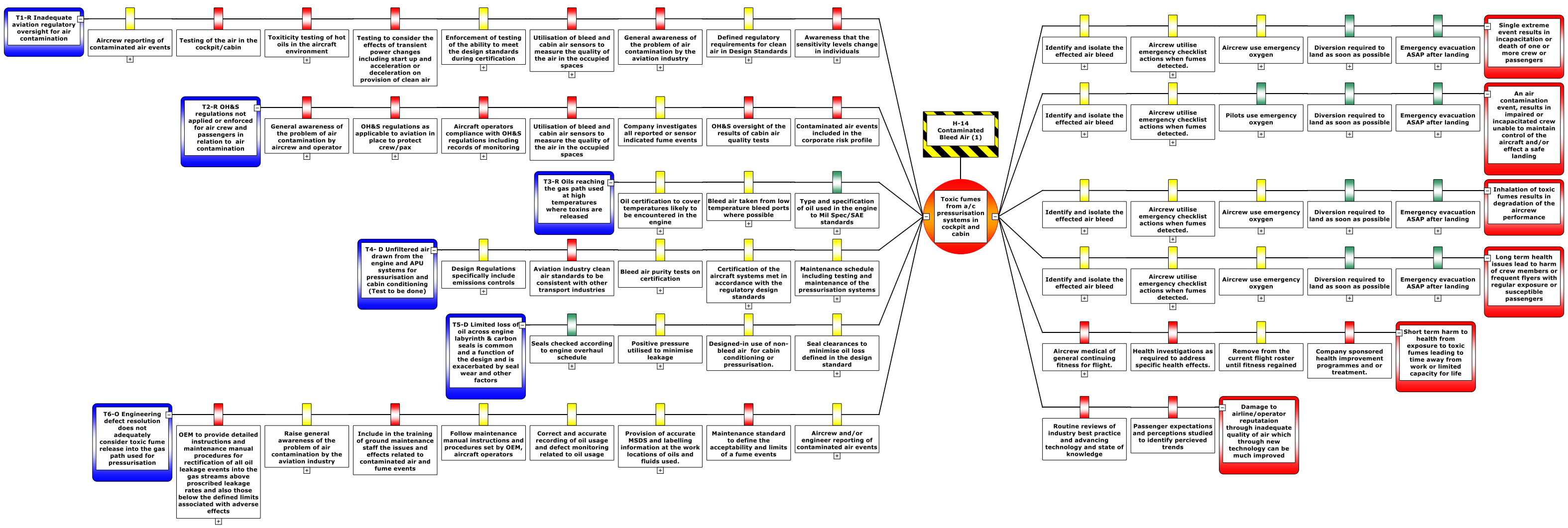
- The level of risk is not the key issue driver but it exists and has caused harm to occupants of pressurised aircraft so it is relevant.
- The aircraft operator's Accountable Manager is responsible for the management of their risks.
- If not appropriately addressed it will leave aircraft operators exposed to challenges and potential liabilities.

The Hazard Analysis (HA)



- DON'T PANIC!
- This is the total picture
- Let's break it down to core elements

Core Elements of the HA



- One Hazard (Contaminated Bleed Air)
- One Top Event (Toxic fumes from a/c pressurisation and conditioning systems in cockpit and cabin)
- 6 Primary threats
- 6 Potential consequences of varying significance.

One Hazard

"Fume contaminated air" - is able to enter the cabin and cockpit through the designed-in air management systems.

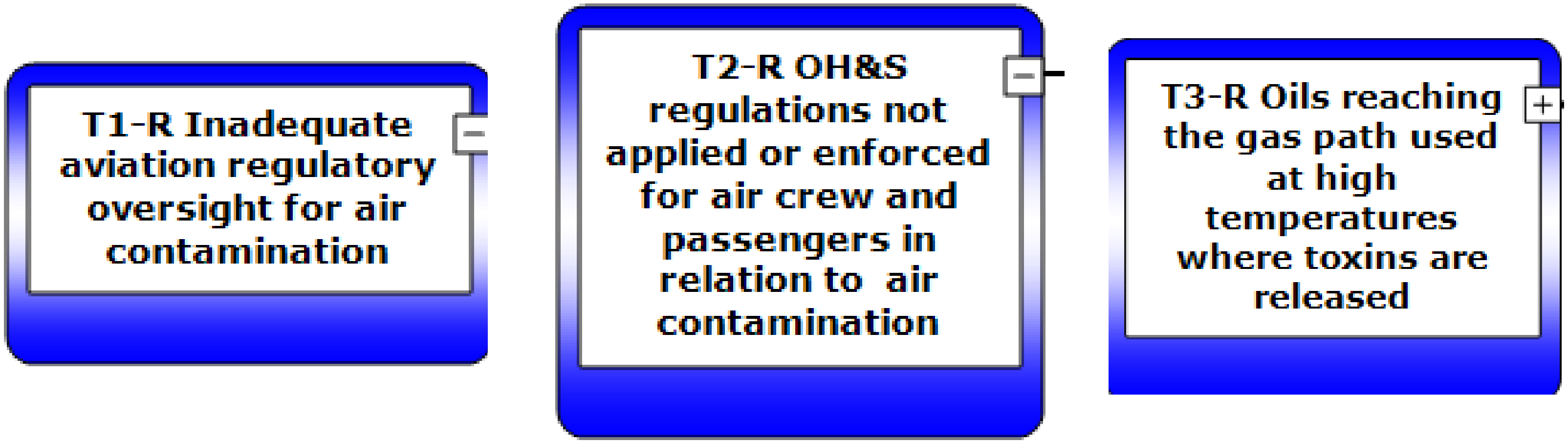
- This is of course a variable, dependent on the engines' current condition, design limits and aircraft type.
- Nonetheless, the fumes from superheated oils used in aircraft engines are demonstrably toxic if breathed in sufficient amounts.

One Top Event

Toxic fumes from the aircraft pressurisation and conditioning systems enters into the cockpit & cabin.

- The top event defines the first point of loss of control
- This also is a variable, that is dependent on the engines' current condition, design limits and aircraft type
- It is not limited to engines having significant oil loss across the seals.

6 Primary Threats



Each threat has differing controls defined in the Hazard Analysis, most of which are not currently in practical use

6 Primary Threats

T4- D Unfiltered air drawn from the engine and APU systems for pressurisation and cabin conditioning

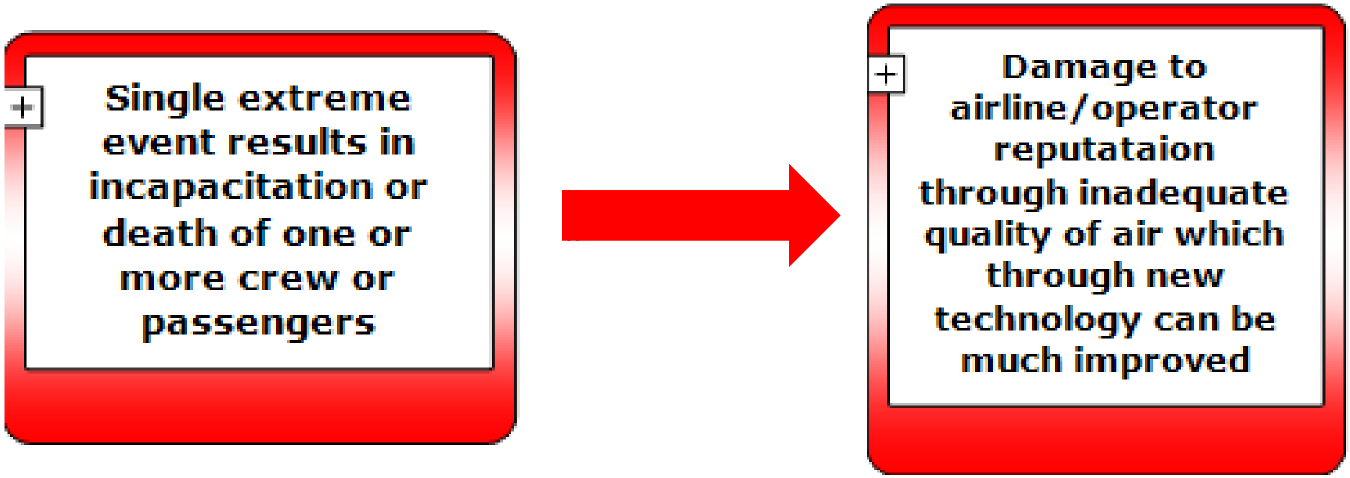
T5-D Limited loss of oil across engine labyrinth & carbon seals is common and a function of the design and is exacerbated by seal wear and other factors

T6-O Engineering defect resolution does not adequately consider toxic fume release into the gas path used for pressurisation

Each threat has differing controls defined in the Hazard Analysis, most of which are not currently in practical use

6 Consequences

1st consequence 6th consequence



The consequences range from the single extreme event in decreasing order of severity to damage to reputation

The Identified Risks

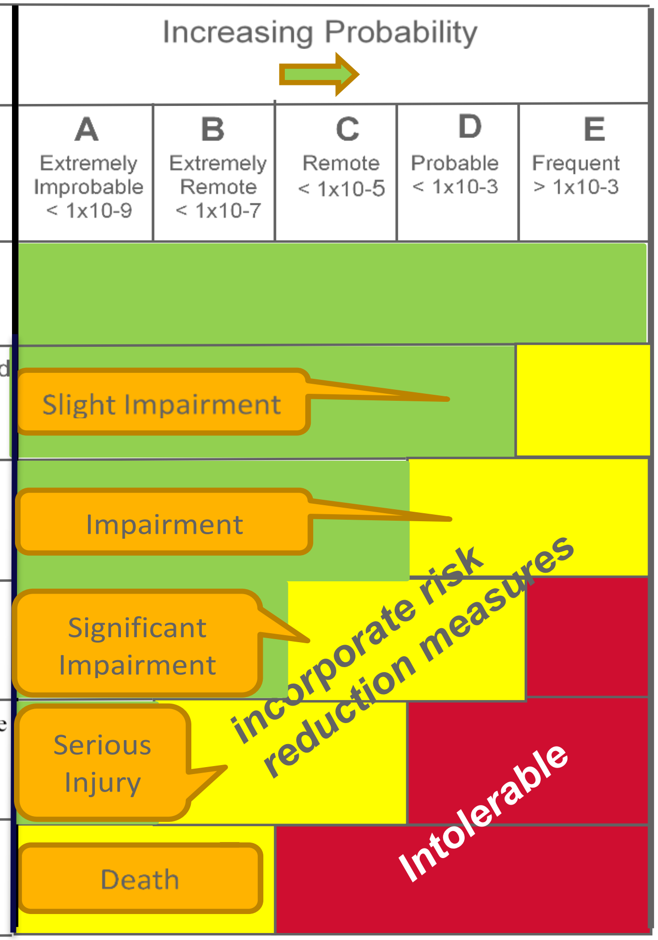
The risks may vary in individual operations depending on the means of assessment employed, we used the CS-25 Amdt. 22, 2018 wording and conclude these to be:

Hazardous: Failure Conditions, which would reduce the capability of the aeroplane or the **ability of the crew** to cope with adverse operating, conditions to the extent that there would be:

- (i) A large reduction in safety margins or functional capabilities;
- (ii) Physical distress or excessive workload such that the flight crew cannot be relied upon to perform their tasks accurately or completely; or
- (iii) Serious or fatal injury to a relatively small number of the occupants other than the flight crew.

A Generic Risk Assessment

Potential Consequence of an Hazardous Fume		
Rating	People	Increasing Severity
0	**No adverse effect**	Pilots - no effect Others - inconvenience
1	**Minor adverse effect (Slight Impairment)**	Pilot – no physical discomfort and slight increase in workload. Others – physical discomfort
2	**Major adverse effect (Impairment)**	Pilots – Physical discomfort and increase on workload, impaired crew efficiency. Others – physical distress
3	**Hazardous adverse effect (Significant impairment)**	Pilots – physical distress, impaired ability to perform tasks accurately or completely. Others – serious physical distress.
4	**Hazardous adverse effect (Single fatality or serious injury)**	Pilots – Serious or fatal injury to one pilot or other crew members
5	**Catastrophic Effect**	**Multiple fatalities (Normally through hull loss)**



Conclusion

- **These Risks Exists in your day to day operations.**
- This operator-based approach demonstrates the possible threats and controls needed to manage the hazard and avoid the potential consequences.
- **Accountable Managers** need to be able to demonstrate adequate control of this hazardous event.
- Detailed copies of the generic Safety Case could be made available to aircraft operators.
- **Are you adequately prepared?**

FLIGHT CREW RELATED ISSUES

AIRCRAFT CABIN AIR CONFERENCE 2019

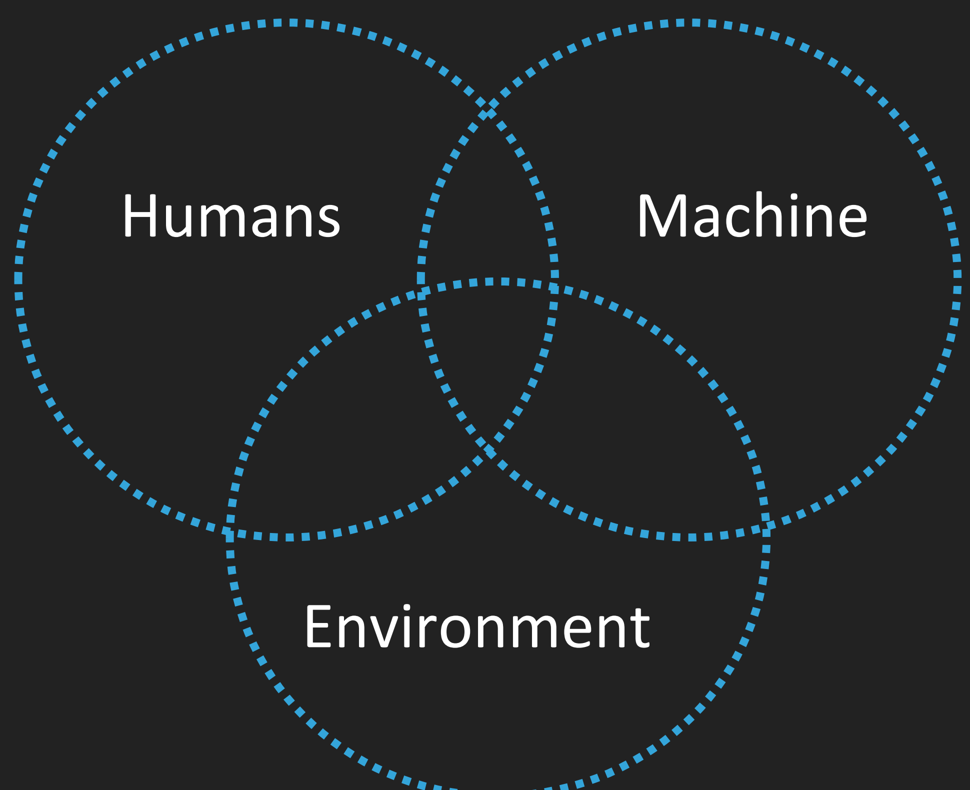
ABOUT HUMAN FACTORS

Gitte Furdal Damm

GITTE FURDAL DAMM

- Danish Aviation College 1997
- Aviation Assistance 1998-1999
- Cimber Air 2000-2012
- Jettime 2014-2016
- About Human Factors 2016 - Now
- Human Factors and System Safety 2019 -2020 Lund University

"Human Factors is the scientific discipline concerned with the *understanding of interactions among humans and other elements* of a system, and the profession that applies theory, principles, data and methods to design in order *to* optimise human well-being and overall system performance" (Human Factors & Ergonomics Society).



ABOUT HUMAN FACTORS

Reykjavik Flight Symposium 2018

ABOUT HUMAN FACTORS

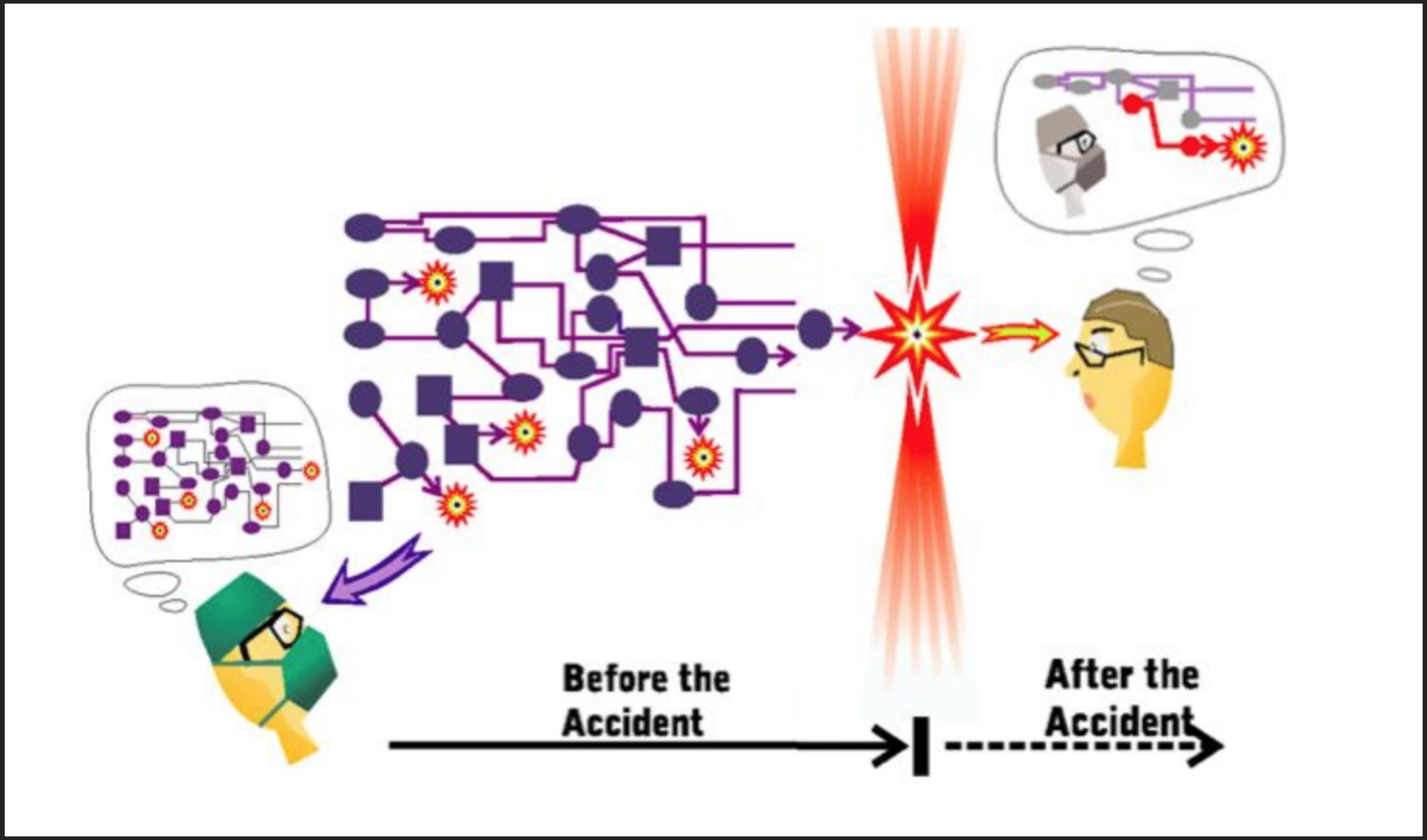
WHY DID I NOT KNOW OF THIS?

- General knowledge about contaminated cabin air?
- Investigations reports methods?
- Training and tools provided?
- When things become the norm?
- Political interests?

From the Flight Crew:

From Investigation Report:

Hindsight Bias



Richard Cook

SMOKE OR FUMES – AIR CONDITIONING

Condition: A concentration of air conditioning system smoke or fumes is identified.

OXYGEN MASKS AND SMOKE GOGGLES (If required).. ON

CREW COMMUNICATION (if required)......... ESTABLISH

RECIRCULATION FAN SWITCHES (Both)............... OFF

[Removes fans as possible source of smoke or fumes. Stops recirculation of smoke or fumes and increases fresh air flow.]

APU BLEED AIR SWITCH.................................... OFF

If smoke or fumes continue:

ISOLATION SWITCH.................................... OFF

[Isolates left and right sides of bleed air system.]

RIGHT PACK CONTROL SELECTOR............ OFF

[Removes right side of air conditioning system as possible source of smoke or fumes.]

If smoke or fumes continue:

RIGHT PACK CONTROL SELECTOR....... AUTO

[Restores right side of air conditioning system.]

LEFT PACK CONTROL SELECTOR...........OFF

[Removes left side of air conditioning system as possible source of smoke or fumes.]

Do not accomplish the following checklists:

PACK OFF
RECIRCULATION FAN

If smoke or fumes are persistent:

Declare an emergency and plan to land at the nearest suitable airport.

Accomplish SMOKE or FUMES REMOVAL checklist on page 757.11.10.

CHECKLIST... COMPLETE

The *'FUSELAGE FIRE OR SMOKE – SMOKE'* checklist in the operator's FCOM had the following memory items:

- *Oxygen Masks.........................On + 100%*
- *Smoke Goggles ....On*
- *Mic switch...................................... MASK*
- *Hot Mic..OFF*
- *Headset..On*
- *Recirc Fans...OFF*
- *Emergency Lights .... ON*
- *Passenger Signs................................ ON*
- *Descend .... ASAP - Check MSA*
- *Land immediately at nearest suitable aport*

8.8

BOEING

737 Flight Crew Operations Manual

Smoke, Fire or Fumes

Condition: Smoke, fire or fumes occur.

1 Diversion may be needed.

2 Don oxygen masks and set regulators to 100%, as needed.

3 Don smoke goggles, as needed.

4 Establish crew and cabin communications.

5 BUS TRANSFER switch . . . . OFF

6 CAB/UTIL switch. . . . . OFF

7 IFE/PASS SEAT switch. . . . . OFF

8 RECIRC FAN switches (both) . . . . OFF

9 APU BLEED air switch . . . . OFF

10 **Anytime** the smoke or fumes become the greatest threat:

►►Go to the Smoke or Fumes Removal checklist on page 8.16

▼ Continued on next page ▼

SMOKE/FUMES/AVNCS SMOKE

LAND ASAP

IF PERCEPTIBLE SMOKE APPLY IMMEDIATELY:

- IF REQUIRED:
  CREW OXY MASKS.......... USE/100%/EMERG

BLOWER..OVRD

EXTRACT..OVRD

CAB FANS..OFF

A320 (all ex. -AIQT, -AIQU, -AIQW)

GALLEY..OFF

END

A320 (-AIQT to -AIQW)

GALY & CAB..OFF

END

SIGNS..ON

CKPT/ CAB COM.............................ESTABLISH

- IF SMOKE SOURCE IMMEDIATELY OBVIOUS, ACCESSIBLE, AND EXTINGUISHABLE:
  FAULTY EQPT.............................ISOLATE
- IF SMOKE SOURCE NOT IMMEDIATELY ISOLATED:
  DIVERSION.............................INITIATE
  DESCENT.............................INITIATE
  Descent to FL 100, or MEA-MORA, or minimum obstacle clearance altitude

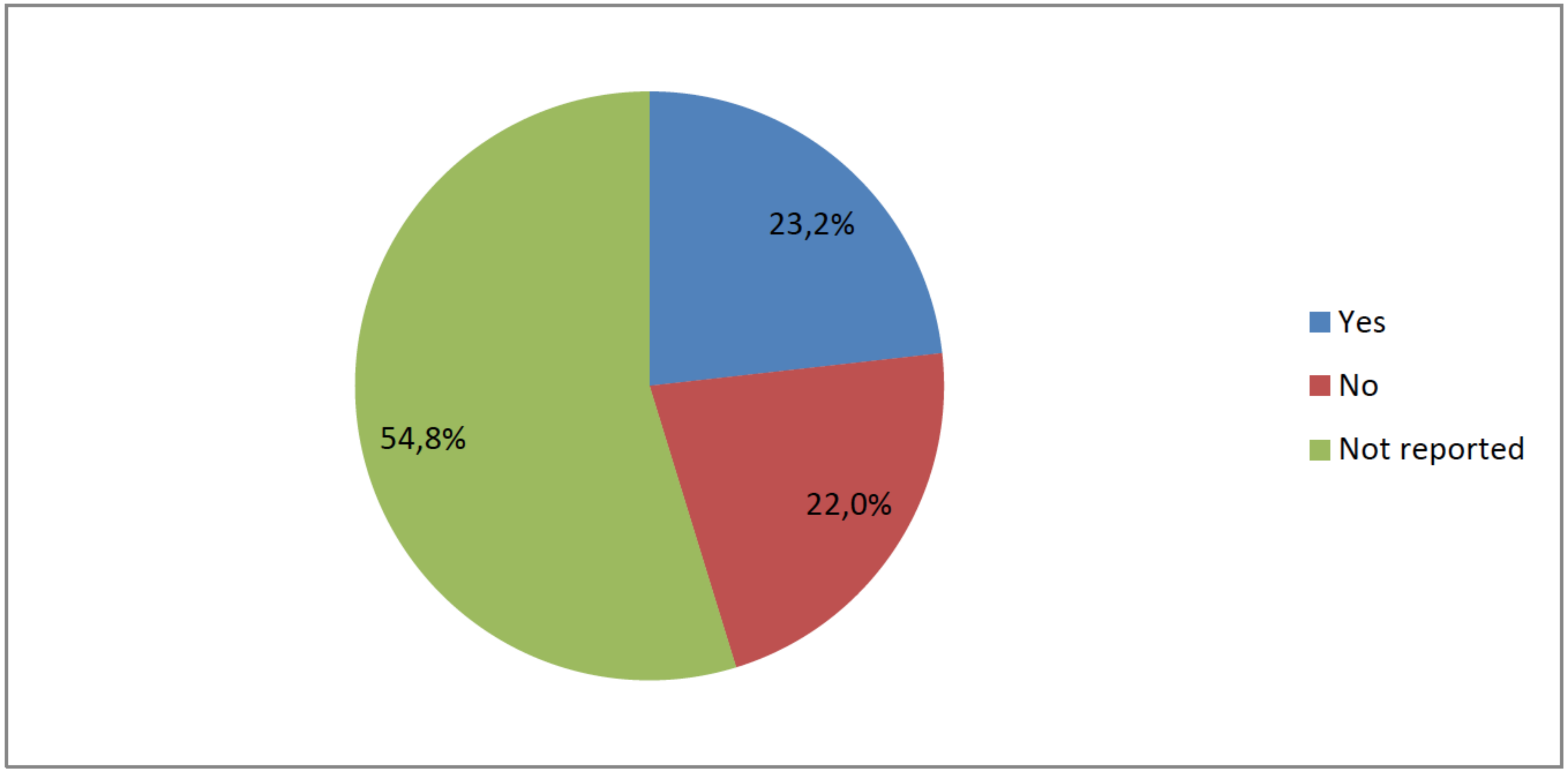
- AT ANY TIME of the procedure, if SMOKE/ FUMES becomes the GREATEST THREAT:
  REMOVAL OF SMOKE/FUMES....CONSIDER
  ELEC EMER CONFIG.................CONSIDER
  Refer to the end of the procedure to Set ELEC EMER CONFIG.

- At ANY TIME of the procedure, if situation becomes UNMANAGEABLE:
  IMMEDIATE LANDING.................CONSIDER

AIR COND SMOKE/CAB EQUIPMENT SMOKE

Use of Oxygen Masks

The 663 reports (between 2006 and 2013) were analysed in regard to the flight crew donning their oxygen masks. The results are: in 154 cases the masks were donned and in 146 they were not. In 363 cases the reports did not include any information regarding oxygen masks. Break down in percent:



Analysis of the reports regarding the use of oxygen masks in the cockpit

NUISANCE OR FLIGHT SAFETY?

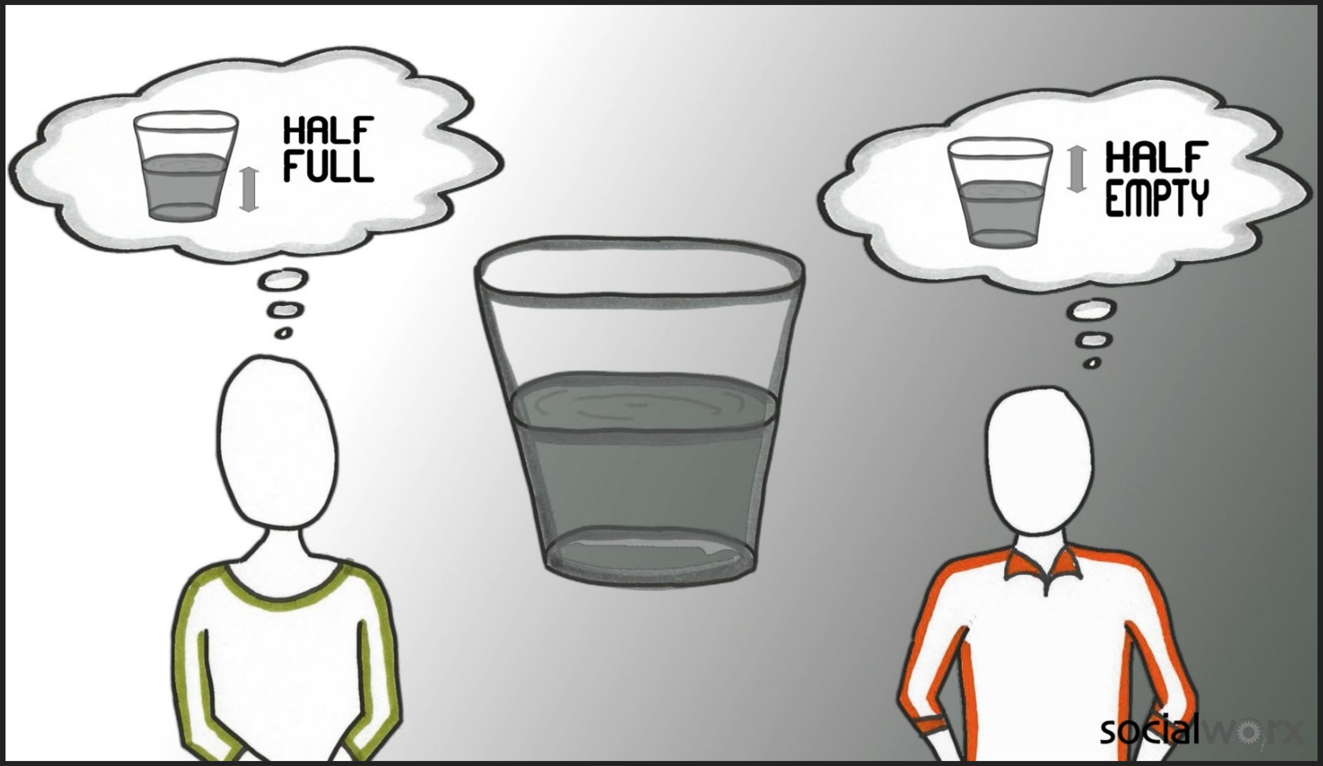
- “ In the past, oil leaks and cabin/flight deck odours and fumes may have come to be regarded as a nuisance rather than a potential flight safety issue”

The Local Rationality Principle

" People are doing reasonable things given their point of view and focus of attention; their knowledge of the situation; their objective and the objectives of the larger organisation that they work for. In the end, what they do makes sense to them at that time. You have to assume that nobody comes to work to do a bad job". **(Sidney Dekker, Field Guide to Understanding Human Error).**

ABOUT HUMAN FACTORS

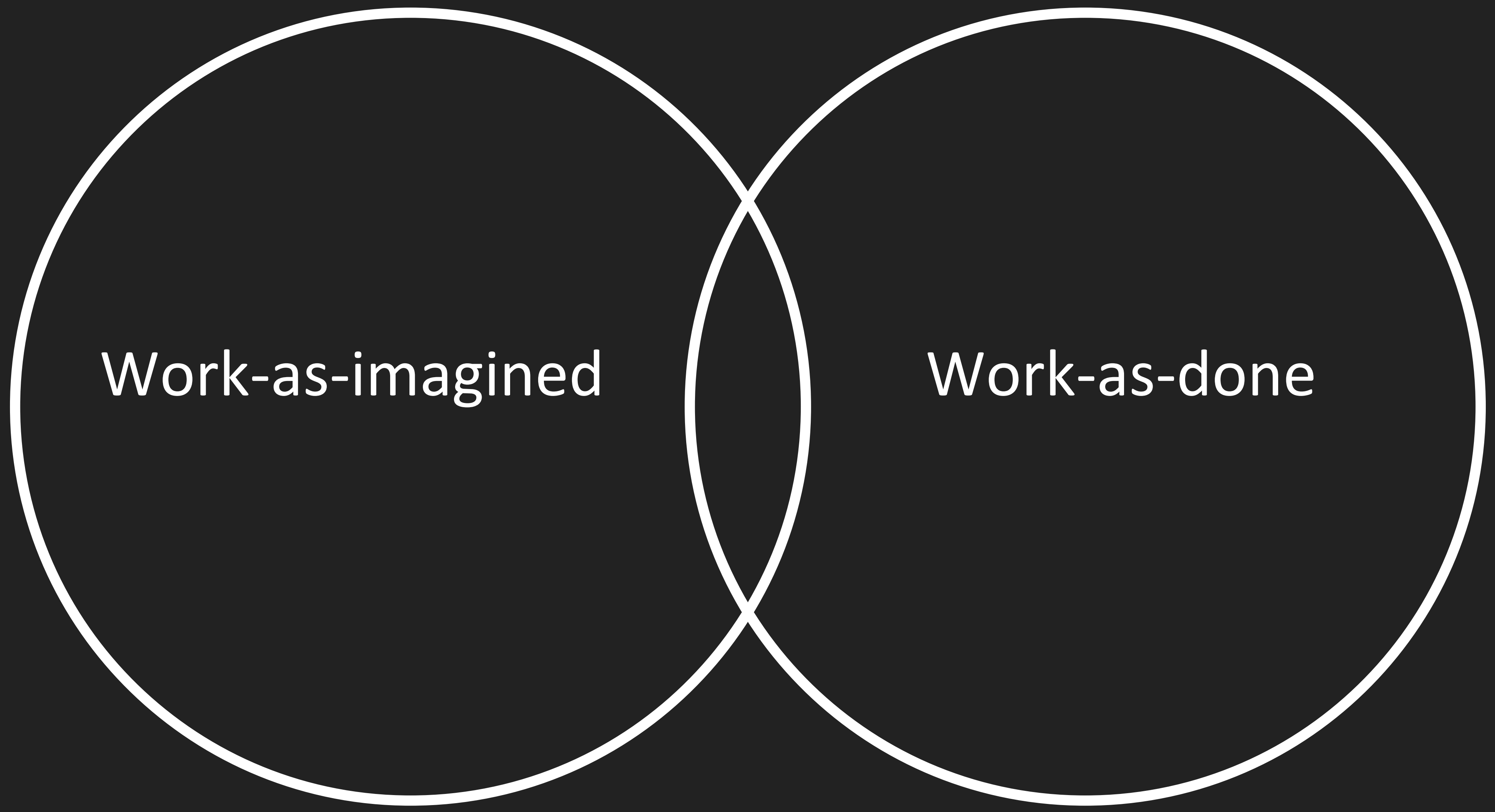
Perception is individual



The ability to see, hear or become aware of something through our senses, and the way in which something is regarded, understood or interpreted shaped by learning, memory, expectation and attention.

CHALLENGES IN CURRENT THINKING

- Lack of education/ training
- Nuisance vs. flight safety
- Tools provided
- The human aspect



Erik Hollnagel

NORMALISATION OF DEVIANCE

The gradual process through which unacceptable practice or standards become acceptable

Considering the human aspect

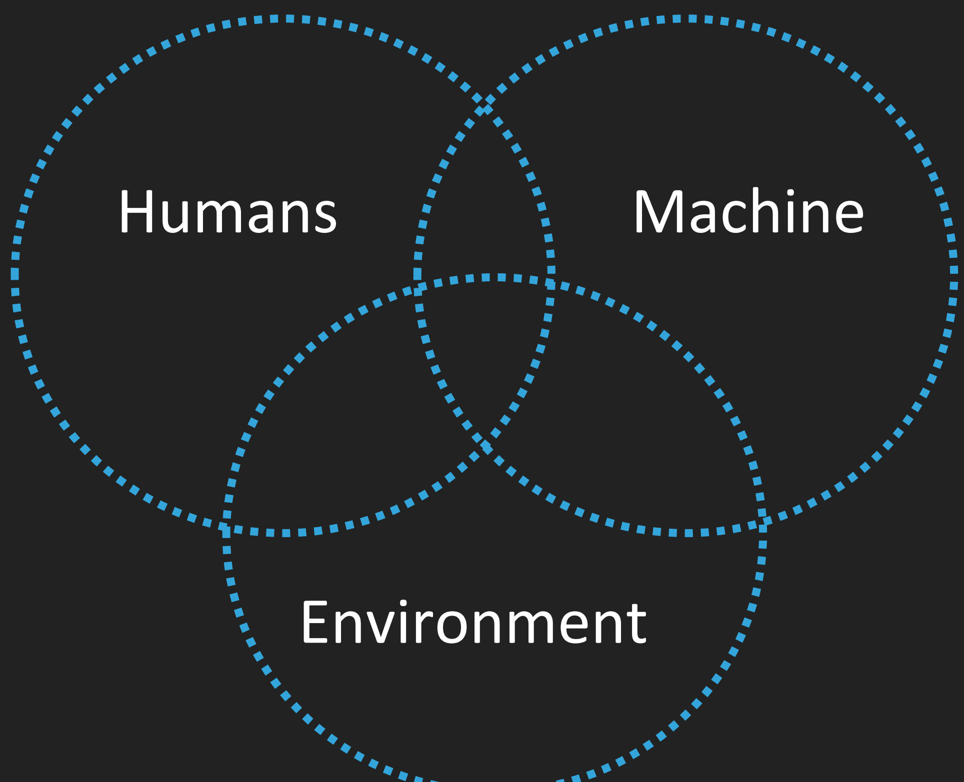
" If professionals consider one thing "unjust" it is often this: split-second operational decisions that get evaluated, turned over, examined, picked apart, and analysed for months - by people who were not there when decisions was taken, and whose daily work does not even involve such decisions"

Sidney Dekker, Just Culture.

WHAT TO DO?

- Think differently
- Educate the practitioners
- Incorporate knowledge in training
- Encourage inputs from practitioners
- Consider the human aspect

"Human Factors is the scientific discipline concerned with the *understanding of interactions among humans and other elements* of a system, and the profession that applies theory, principles, data and methods to design in order *to* optimise human well-being and overall system performance" (Human Factors & Ergonomics Society).



ABOUT HUMAN FACTORS

THANK YOU FOR YOUR ATTENTION

Suspected air quality problems on board

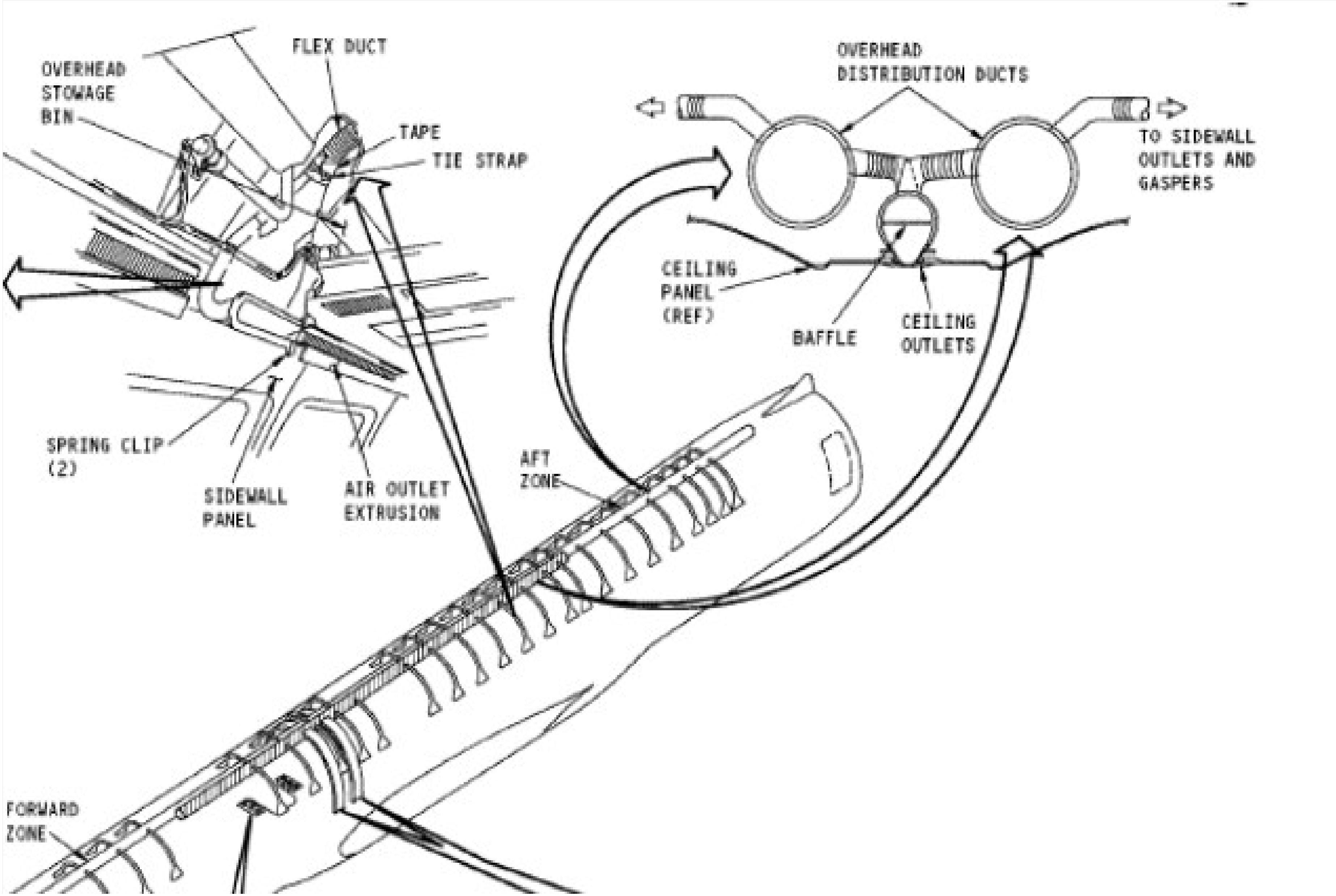
Experiences & Actions

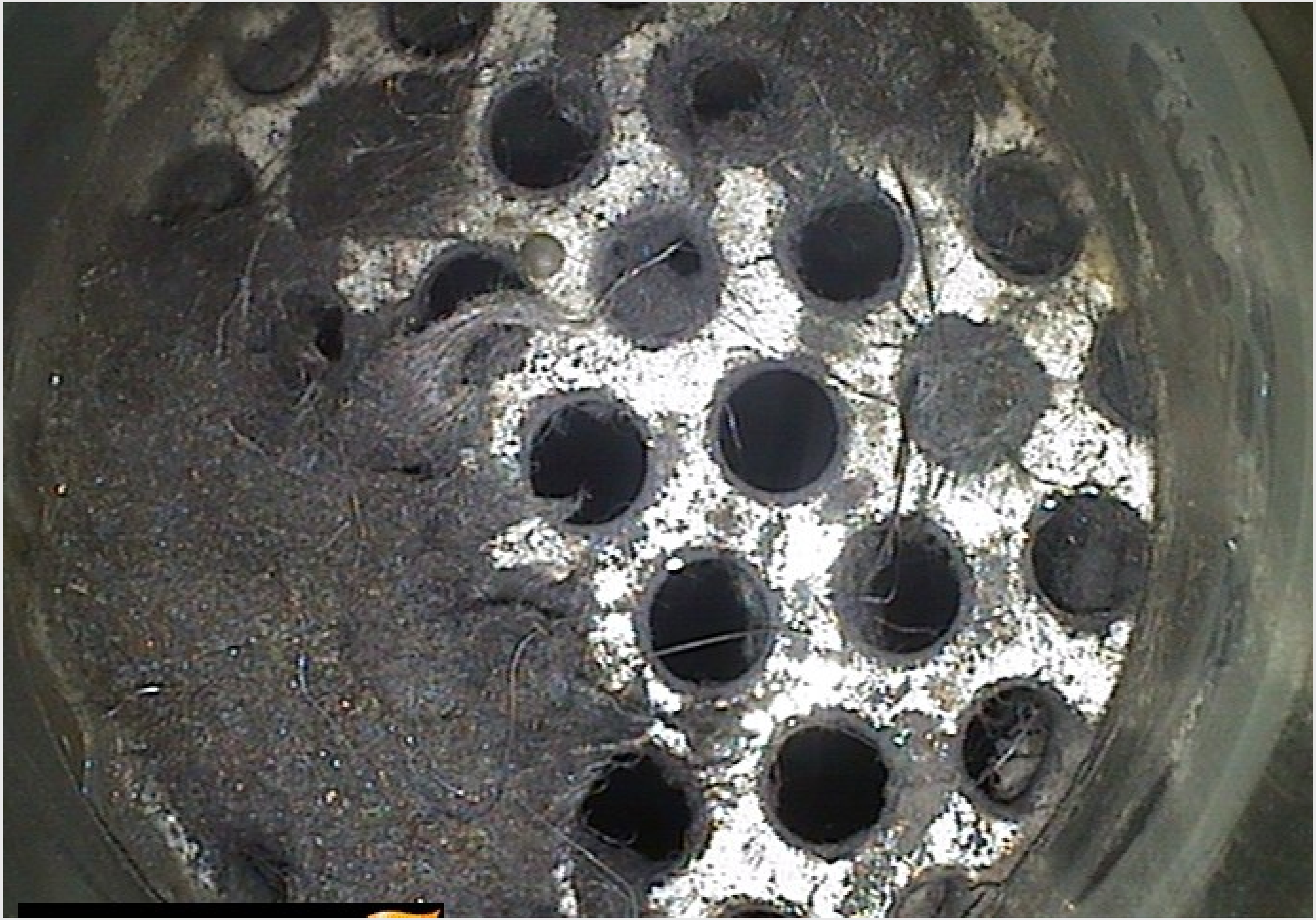
Aircraft Cabin Air Conference 2019

Richard Hansen Technical Safety Officer

First serious incident reported in year 2012
Boeing 757 A/C - Registration: TF-ISL

Cabin Crew not able to perform duties due to illness. Aircraft diverted to the nearest airport


FLEX DUCT
OVERHEAD
STOWAGE
BIN
TAPE
TIE STRAP
SPRING CLIP
(2)
SIDEWALL
PANEL
AIR OUTLET
EXTRUSION
OVERHEAD
DISTRIBUTION DUCTS
TO SIDEWALL
OUTLETS AND
GASPERS
CEILING
PANEL
(REF)
BAFFLE
CEILING
OUTLETS
AFT
ZONE
FORWARD
ZONE



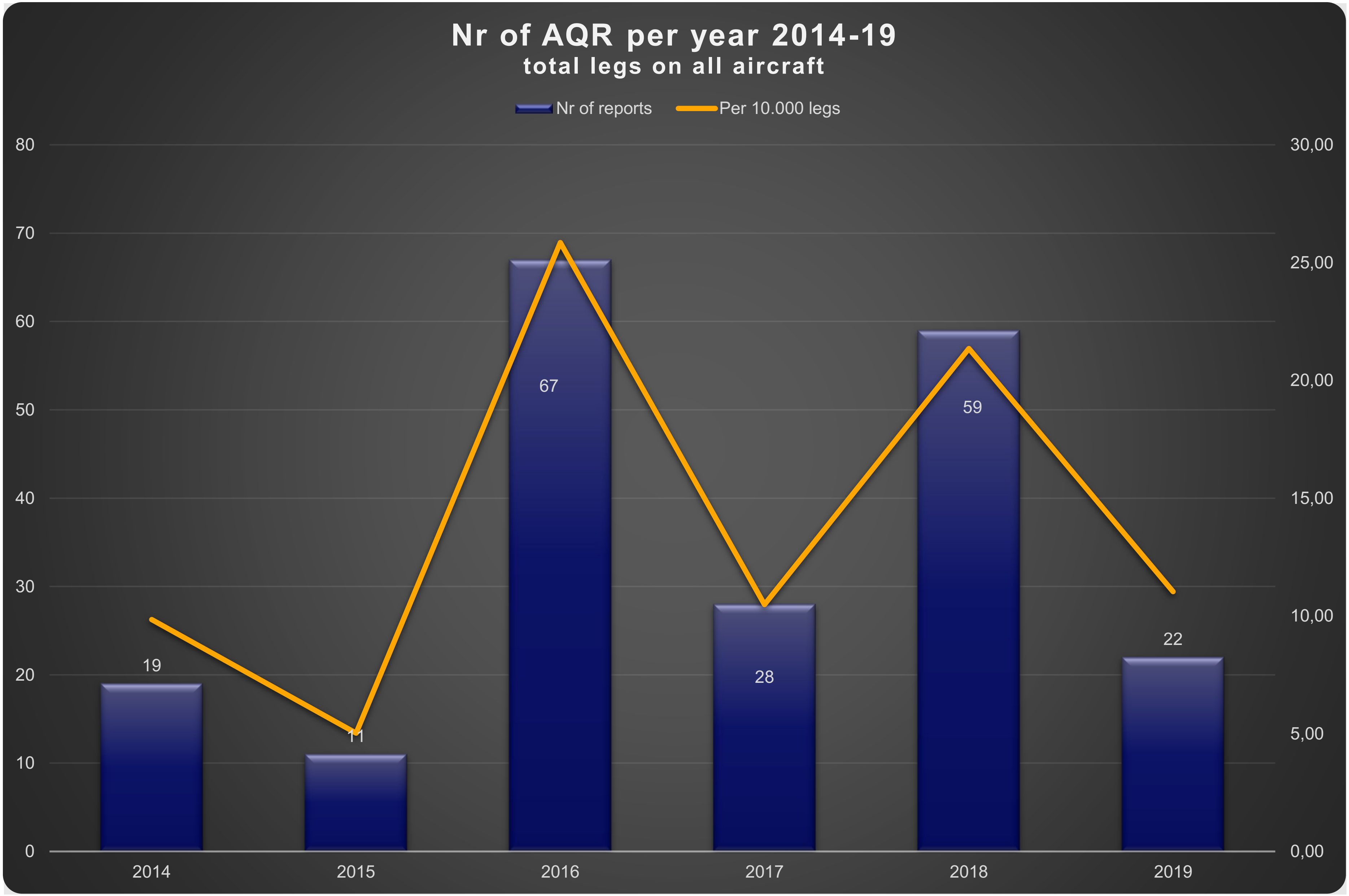
- Cabin crews more aware of CAQ after this incident
- Increase in CAQ reports
- New Safety Management System implemented
- Reporting system more accessible and effective
- Employees encouraged to report safety issues
- Flight crew informed about possible causes for discomfort on board

Common description in reported cabin crew illness

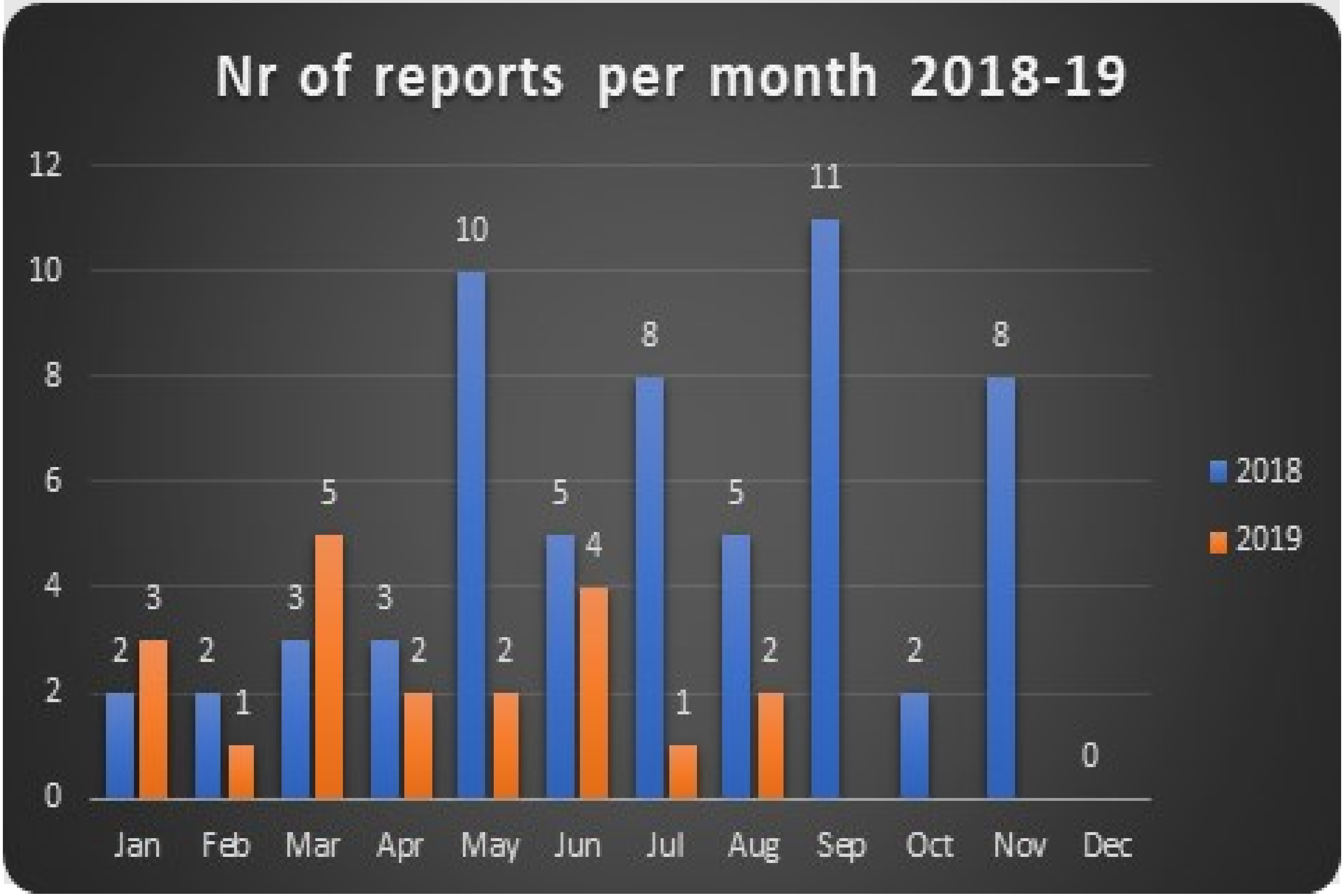
Cabin crew illness/dizzy/shortness of breath
CC illness - 2 cc exp headache, nausea, oxy
CC illness – oxy
Cabin crew ill/dizziness
Crew illness/dizziness
CC illness - 4 cc experienced dizziness
CC illness - all cc exp dizzy, headache
CC illness - 1 cc exp nausea, dizzy, oxy
Poor air quality in cabin
Cabin crew illness - oxy, dizzy, nausea, headache

SYMPTOMS

Toxic aero syndrome	Hypoxia	Motion Sickness	Hyper ventilation
• Fatigue • Blurred vision • Loss of consciousness • Dizziness • Headaches • Vomiting or nausea • Irritation to eyes, nose and throat • Confusion difficulties in concentration	• Changes in skin colour, ranging from blue to cherry red. • Confusion difficulties in concentration • Coughing • Fast heart rate. • Rapid breathing. • Shortness of breath. • Sweating. • Wheezing.	• Nausea. • Pale skin. • Cold sweats. • Vomiting. • Dizziness. • Headache. • Increased salivation. • Fatigue.	• Dizziness • Lightheaded • Weakness • Confusion • Fast heart rate • Shortness of breath. • Numbness or tingling in hands or feet • Anxiety • Fainting • Sore chest muscles.

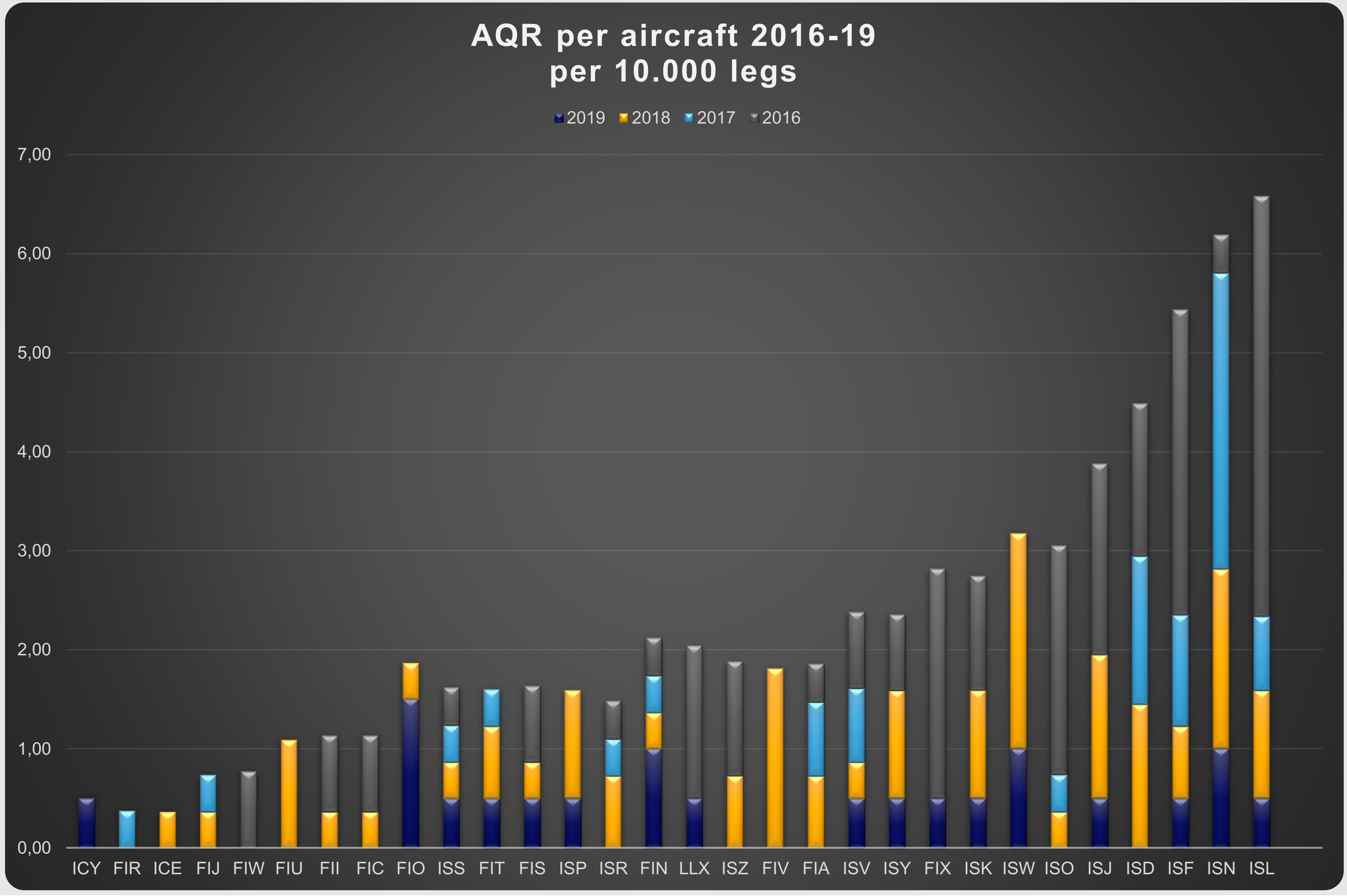

Nr of AQR per year 2014-19
total legs on all aircraft
Nr of reports
Per 10.000 legs
80
70
60
50
40
30
20
10
0
30,00
25,00
20,00
15,00
10,00
5,00
0,00
19
11
67
28
59
22
2014
2015
2016
2017
2018
2019

ICELANDAIR

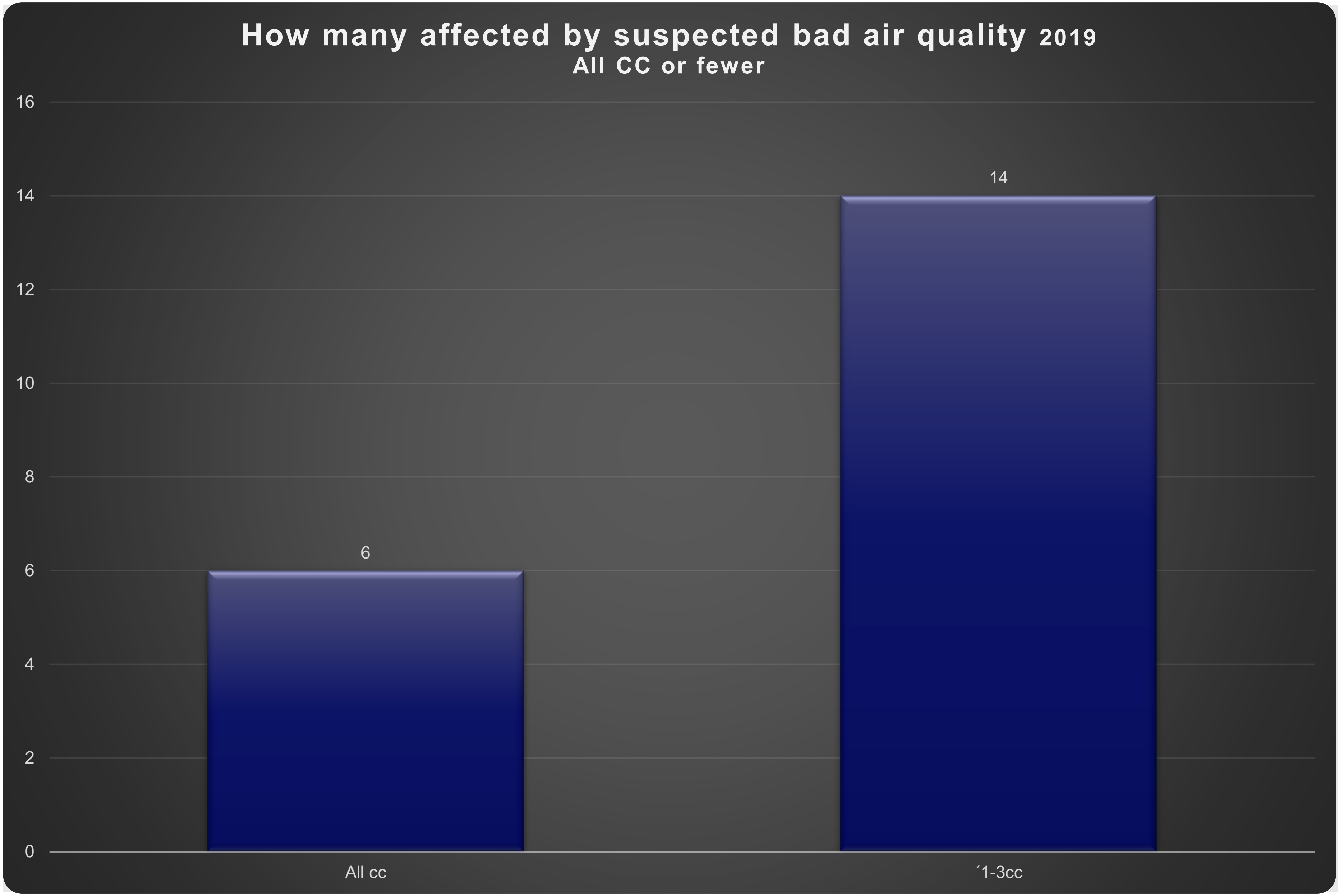


Nr of reports per month 2018-19
12
10
8
6
4
2
0
2
3
2
1
3
5
3
2
10
2
5
4
8
1
5
2
11
2
8
0
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
2018
2019

ICELANDAIR


AQR per aircraft 2016-19
per 10.000 legs
2019
2018
2017
2016
7,00
6,00
5,00
4,00
3,00
2,00
1,00
0,00
ICY FIR ICE FIJ FIW FIU FII FIC FIO ISS FIT FIS ISP ISR FIN LLX ISZ FIV FIA ISV ISY FIX ISK ISW ISO ISJ ISD ISF ISN ISL

ICELANDAIR


How many affected by suspected bad air quality 2019
All CC or fewer
16
14
12
10
8
6
4
2
0
6
14
All cc
´1-3cc

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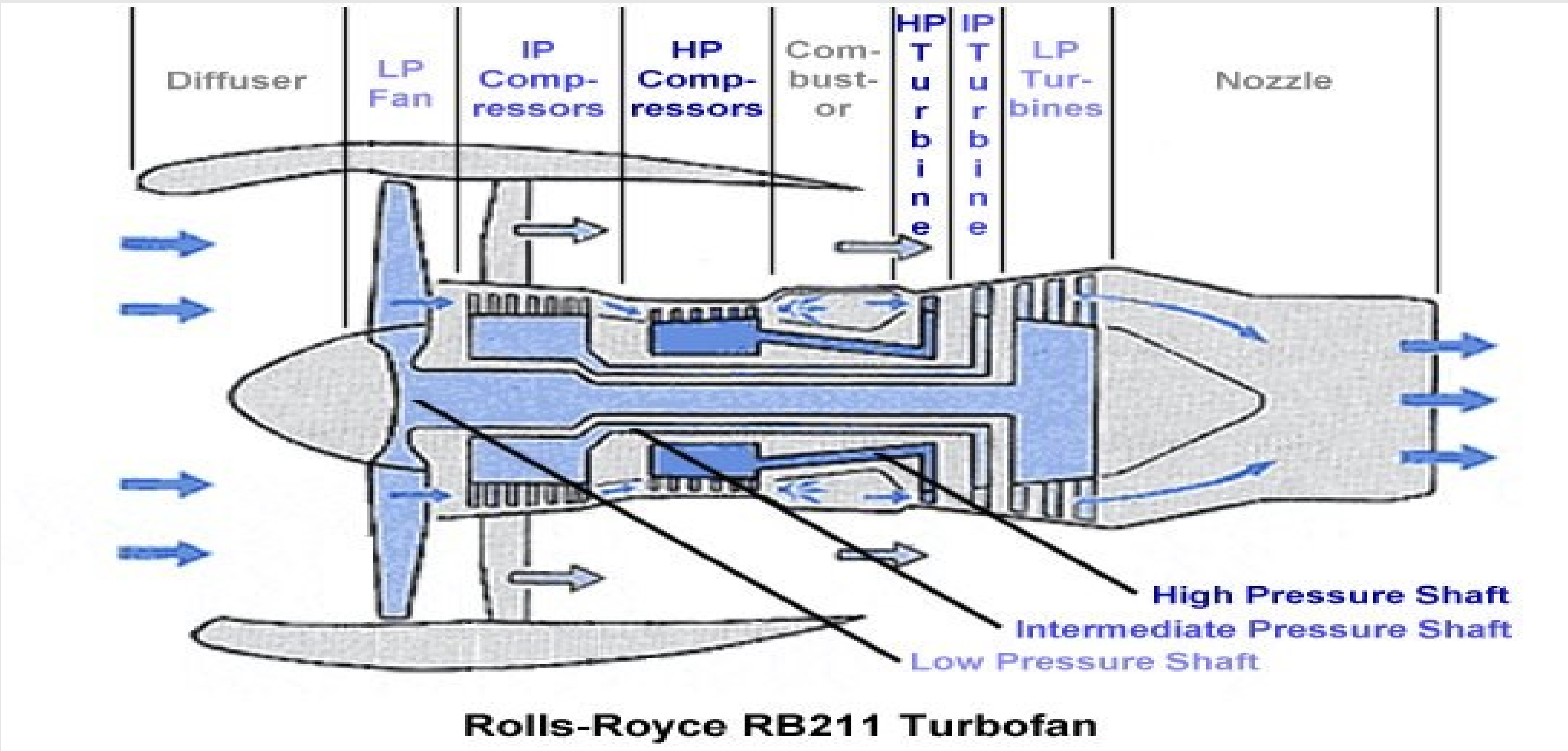
One incident where engine borescope indicated a defect seal on engine shaft to be the cause for oil smell in cabin. The engine in question was replaced

Reported incidents where defect APU gearbox pressure regulating valve, was presumably the cause for oil smell in cabin

One incident due to leaking seal on engine shaft



GEARBOX REGULATING VALVE

Identification and Location

The gearbox regulating valve is a normally open, air pressure closed valve.

The gearbox regulating valve is mounted above the de-oil solenoid valve on the front of the gearbox.

The gearbox regulating valve is an LRU.

Purpose

The gearbox regulating valve helps provide and maintain gearbox

If the gearbox regulating valve fails mechanically closed:

- Oil will be pushed through the carbon seals, possible smell in cabin, smoke out of exhaust, or oil consumption during ground operations
- In-flight operations would be normal

Fu

increase.

When the gearbox pressure increases, pressure is applied to the poppet. When the force exceeds pre-load on spring, the poppet will modulate to relieve all pressure in excess of 4.5 psid above ambient. Air is vented through the discharge orifice of the sleeve and the discharge port of the valve.

Maintenance Tip

If the gearbox regulating valve fails mechanically open:

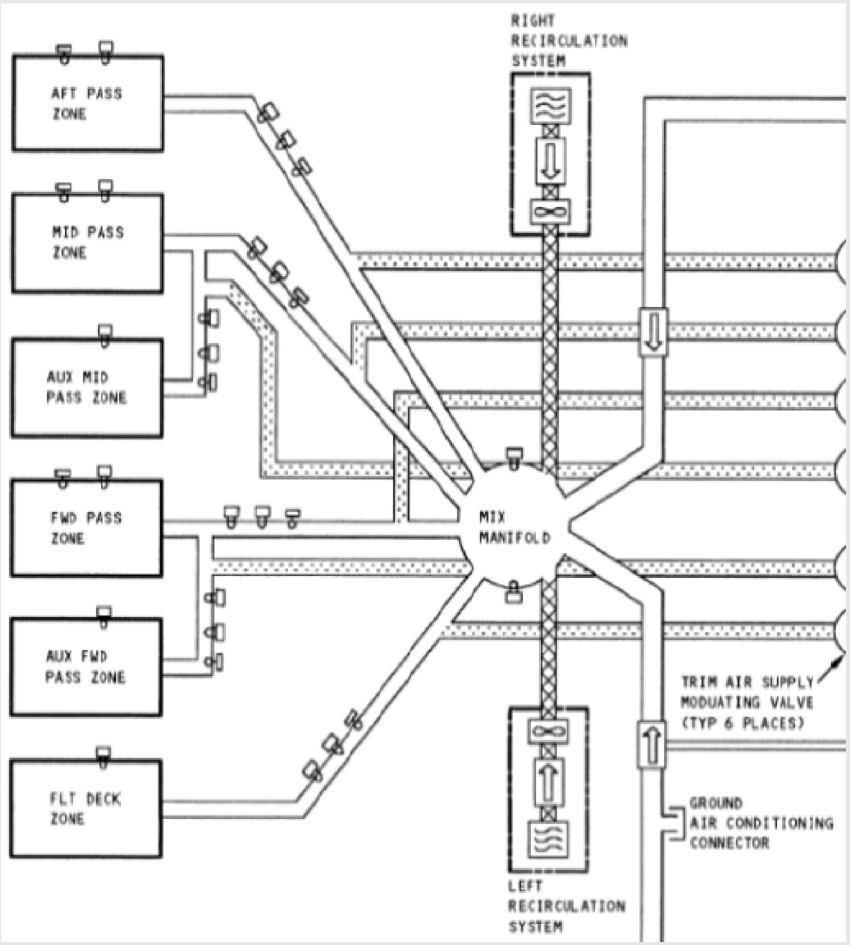
- The APU operates normally during ground operations
- Low Oil Pressure auto shutdowns occur in-flight operations
    - Interrogation would display LOW OIL PRESSURE as reason not operating
    - Fault LRU would display SEE MNT MANUAL

If the gearbox regulating valve fails mechanically closed:

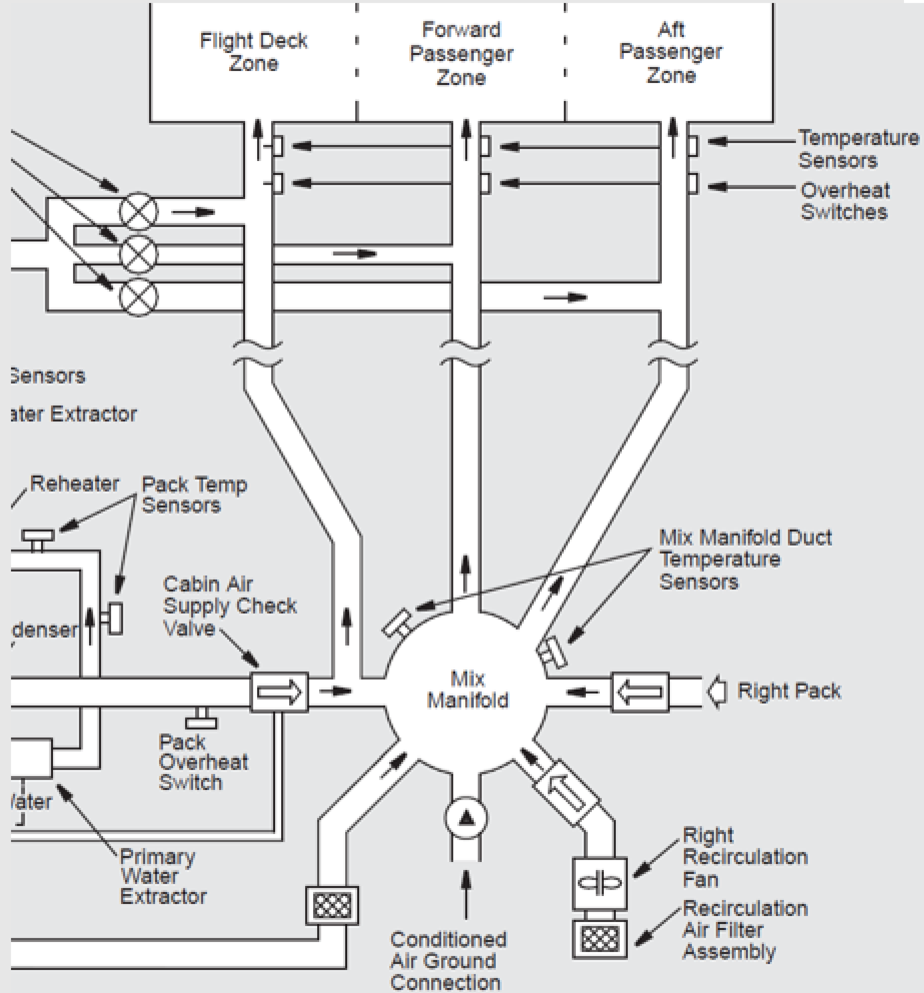
- Oil will be pushed through the carbon seals, possible smell in cabin, smoke out of exhaust, or oil consumption during ground operations
- In-flight operations would be normal

ICELANDAIR

Difference between ACS on B767 and B757



ACS Boeing 767



ACS Boeing 757

Guidelines in case of illness of crew members in flight

Illness of Crew Member/s (in-flight)

Guidelines when a crew member feels unwell and/or ill during flight.

Immediatly inform SCCM and Commander of Crew Members condition.
Important, regardless of severity of illness

Is the Crew Member **able to perform duties?**?

YES

Observe and monitor health status.

NO

Commence First Aid and contact MedAire

In case of serious illness, use **ALERT CALL**.

Is there any suspicion of **Air Quality/Odour event**?

NO

SMS360 Report

All Crew illness shall be reported, regardless of severity.

YES

Treat the symptoms and contact MedAire;

- Administer **Oxygen** from portable oxygen bottle, until symptoms have subsided.
- Contact **MedAire** and follow recommendations.
- Continue oxygen treatment if neccesary.

The importance of reporting.

For effective and efficient process of investigation and overall management, reporting is vital.

Filling in the CTL, SMS360, Air Quality Report and AJTL is mandatory.

Cabin Technical Log

Suspicion of Air Quality/Odour event shall be logged in CTL.

It is important for consise technical inspection/analysis.

Include;
- Cabin Temperature
- Airflow of vents in galley/cabin
- Smell or Odour
- Other

Air Quality Report

Where?
In Forms-folder in Flight Deck (and Comply-Resources-Air Quality Report)

Who reports?
All Crew Members experiencing symptoms

Commander will place the report in the AJTL

If report is submitted post-flight, attach a copy with SMS360 report.

SMS360

All Crew illness shall be reported, regardless of severity

Where?
https://ice.sms360.net (mywork)

Who reports?
Commander, SCCM and/or Crew Member involved.

AJTL

Enter „Suspected Air quality event“ in the **defects** column.

Who Reports ?
Commander

Standardized Cabin Air Quality Reporting Form

Based on IATA Guidance for airline health and safety staff on the medical response to Cabin Air Quality Events

ICELANDAIR

ANNEX 1

Standardized Cabin Air Quality Reporting Form

Based on IATA Guidance for airline health and safety staff on the medical response to Cabin Air Quality Events

Section 1: Flight and Reporter Details

*Note: For each question, check all that apply. If one answer is dominant for a given question, write an * next to that item.*

AC number: ____________ AC type: ____________ Flight date (DDMMYYYY) ____________
Tech log # (if known): ____________ Departure stn.: ____________ Arrival stn.: ____________
Reporter name: ____________ Employee no.: ____________
Email: ____________ Phone: ____________

Form completed by:

- Flight crew
- Cabin crew
- Maintenance
- Other

____
PIC signature (operator discretion)

Phase(s) of flight:

- Parked (pre-flight)
- Pushback
- Engine start
- Taxi-out
- Take-off
- Climb
- Cruise
- Descent
- Approach
- Landing
- Taxi-in
- Parked (post-flight)

Estimated duration of incident:

_______ (hrs.) _______ (min.)

Engine power level changes:

- Yes
- No
- Unknown

Known history of similar conditions on same aircraft?

- Yes
- No
- Unknown

Recent aircraft service history:

- None
- De-icing or anti-icing
- Engine/APU oil serviced
- Hydraulic fluid serviced
- Pesticide application
- Other: ____________
- Unknown

Section 2: Smoke or Fire Information

*Note: For each question, check all that apply. If one answer is dominant for a given question, write an * next to that item.*

Evidence of smoke or fire?

- Smoke
- Fire
- Neither smoke nor fire

Type of smoke or fire?

- Localized smoke
- Generalized smoke
- Open flame

Location of smoke or fire:

- Cabin; *if cabin specify:*
- Forward cabin
- Mid cabin
- Aft cabin
- Flight deck
- Lavatory ____________
- Galley ____________
- Cargo

Section 3: Fume Information

*Note: For each question, check all that apply. If one answer is dominant for a given question, write an * next to that item.*

If fumes, describe type:

- Acrid
- Chemical
- De-icing
- Dirty socks
- Exhaust
- Electrical
- Fuel
- Musty or mouldy
- Oily/burning oil
- Vomit
- Other ____________

Intensity of fumes

- Mild
- Moderate
- Strong
- Nauseating

If fumes in cabin:

- Forward cabin
- Mid cabin
- Aft cabin
- Galley___________________
- Lavatory

Apparent location of fumes in cabin/flight deck:

- Air supply system vents
- Cabin item
- Flight deck equipment
- Galley equipment
- Other: _________________
- Unknown

If fumes in flight deck:

- General flight deck area

If fumes in cargo:

- Known source
- Unknown source
- If known, identify: ______________________________

Potential source of fumes coming from outside the aircraft:

- De-icing or anti-icing underway
- Fueling underway
- Proximity to ground service vehicle exhaust
- Proximity to other aircraft (exhaust)
- Other: _____________________________

Section 4: Other Observations — All Events

Note: For each question, check all that apply.

- Blocked drain
- Cabin item: ________________
- In-flight entertainment system malfunction
- Galley equipment malfunction
- Air outlets in galleys closed
- Air outlets in galleys open
- Leak or spill
- Lights flickering or malfunction
- Dry-ice being used in galleys
- Irregular equipment noise
- Other: _____________________

Air supply source:

- APU
- Engines
- Ground conditioned air unit
- Ground air starter
- Other: ________________________________

Section 5: Symptoms and Reactions — All Events

Note: For each question, check all that apply.

Symptoms reported?

- Yes; *if yes, complete table below*
- No
- Unknown

If yes, symptoms reported by:

- Flight crew
- Cabin crew
- Maintenance
- Passenger(s): Seat # __________

Symptoms/reported by	Flight crew	Cabin crew	Maintenance	Passenger(s)
Abnormal taste				
Dizziness				
Fatigue or weakness				
Headache				
Irritated eyes, nose, throat				
Slowed thinking				
Tingling				
Trouble breathing				
Nausea				
Other				

Comments:

____

Emergency equipment used?

- Yes; *if yes, complete table below*
- No

Equipment/used by	Flight crew	Cabin crew	Maintenance	Passenger(s)
Oxygen mask				
Smoke goggles				
Portable breathing equip.				
Portable oxygen bottle				
Fire extinguisher				
Drop down masks				

Medical assistance required?

- None
- Flight crew
- Cabin crew
- Passenger(s): Seat # ____________
- Maintenance

Type of medical assistance (If applicable)

- On-board only
- Medical advisory service
- Emergency medical services met aircraft
- Emergency room or clinic
- Other: ______________________

Additional details:

____

Section 6: Maintenance Follow-Up and Information — All Events

Note: For each question, check all that apply.

Maintenance fault or source identified?

- Yes
- No

Impact on operation

- None
- Diversion
- Return to base
- Aircraft change
- Flight cancelled
- Gate delay
- Other: ____________________

Maintenance action(s), if known:

____

If needed, provide additional comments

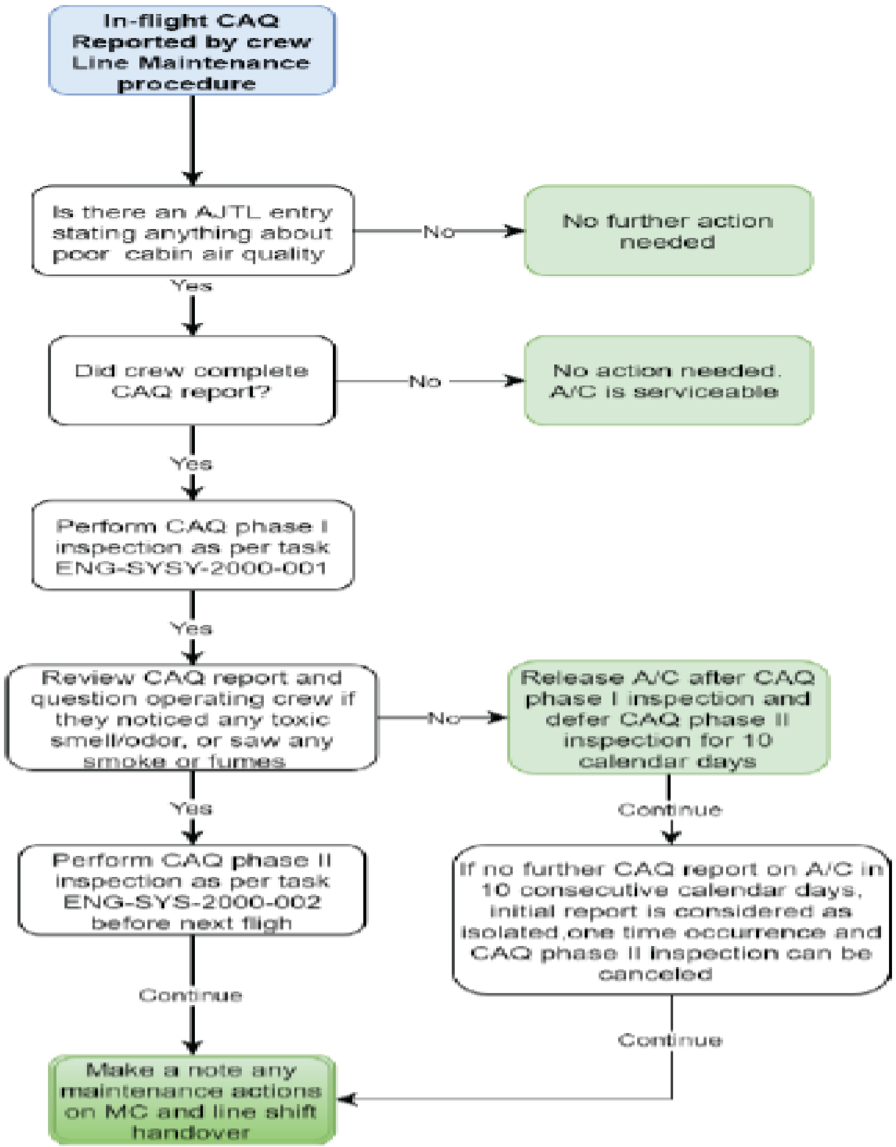
____

Cabin Air Quality

Phase 1 inspection

Task No: ENG-SYS-2100-001

CAQ flow chart - Line Maintenance procedure



Accomplishment Instructions

Subtask	Description	Acc. By
	Part 1 - Preparation	
1.1	Go over the attached flow chart **at the bottom** of this task to determine if either Phase 1, Phase 2, both or neither inspections are required. **NOTE:** If neither task is applicable. N/A the rest of this task and close in Maintenix.	
1.2	Prepare and make sure a man-lift is available for APU access	
1.3	In Maintenix, determine how much is left of interval for HEPA filter replacement task 21-004-00-X, record FH left below: FH left: ________________ FH **NOTE:** Contact Maintenance Control if unsure how to perform this action.	
	Part 2 – HEPA filter **If the HEPA filters are replaced, make sure they are sealed in a bag and routed to U/S part shelf on KEF Line.** **Notify Maintenance Control of the location of the HEPA filter so they can be sent for lab analysis.** **NOTE: HEPA filters do deliver 100% airflow even though they are 99% clogged!**	
2.1	If HEPA filters are found in US condition or have less than 600 FH remaining, replace the filter i.a.w AMM 21-25-02. Contact Maintenance Control to reset the time of task 21-004-00-X in Maintenix. **NOTE:** If the HEPA require replacement, N/A all other steps in **Part 2**.	
2.2	Inspect HEPA filters by removing the AFT bulkhead heating system access panel i.a.w. AMM 25-50-03-004-001.	
2.3	Use a flashlight for a look at the HEPA filters to determine the condition of the filters.	
2.4	If the HEPA filters are found dirty, replace i.a.w AMM 21-25-02. Contact Maintenance Control to reset the time of task 21-004-00-X in Maintenix.	

Part 3 – Cabin inspection		
3.1	Replace all cabin and flight compartment zone temperature sensor filters and make sure that the fans are operational i.a.w AMM 21-61-09-209-001.	
3.2	Check cabin, lavatories and galleys for any unusual odor, for example: • Food in galley • Urine Smell in lavatories and surrounding area • Electrical Smell in Cabin/Galley • If oil, hydraulic or de-icing odor, fumes found in flight compartment, cabin or galley investigate source	
3.3	Visually inspect FWD and AFT galley ventilation filters for cleanliness, replace if found dirty. Check for adequate airflow by using a piece of A4 paper to cover the ventilation grille, see if airflow is adequate to hold the paper in place.	
3.4	Open one passenger PSU (1/3) in each PSU and galley (close after measurement) and check for adequate airflow out of gaspers with velocity meter. **NOTE:** Normal airflow over passenger approximately 3-5 m/s **NOTE:** Normal airflow in galley approximately 10+ m/s (at least)	
3.5	In the flight compartment, check EICAS STATUS and MAINT page for any ATA 21 (Air Conditioning) or ATA 36 (Pneumatics) related messages.	
3.6	View EICAS ECS page and confirm proper operation of the following valve and temperature values raise/lower with operation of the temperature knob on the P5 overhead panel. - This task is similar to AMM 21-51-00-705-184 – Pack/Zone System Health Check **NOTE:** On some aircraft zone valve indication will blank in full open position. **NOTE:** Valve indication can be seen as "percentage of open". The values as follows: • 0,0 = Fully Closed • 1,0 (or blank) = Fully Open **NOTE:** Temperature indications can be seen as follows: • Full cold, heat decreases towards appr. 17 degrees • Full hot, heat increases towards appr. 30 degrees Check the following valves on the EICAS ECS page: • FLT DK pneumatic trim valve • FWD pneumatic trim valve • AFT pneumatic trim valve • Master TRIM VALVE – check for normal open/close travel	
3.7	Operate the air condition packs, walk the cabin aisle (FWD to AFT) and check for any unusual noise from sections of the overhead duct caused by ruptured/unconnected tubes/lines. **NOTE:** Normally, in these circumstances a low hissing sound might be audible. **NOTE:** Make sure HEPA filter inspection is complete before you do this.	

Part 4 –Exterior/E&E inspection		
4.1	Check RAM air intake door for any obstructions and proper operation as per AMM 21-53-00-735-014 – System Test – Ram Air System **NOTE:** If not applicable, it is sufficient to remain in GND MODE.	
4.2	Perform an operational test of the Recirculation System/Fans i.a.w AMM 21-25-00-005-040.	
4.3	Perform BITE test on Cabin Temperature Controllers i.a.w AMM 21-51-00-745-159.	
4.4	Perform BITE test on Cabin Pressure Controller i.a.w AMM 21-31-00-705-085.	
4.5	Perform BITE test on the Yaw Damper Module i.a.w installation test of AMM 22-21-04-424-033.	
4.6	Open engine cowlings and check Engines and APU for any obvious oil and/or hydraulic leaks.	
4.7	Open the air-condition bay and check for any air or fluid leak above or around air-condition packs and intake.	

CORRECTIVE ACTION IN AIR QUALITY ISSUES IN GENERAL

ACTIONS TAKEN
regarding
Cabin Air Quality

1. ENGINES

Swapping engines and parts;

Oil replacement

(TCP free oil on all B757 and B737 since 2005)

2. ACS

Air filter exchange;

Air condition ducts inspection and system cleaning

3. AIR QUALITY TESTING

On ground (Aerotracer) on passenger flights and special flights

Measurements include:

- atmospheric pressure and oxygen ratio
- temperature and humidity
- noise volume
- airspeed and distribution
- microbial and mold testing
- odor test (Aerotracer)
- Other test for: CO (Carbon Monoxide), CO_2 (Carbon Dioxide), SO_2 (Sulfur Dioxide), O_3 (Ozone), VOC.

4. Icelandair‘s Medical Officer review:

- Medical examinations
- Blood tests from crew members immediately after suspect flights.
- No findings - All “normal“ results.

5. Investigation from the Icelandic Accident Investigation Committee (RNSA)

- No findings – All “normal“ results.

On Going Actions - FACTS

Icelandair is participating in the European research project'FACTS‘.

The project is to determine the potential contamination of cockpit and cabin by engine oil.

Several test flights have already been flown.

Validate the Bleed Air Contamination Simulator (BACS).

Furthermore, these test flights are intended to provoke fume events during the flights to be able to capture samples for analysis into the contaminants in the air.

Recommendation

1. Get clear information about what chemical compound shall be looked for (FACTS)

2. Measure equipment on board every aircraft, that can collect samples of these compounds

3. Get clear information on where the hazardous to health limits are for these compounds

4. Total clean air system is promising, and should be tested further.


THANK YOU FOR YOUR ATTENTION
ICELANDAIR

Why the brain is a vulnerable ‘target organ’ to chronic low-dose OP exposure

Prof Vyvyan Howard FRCPath

Centre for Molecular Biosciences

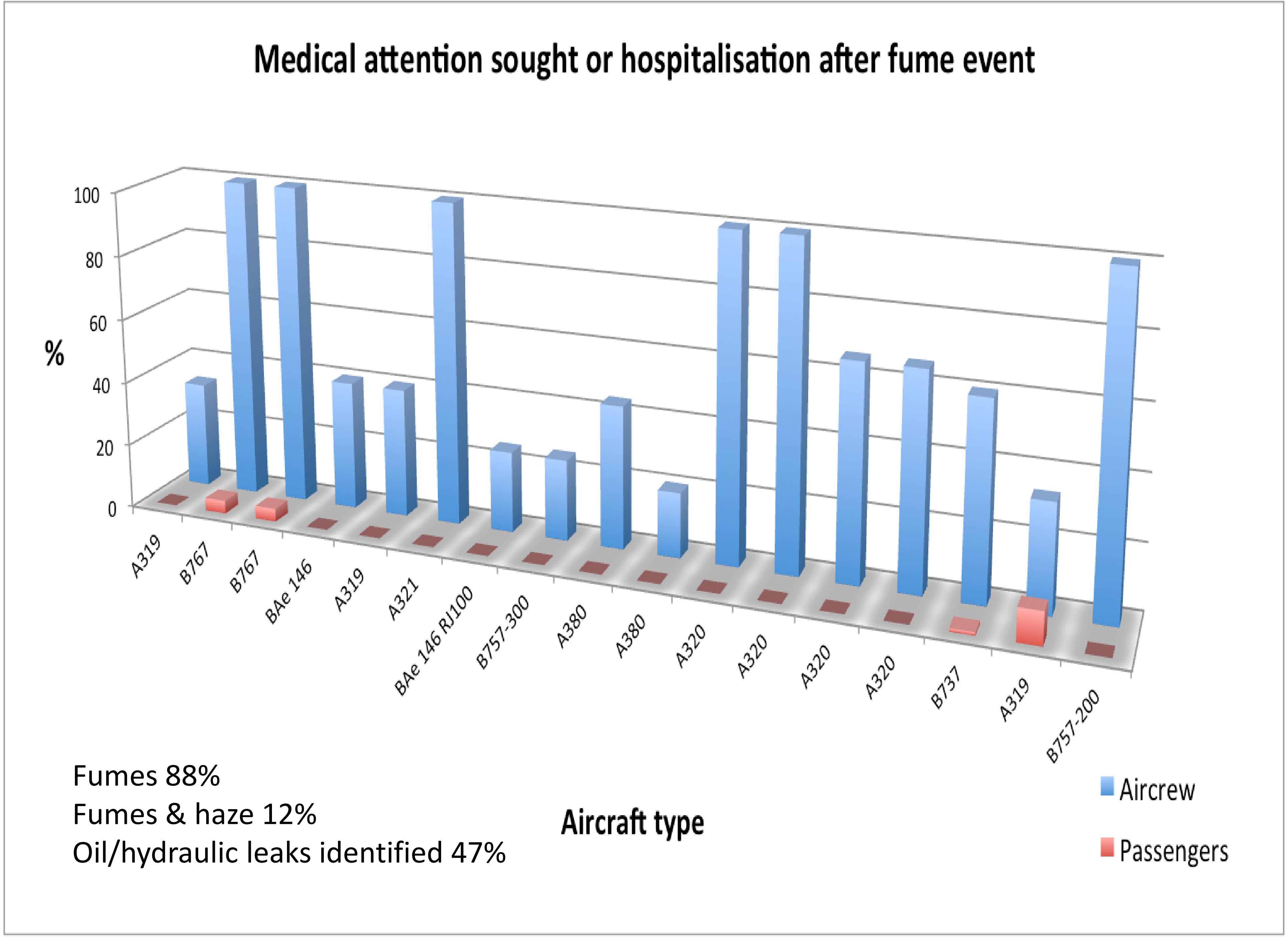
University of Ulster

v.howard:ulster.ac.uk

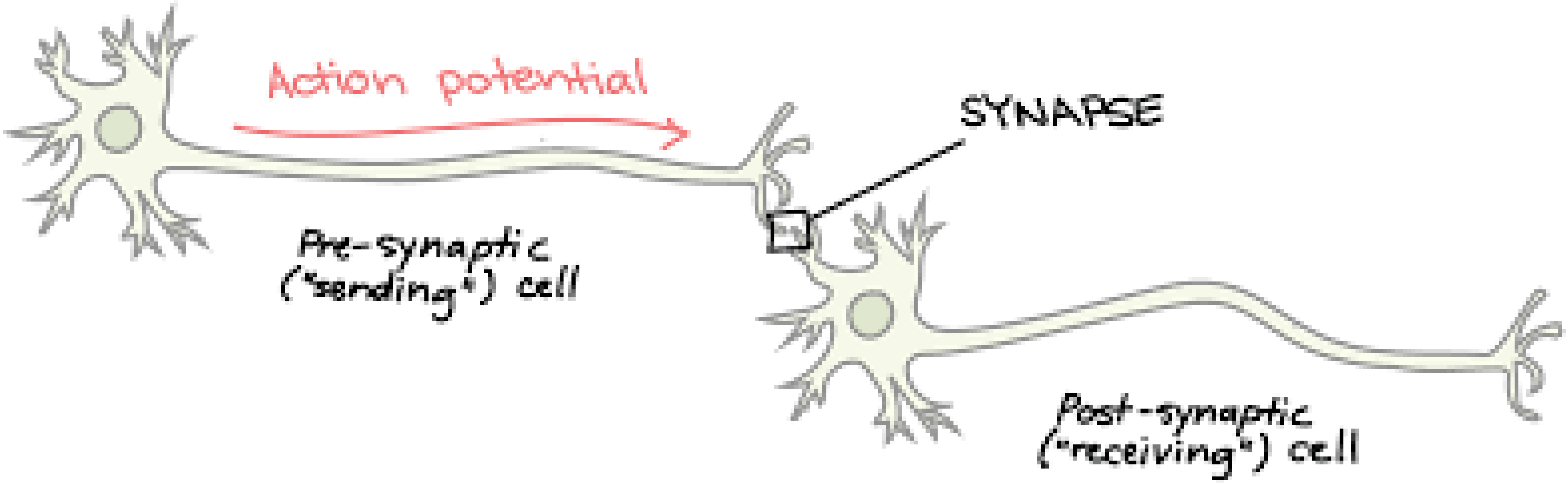
Aircraft Cabin Air Conference 2019

Critical research questions

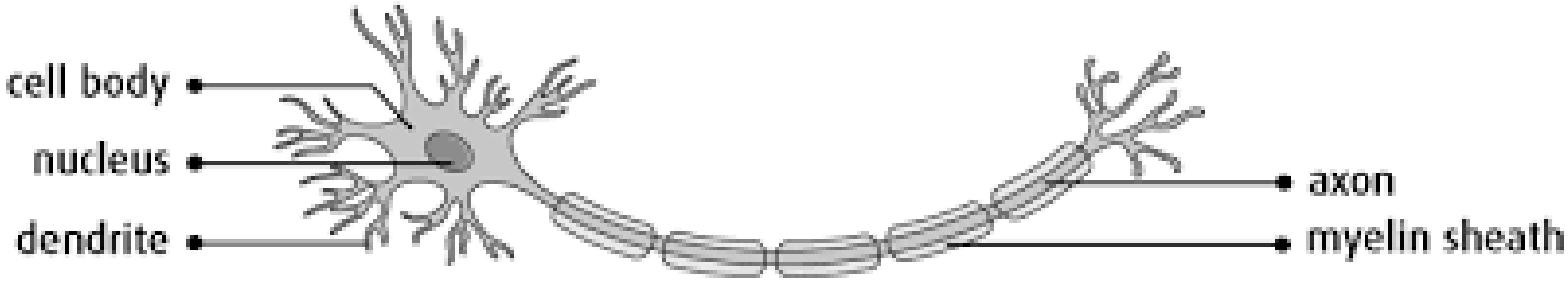
- Why are pilots and cabin crew more vulnerable to the effects of ‘fume events’ than the passengers, particularly for neurological sequelae? One would expect the opposite – healthy worker effect
- What is the effect of continual exposure to a low-dose complex mixture of fugitive turbine engine emissions for individual cumulative exposure times measured in thousands of hours?
- What is the effect continual exposure to an aerosol of combustion nano-particles on the kinetics of TAPS and other pyrolysis chemicals across the blood brain barrier?


Medical attention sought or hospitalisation after fume event
%
100
80
60
40
20
0
A319
B767
B767
BAe 146
A319
A321
BAe 146 RJ100
B757-300
A380
A380
A320
A320
A320
A320
B737
A319
B757-200
Aircraft type
Aircrew
Passengers
Fumes 88%
Fumes & haze 12%
Oil/hydraulic leaks identified 47%

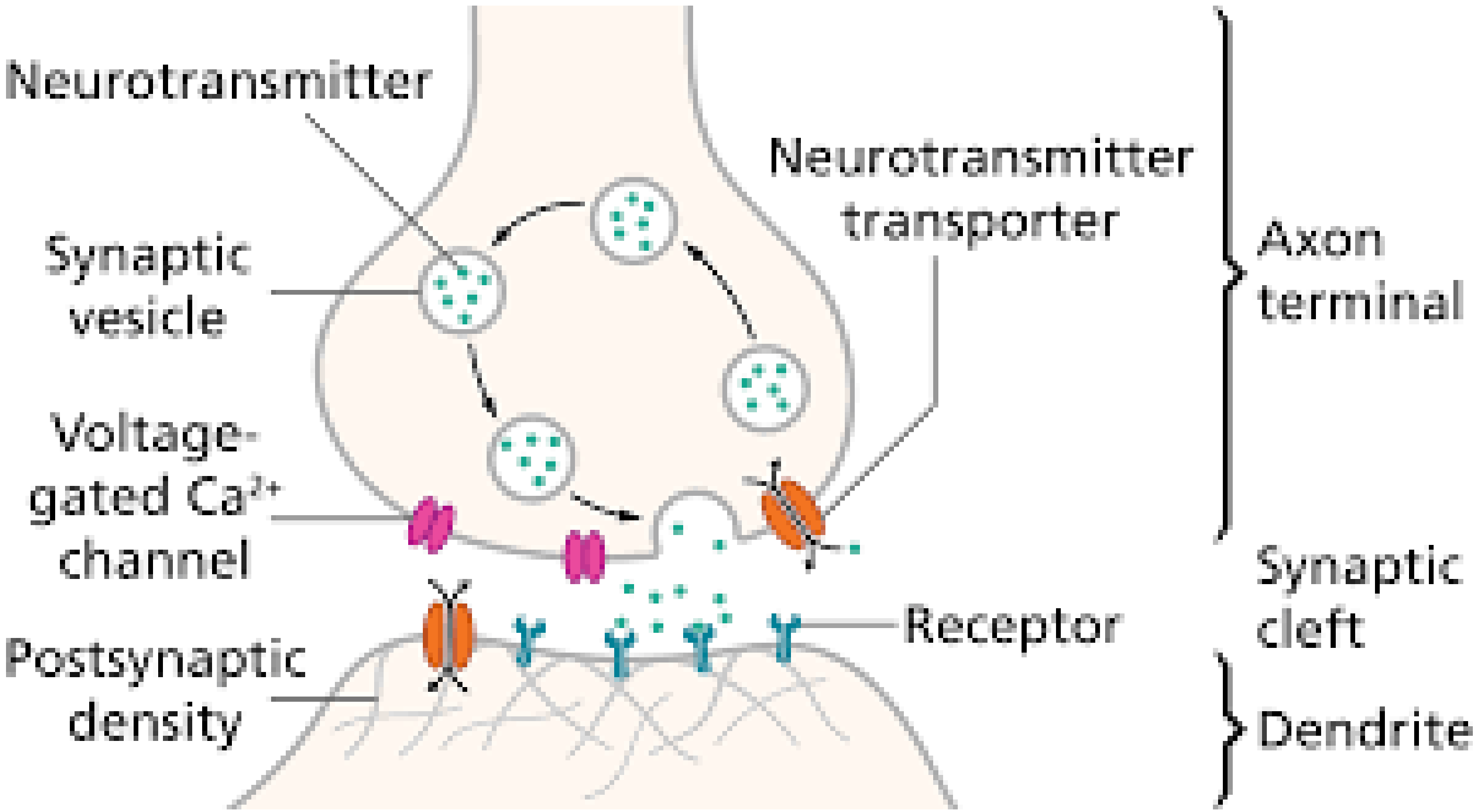
The basic anatomy and physiology of nerve cells



Structure of a Neuron



Synapses



Neurotransmitter
Synaptic vesicle
Voltage-gated Ca^{2+} channel
Postsynaptic density
Neurotransmitter transporter
Receptor
Axon terminal
Synaptic cleft
Dendrite

Axonal transport

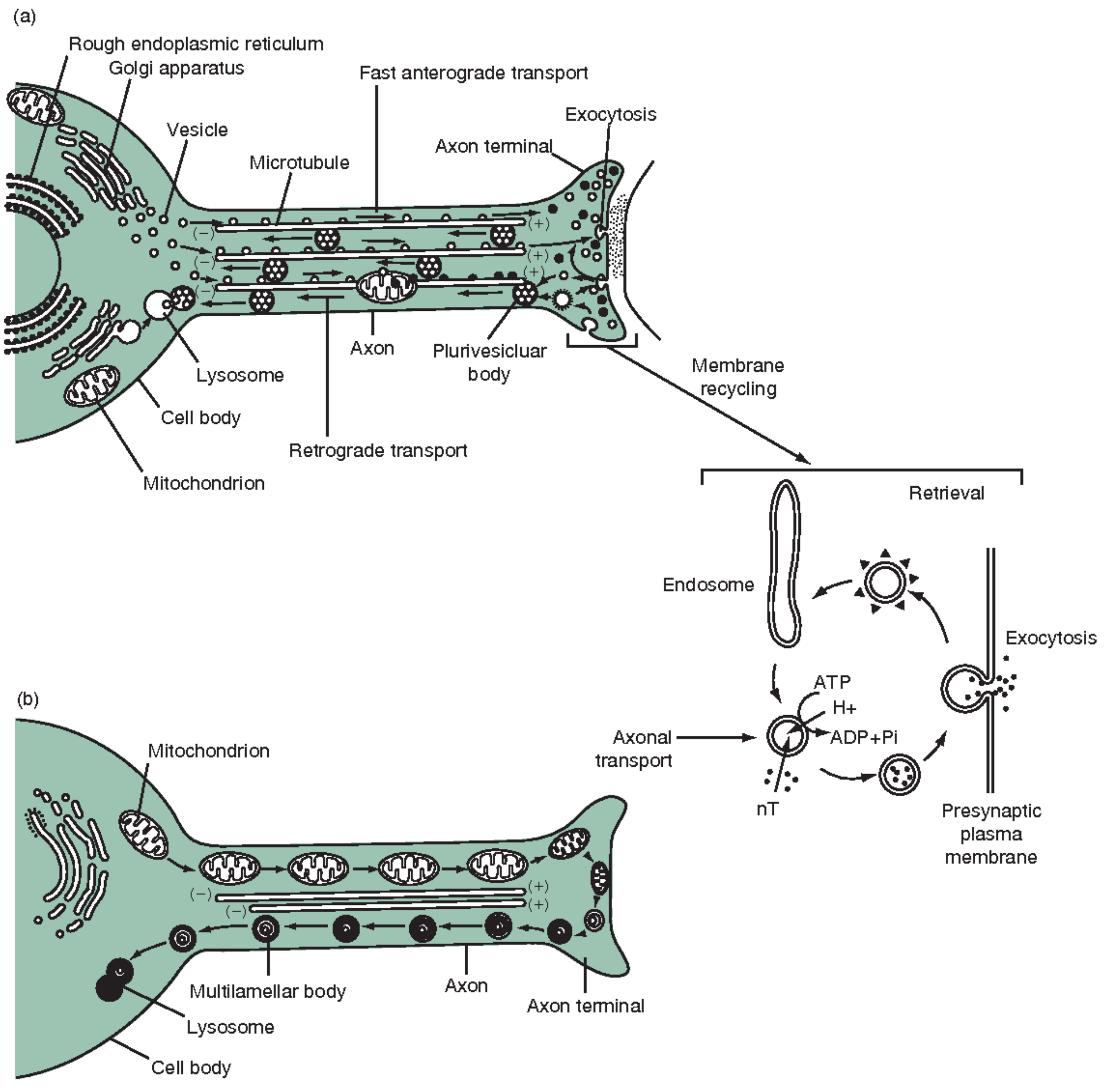
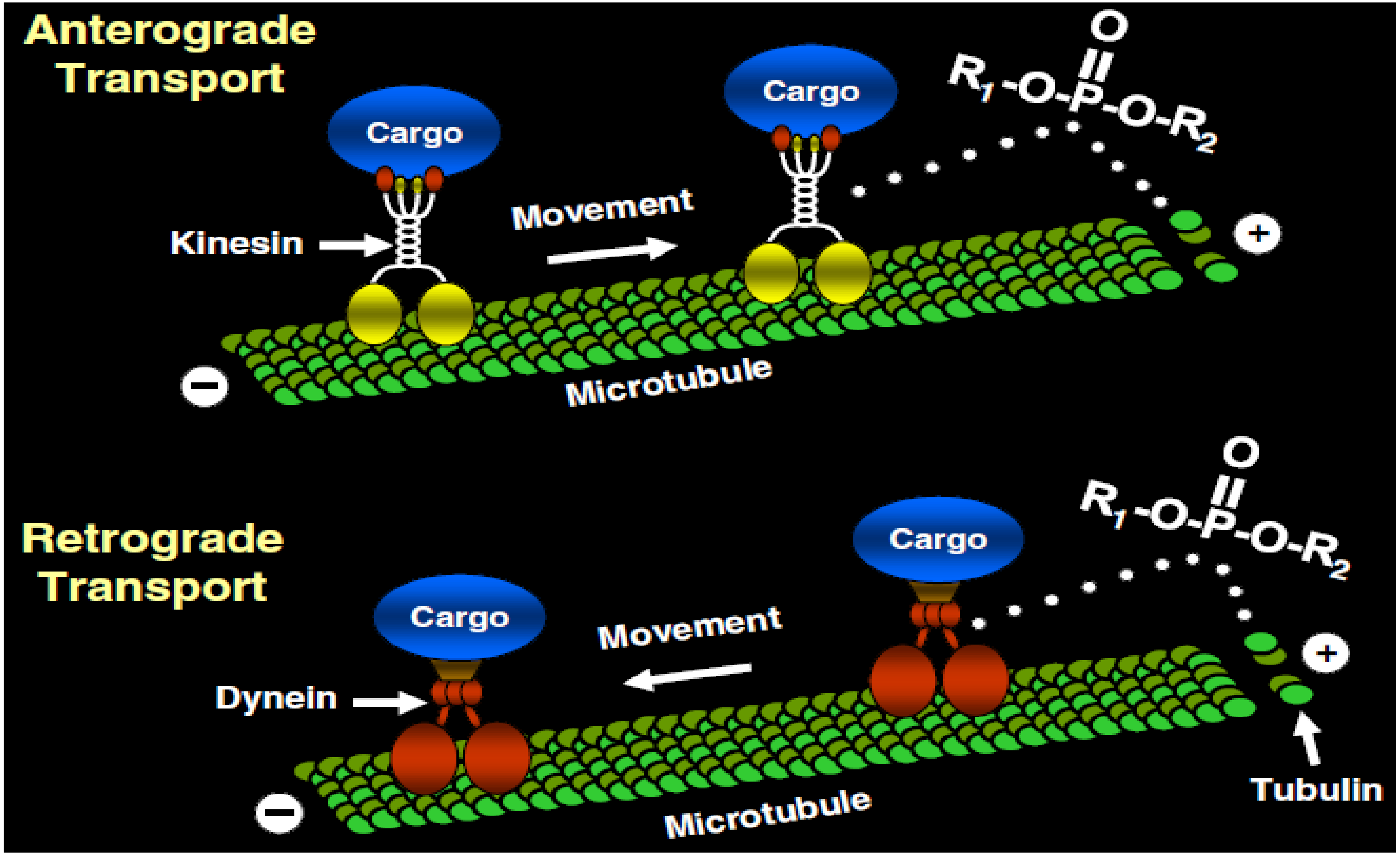
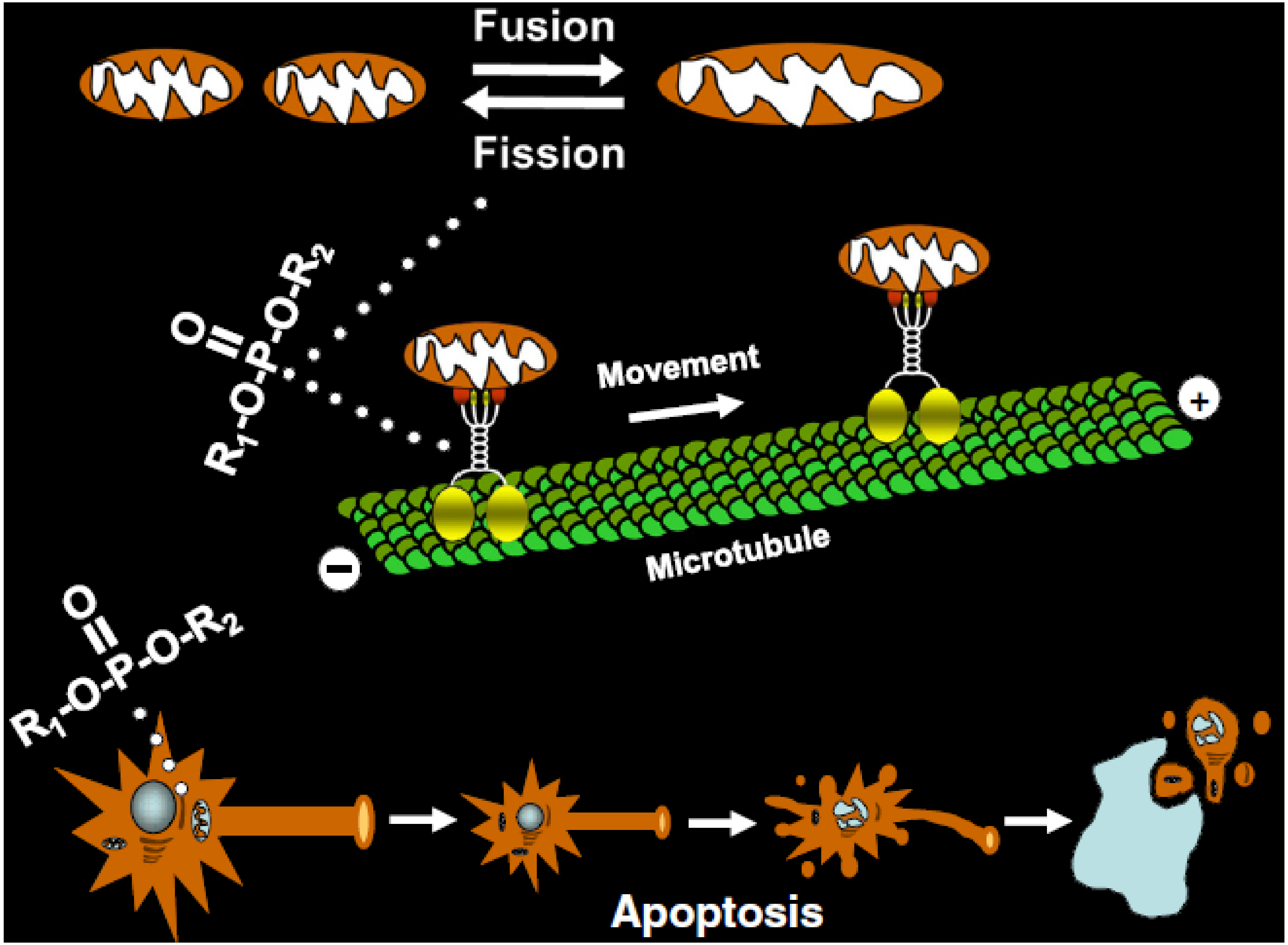


FIGURE 1.10 Fast axonal transport

Axonal transport

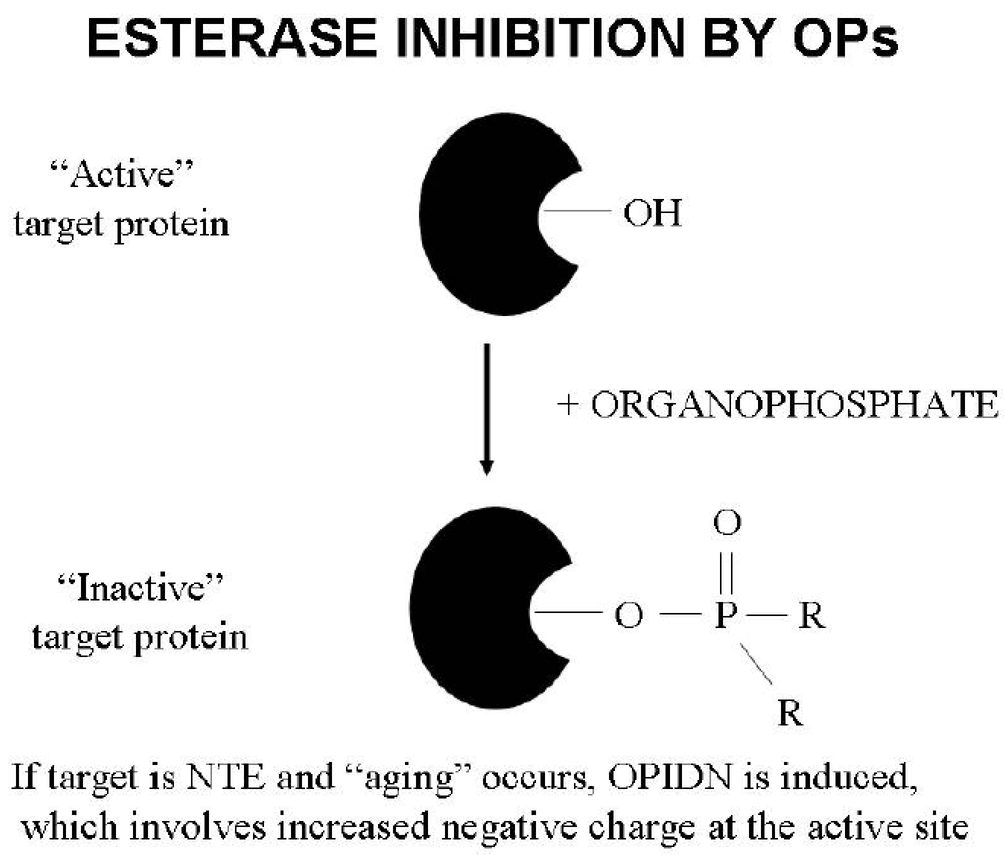



Fusion
Fission
Movement
Microtubule
+
−
R_1-O-P(=O)-O-R_2
R_1-O-P(=O)-O-R_2
Apoptosis

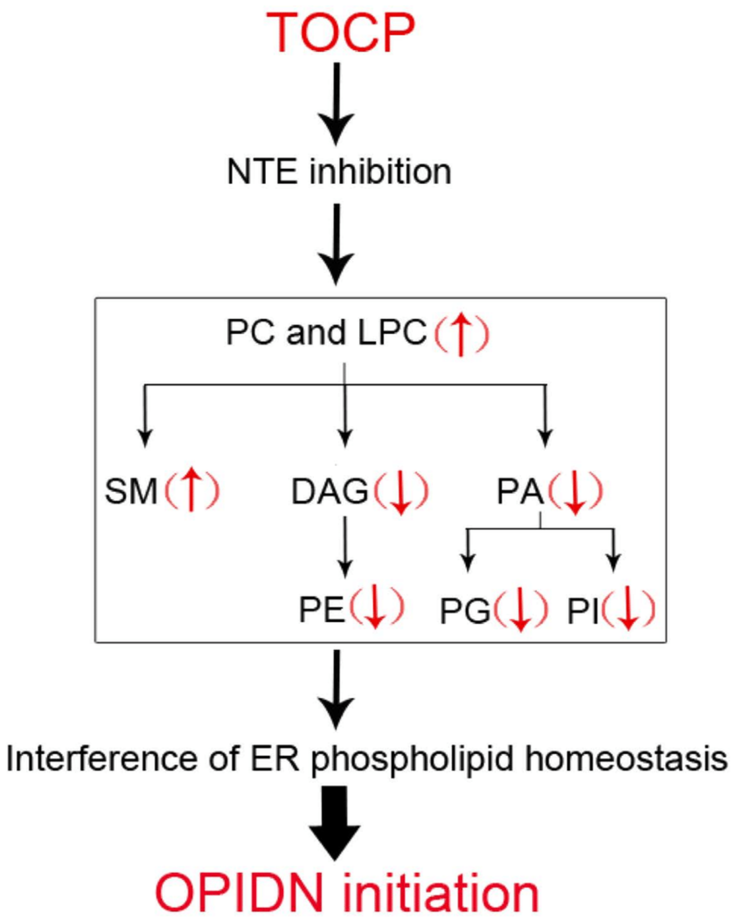
High dose OP exposure scenarios

- OPIDN
- Nerve gas effects

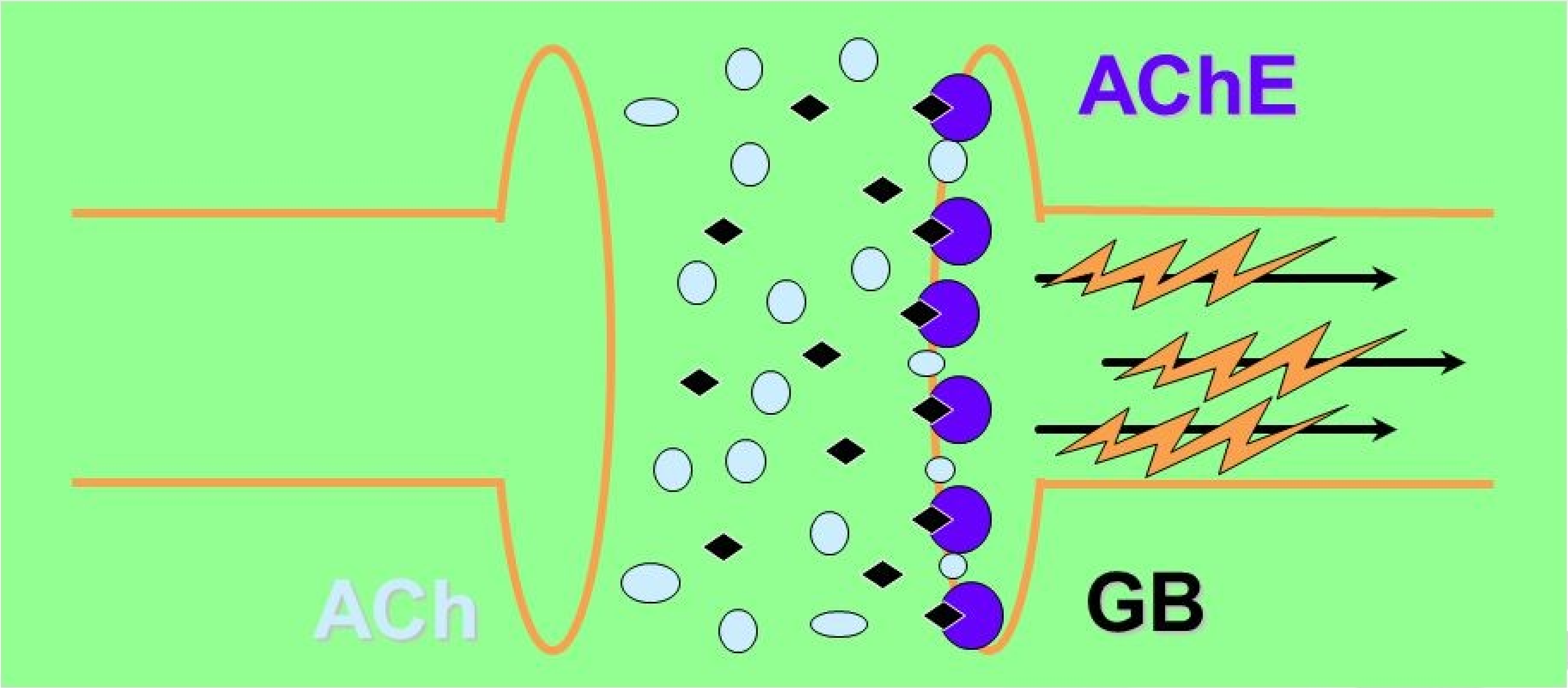
OrganoPhosphateInducedDelayedNeuropathy is a **HIGH DOSE** condition



TOCP can cause OPIDN at acute high doses



Nerve Agents Inhibit ACHE

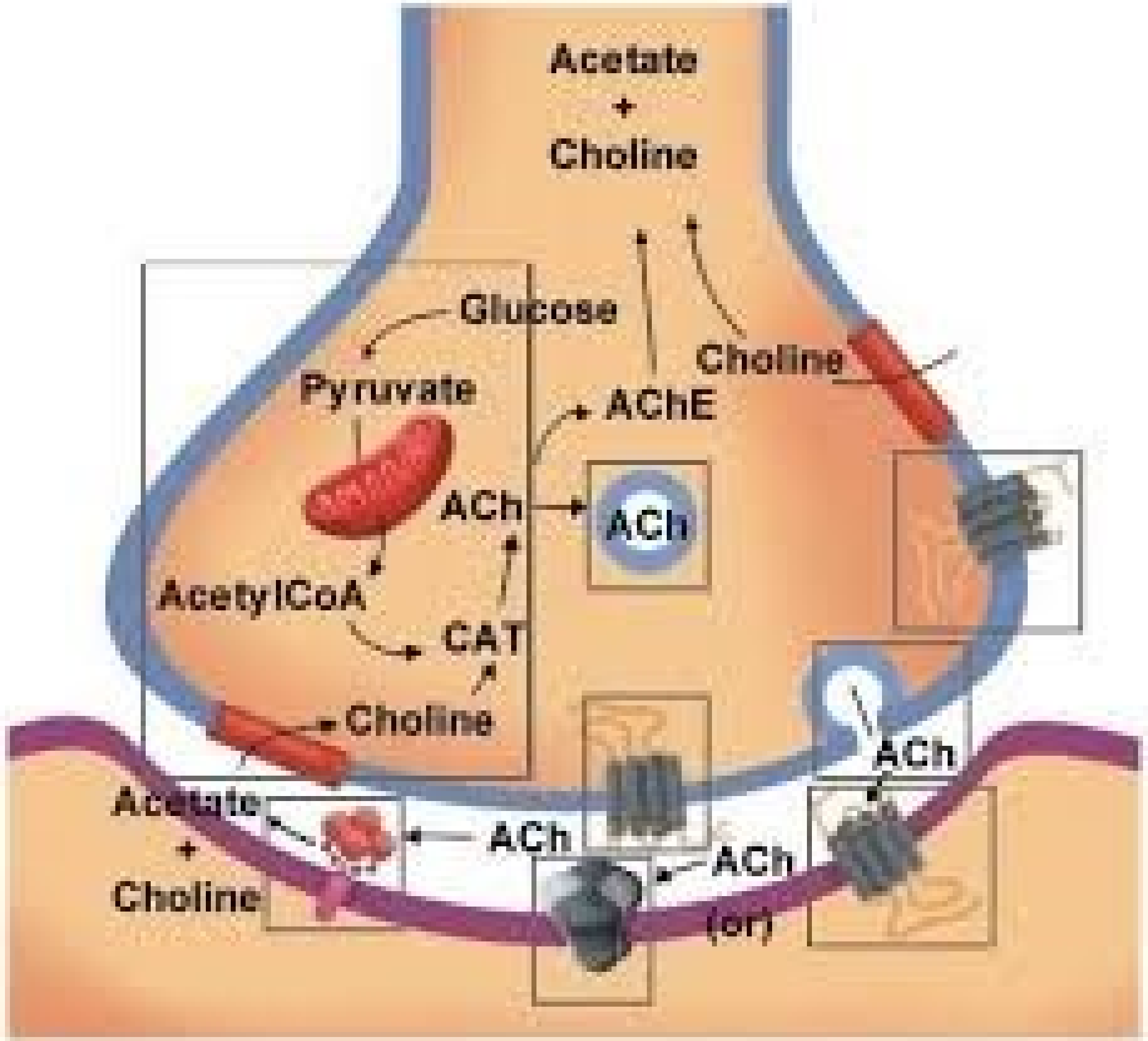


ACh accumulates and causes over-stimulation of nerves, muscles and glands.

What does acetyl choline do?

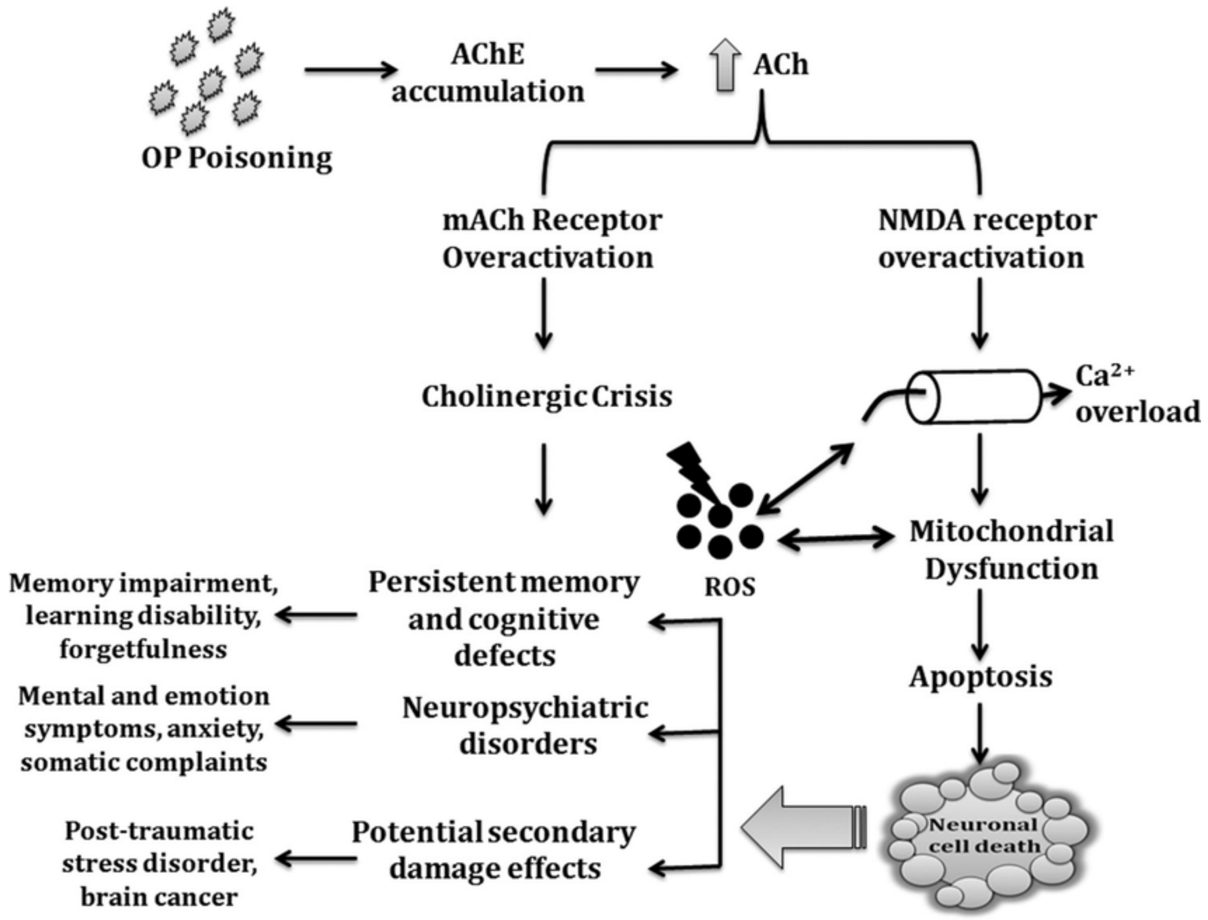
Effects

- Acetylcholine is a transmitter in two kinds of synapses, meaning nerve agents function in two ways.
- Muscarinic receptors:
  - Smooth muscle
  - Glands
- Nicotinic receptors:
  - Skeletal Muscles
  - Ganglion



Acetate
+
Choline
Glucose
Pyruvate
Choline
AChE
ACh
ACh
AcetylCoA
CAT
Choline
ACh
Acetate
+
Choline
ACh
ACh
(or)

However not all adverse effects of OPs are high dose



Contents lists available at SciVerse ScienceDirect

Pharmacology & Therapeutics

journal homepage: www.elsevier.com/locate/pharmthera

Associate Editor: C.N. Pope

Functional consequences of repeated organophosphate exposure: Potential non-cholinergic mechanisms

A.V. Terry Jr. *

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Animal Behavior Center, Georgia Health Sciences University, Augusta, GA 30912, United States

Functional consequences of repeated organophosphate exposure: Potential non-cholinergic mechanisms.
A.V. Terry
Pharmacology & Therapeutics 134 (2012) 355–365

The purpose of this review is to discuss several non-cholinesterase targets of OPs that might affect such fundamental processes and includes cytoskeletal and motor proteins involved in axonal transport, neurotrophins and their receptors, and mitochondria (especially their morphology and movement in axons).

117 References cited (41 in vivo, 12 in vitro, 15 in silico)

Terry, 2012

….. there is now substantial evidence that this canonical (cholinesterase-based) mechanism cannot alone account for the wide variety of adverse consequences of OP exposure that have been described, especially those associated with repeated exposures to levels that produce no overt signs of acute toxicity. These include covalent binding of OPs to tyrosine and lysine residues, which suggests that numerous proteins can be modified by OPs. In addition, the mechanisms of oxidative stress and neuroinflammation and the known OP targets of motor proteins, neuronal cytoskeleton, axonal transport, neurotrophins and mitochondria. This type of exposure has been associated with prolonged impairments in attention, memory, and other domains of cognition, as well as chronic illnesses where these symptoms are manifested (e.g., Gulf War Illness, Alzheimer's disease).. precisely the spectrum of symptoms reported for air crew by Michaelis, Burdon & Howard (2017)

Low dose effects of OPs detailed by Terry

Table 1
Non-cholinesterase targets of OPs (at physiologically relevant concentrations).

Target	Description/functions	Reference(s)
Papain	Cysteine protease found in lysozomes	Chaiken & Smith, 1969
Carboxylesterase	Serine hydrolase/enzyme that hydrolyzes carboxyl esters	Su et al., 1971; Chanda et al., 1997
Adenylyl cyclase	Enzyme that catalyzes the conversion of ATP to cyclic AMP/important in the G protein signaling cascade	Huff et al., 1994; Song et al., 1997; Auman et al., 2000
Neuropathy target esterase	Phospholipase enzyme important in phospholipid metabolism, neurite outgrowth and process elongation during neuronal differentiation	Lush et al., 1998
Acylpeptide hydrolase	Serine protease enzyme that catalyzes the removal of N-acylated amino acids from acetylated peptides role in the coordinated protein-degradation	Richards et al., 2000
M_2 muscarinic receptors	Second messenger coupled acetylcholine autoreceptor	Bomser & Casida, 2001[a]
Fatty acid amide hydrolase	Serine hydrolase enzyme that catabolizes a class of bioactive lipids called the fatty acid amides including endocannabinoids (e.g., anandamide)	Quistad et al., 2001
Cannabinoid CB1 receptors	G protein-coupled receptors for endocannabinoids/functions not fully understood, but may play roles in neurotransmitter release, synaptic plasticity, pleasure, appetite, memory/concentration, perception of time, pain tolerance, etc.	Quistad et al., 2002
Albumin	Most abundant transport protein in plasma, also regulates the colloidal osmotic pressure of blood	Peeples et al., 2005
Transferrin	Glycoprotein that binds and transports iron in the plasma	Grigoryan, Li, Anderson, et al., 2009; Grigoryan, Li, Xue, et al., 2009; Grigoryan, Schopfer, Peeples, et al., 2009
Kinesin	Motor protein involved in anterograde axonal transport in neurons as well as other cellular functions such as mitosis, meiosis, etc.	Grigoryan, Li, Anderson, et al., 2009; Grigoryan, Li, Xue, et al., 2009; Grigoryan, Schopfer, Peeples, et al., 2009
ATP synthase	Mitochondrial enzyme responsible for synthesizing ATP from ADP and inorganic phosphate	Grigoryan, Li, Anderson, et al., 2009; Grigoryan, Li, Xue, et al., 2009; Grigoryan, Schopfer, Peeples, et al., 2009
Tubulin	Globular proteins that form microtubules (i.e., polymers of dimerized tubulin which serve structural roles in the cytoskeleton, support intracellular transport, mitosis, etc.)	Jiang et al., 2010

[a] OP-phosphorylation of M2 receptors reported by Bomser and Casida (2001) (using chlorpyrifos oxon) was not observed in experiments where paraoxon or a biotin labeled fluorophosphonate was evaluated (Proskocil et al., 2010).

Gao J, Naughton SX, Beck WD, Hernandez CM, Wu G, Wei Z, et al. NeuroToxicology Chlorpyrifos and chlorpyrifos oxon impair the transport of membrane bound organelles in rat cortical axons. Neurotoxicology. 2017;62:111–23.

- detected anterograde axonal transport deficits associated with the oxon metabolite of chlorpyrifos at 0.1 nM *in vitro,* in cultured embryonic rat neurons, a very low concentration.

Why are UFPs in cabin air of critical importance?

1) CV Howard: nanotoxicology review : University of Ulster

- UFPs can cross the BBB and chemicals adherent to their surface ‘piggyback’ into the brain. Pharmaceuticals are already being delivered thus. Their continual presence in cabin air will enhance the penetration of neurotoxic substances into the brain.
- A common feature of all UFPs, irrespective of their composition, is to induce inflammation, predominantly by ROS production.

- Elsaesser A, Howard CV (2012), Toxicology of nanoparticles , Adv. Drug Deliv. Rev. 64: 129–137

2) Byron Jones- Kansas State University

- Oil contamination of bleed air- Fine oil fog: 10-150 nm or below.
- particulates as a marker of oil contamination in bleed air
- Sensors to be developed for UFPs 10nm & below

Jones B, Roth J, Hosni M et al. The Nature of Particulates in Aircraft Bleed Air Resulting from Oil Contamination. LV-17-C046. In: *2017 ASHRAE Winter Conference—Papers*. Kansas State University, 2017.

Conclusions

- The basic physiology and anatomy of neurons in the CNS makes the brain particularly vulnerable as a target to damage by OPs at repeated low dose
- The basic mechanisms – particularly impaired axonal transport - to explain this vulnerability have been published and reviewed in the scientific literature
- The stance of some stakeholders to only address high dose exposure pathologies, such as OPIDN, ignores that literature and is scientifically unsustainable
- The presence of an aerosol of UFPs in cabin air will have the effect of increased penetration of the blood brain barrier by UFPs which will be accompanied by any OP molecules adherent to their surfaces

Bleed Air Contamination Detection

Byron W. Jones
Kansas State University

Aircraft Cabin Air Conference
London 2019

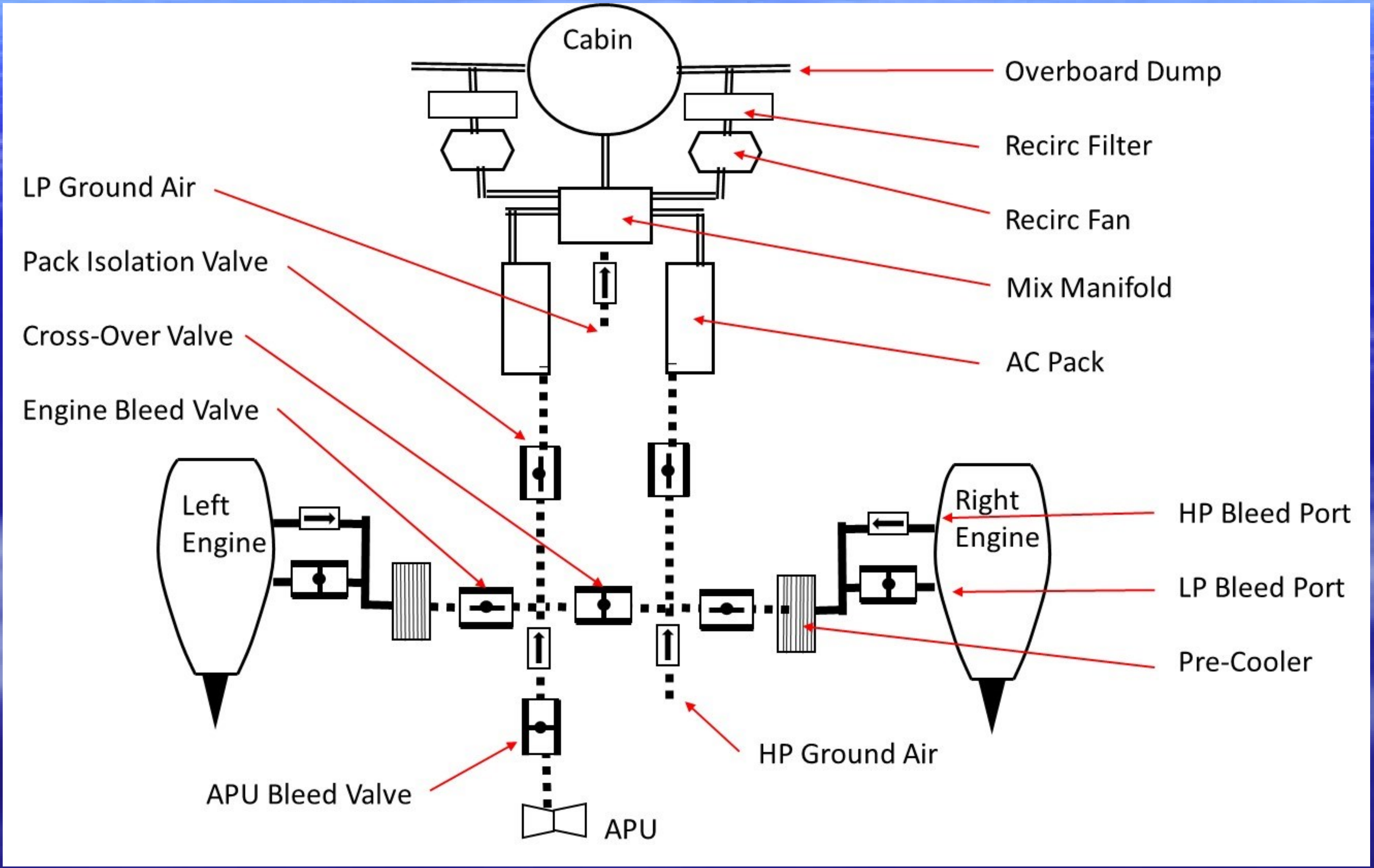
How do we ensure no oil in the bleed air supplied to the cabin?

(existing fleet)

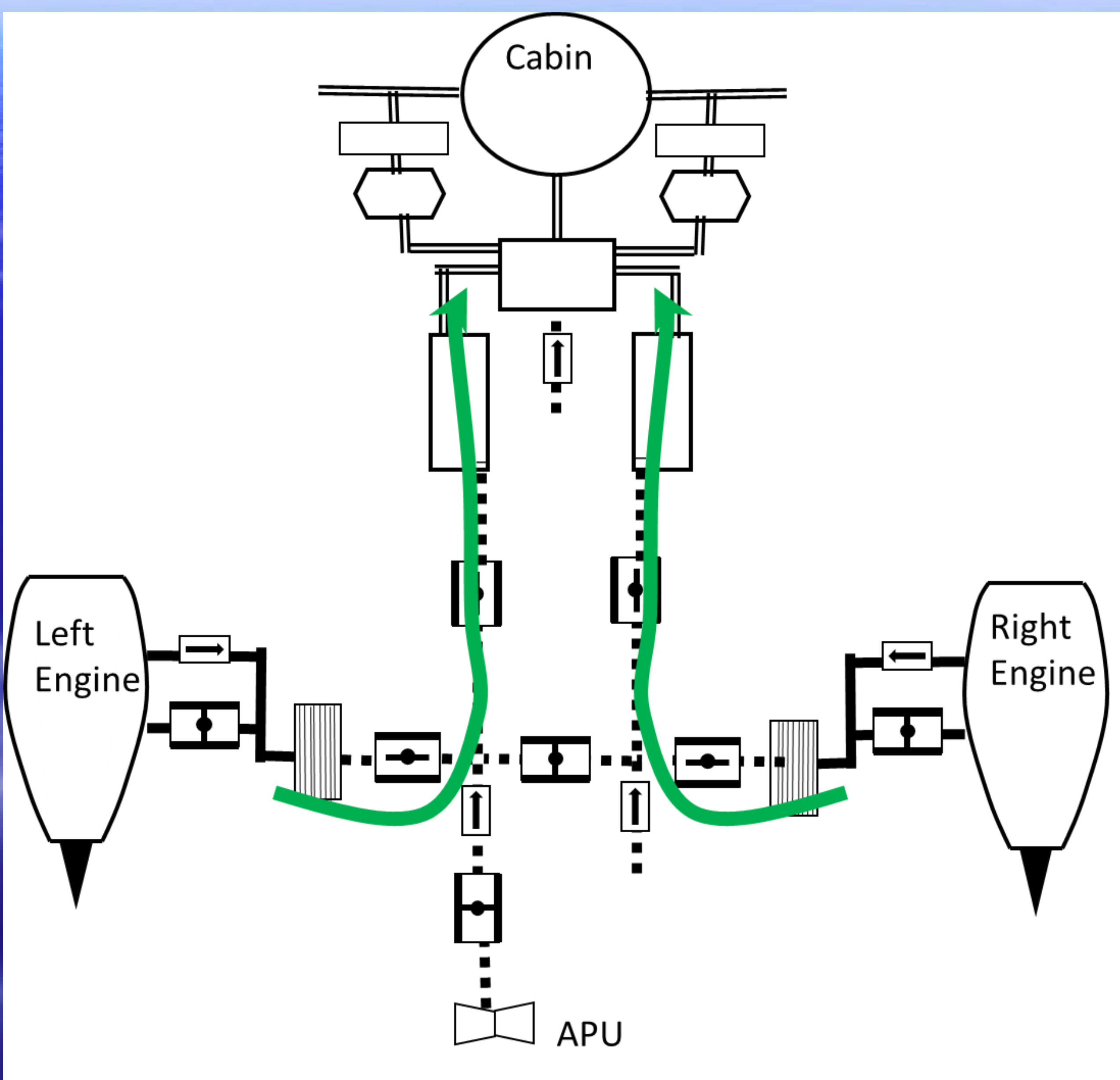
Two Options (at least):

- Detect and Isolate
- Clean the Bleed Air

Simplified Cabin Air System

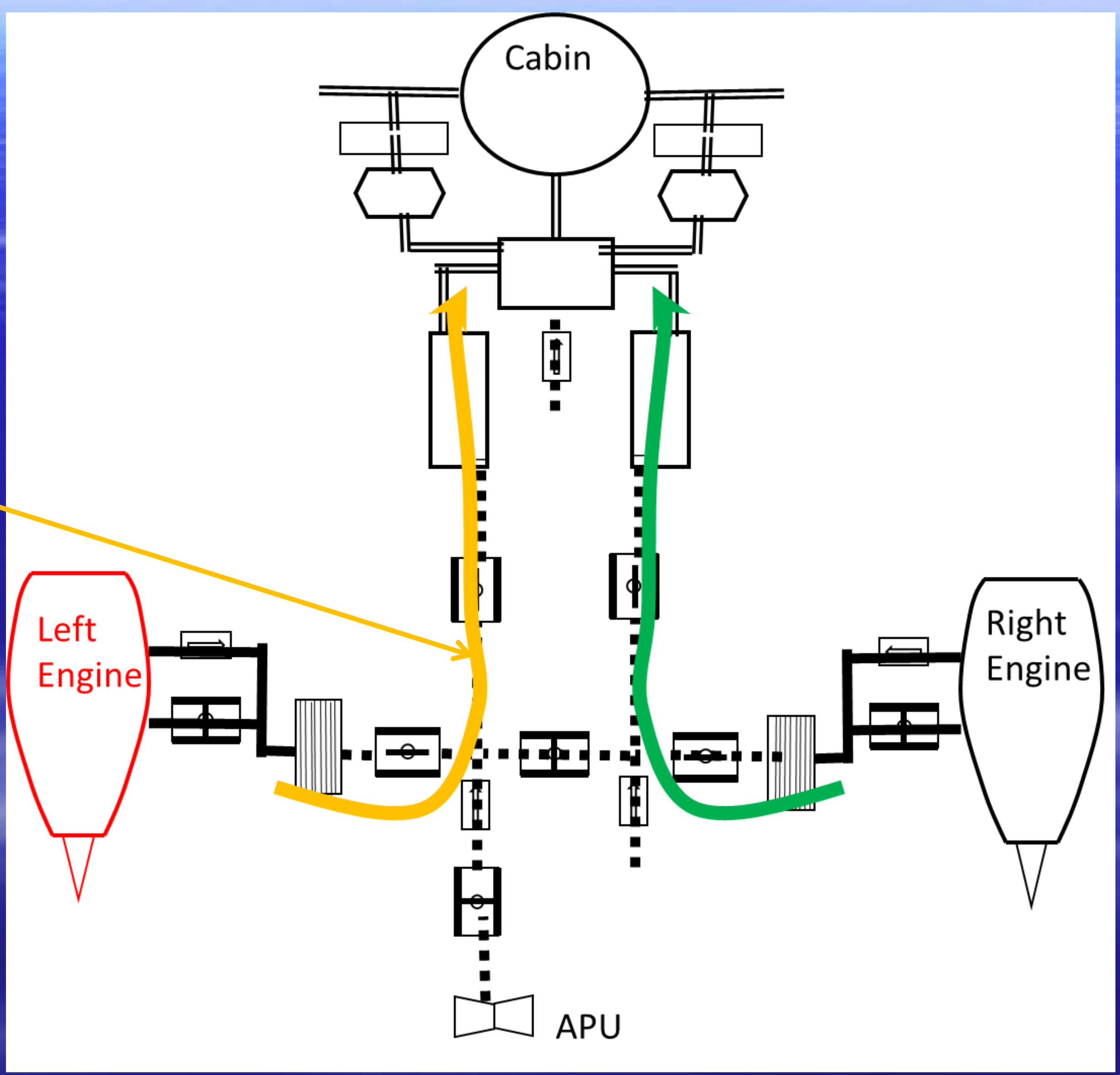


Normal Operation

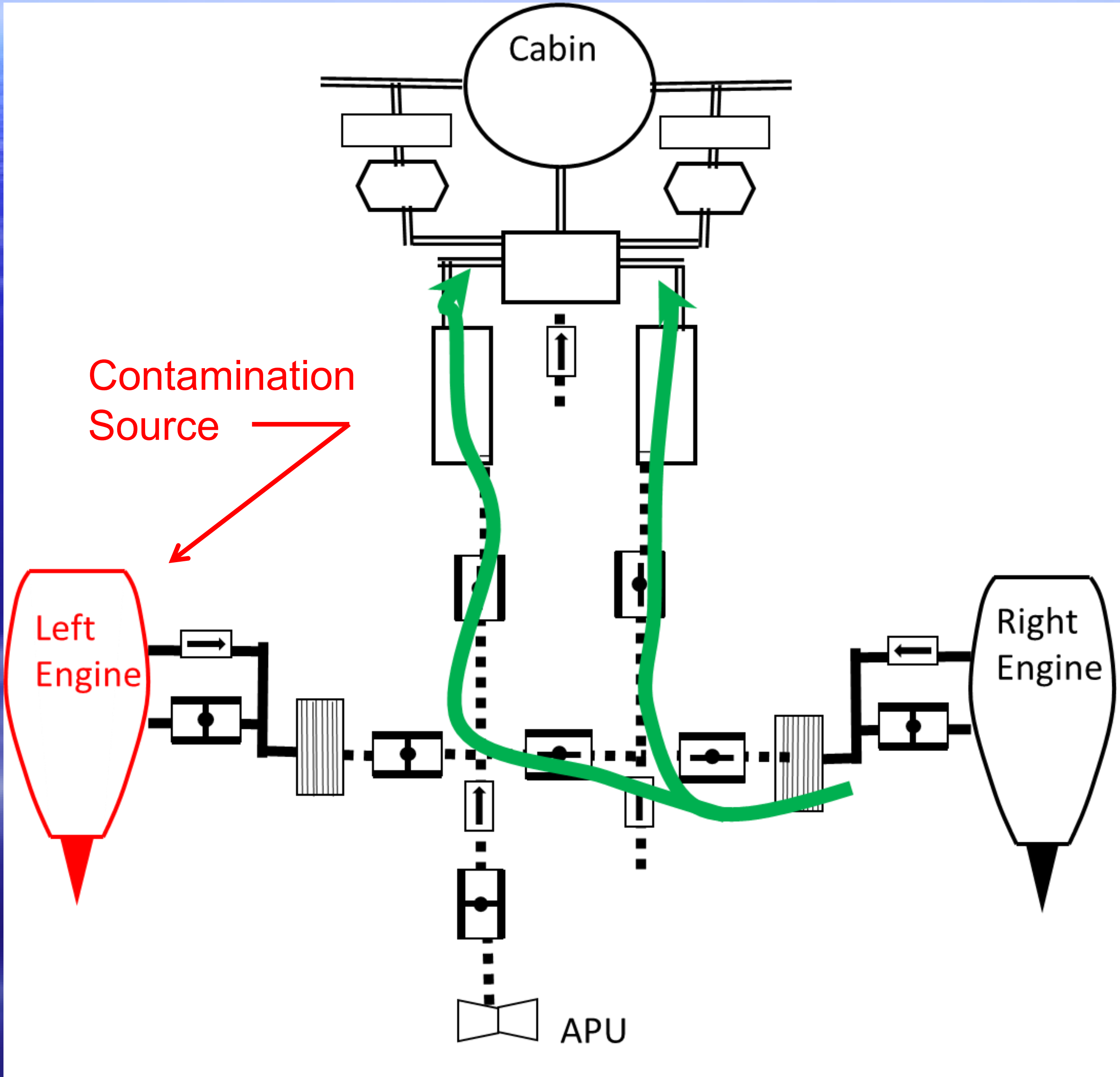


Contamination Detected

Contaminated Air

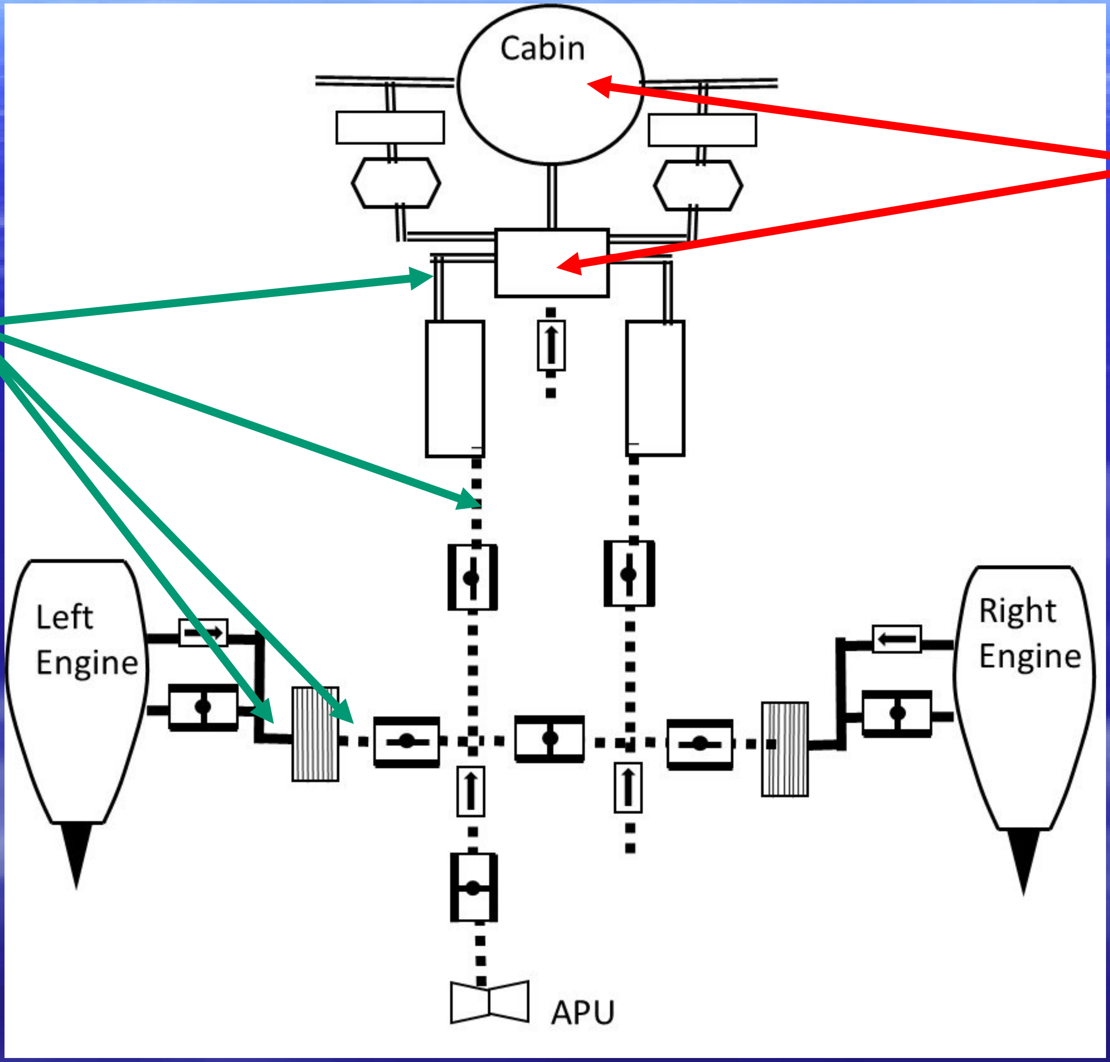


Contamination Source Isolated



Where to Detect

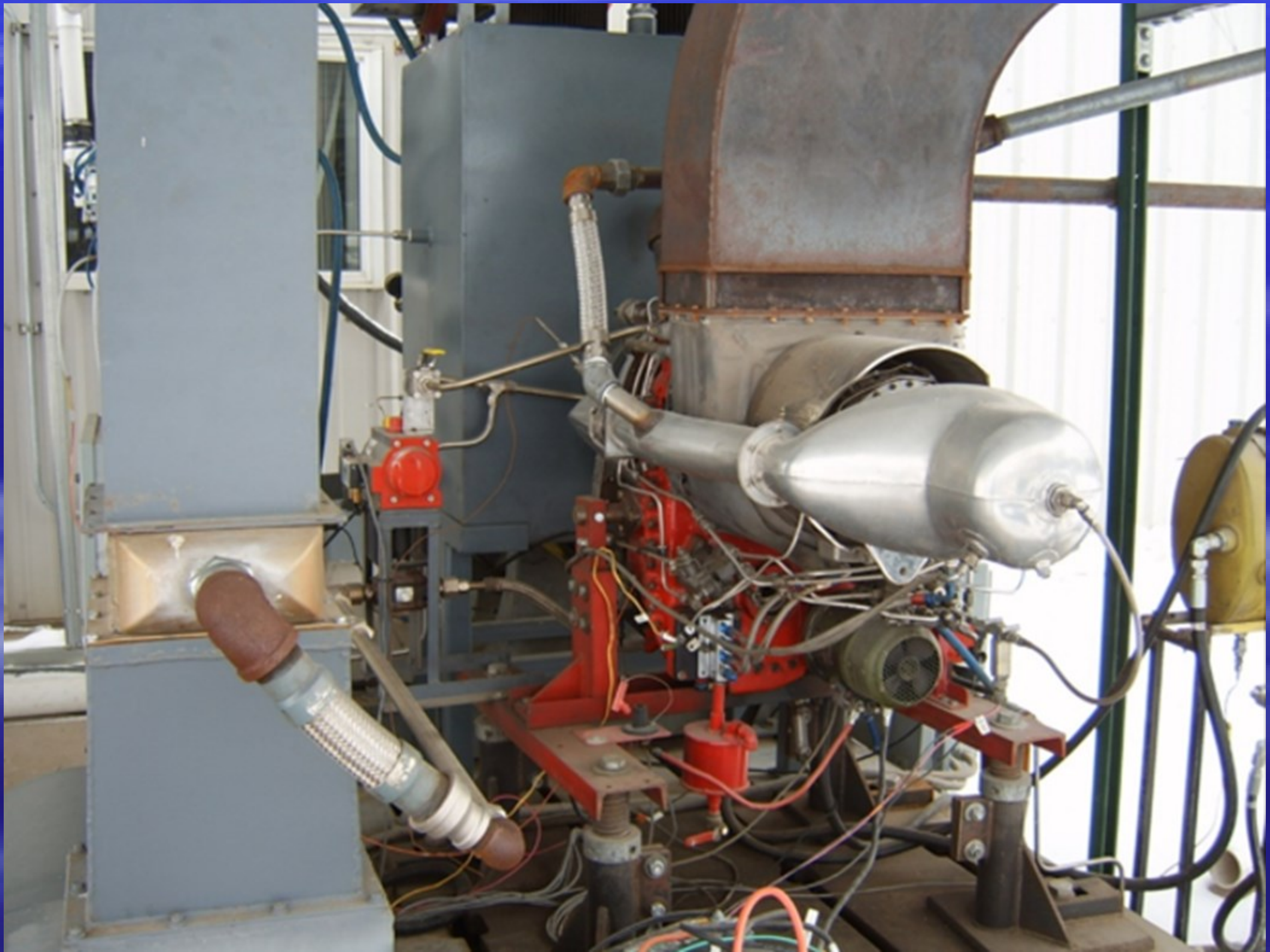
Source determination easy.



Source determination difficult plus confounding from cabin sources.

Much of the Available Data from VIPR Project

And from Associated FAA-ACER Project



Detection Requirements

Real-time sensing, detect within minutes if not seconds.

As a minimum, detect at levels associated with acute contamination events.

Hopefully, detect at much lower levels.

What Level of Contamination

VIPR: 1200 gr/h oil for ~20 kg/s air flow   17 ppm by mass

ACER: 60 gr/h oil for ~1.5 kg/s air flow   11 ppm by mass

Levels are associated with acute contamination events.

May need to detect at levels at least an order of magnitude less for low level contamination detection, i.e. oil contamination on the order of 1 ppm by mass.

Potential Markers

Carbon Dioxide

Carbon Monoxide

Total Volatile Organic Compounds (TVOC)

Specific VOCs

- Formaldehyde
- Acetaldehyde
- Other?

Specific Semi-Volatile Compounds (SVOC)

- Tricresyl Phosphate (TCP)
- Others?

Particles

- Ultrafine Particles

Other? List is not necessarily comprehensive

Carbon Dioxide

At the levels of oil contamination associated with an acute contamination event, CO_2 concentrations will be raised by a few ppm at most.

Given background levels around 400 ppm, CO_2 is not sufficiently sensitive to be useful.

Conclusion: No
But may be useful for indicating engine exhaust.

TVOC

VIPR: ~500 ppb rise in TVOC over background with ~17 ppm by mass of oil

Possibly useful at altitude with good sensor for acute contamination event.

Problematic for lower levels of contamination.

Background levels in urban environments limits usefulness on ground.

Sensors available but need to be demonstrated viable for this application.

Conclusion: Maybe

Formaldehyde

VIPR: ~300 ppb rise in formaldehyde over background with 17 ppm by mass oil

Low background levels. Should be effective for acute contamination event.

Possibly useful for low-level contamination.

Sensors available but need to be demonstrated viable for this application.

Possible confounding by engine exhaust on ground.

Conclusion: Promising

Acetaldehyde

VIPR: ~200 ppb rise in acetaldehyde over background with ~17 ppm by mass oil

Low background levels. Should be effective for acute contamination event.

Possibly useful for low-level contamination.

Sensors not as readily available as for formaldehyde.

Possible confounding by engine exhaust on ground.

Conclusion: Promising but formaldehyde probably better.

Other VOCs

Other VOCs present but at lower concentrations.

Nothing to indicate they would be better than formaldehyde or acetaldehyde.

Tricresyl Phosphate

VIPR: ~ 1 ppb with 17 ppm by mass oil

No real-time sensors readily available with the necessary detection levels.

Trend is to reduce or eliminate TCP in oil.

Conclusion: No

Ultrafine Particles

VIPR (Minimal Ingestion of Engine Exhaust)

Ambient:	~1×10^4 particles/cm^3
Bleed Air, No Oil:	~1×10^3 particles/cm^3
Bleed Air, Oil*:	~2×10^7 particles/cm^3

ACER (Significant Ingestion of Engine Exhaust)

Ambient, Engine Off	~2×10^4 particles/cm^3
Ambient, Engine On:	~2×10^5 particles/cm^3
Bleed Air, No Oil:	~2×10^5 particles/cm^3
Bleed Air, Oil*:	~2×10^7 particles/cm^3

* ~ 17 ppm by mass oil

Ultrafine Particles

Highly sensitive measurement. Certainly able to detect acute contamination event.

Should be able to detect contamination rates below 1 ppm of oil by mass if results scale to lower contamination rates.

Available sensors are expensive and not well suited for aircraft applications.

Conclusion: Very promising if suitable sensors become available.

Research Needs

Need to collect data at lower contamination concentrations to determine ability to detect low level contamination.

What works for oil may not work for hydraulic fluid; need data for hydraulic fluid.

High bleed air temperature key factor in producing VOCs and CO. High rotational speeds key factor in generating ultrafine particles. Need data for low power levels and for APUs. Is in-flight detection sufficient?

Discussion

Real time detection of acute contamination events is feasible. No technological breakthroughs required.

Detection does not have to be perfect to be useful. If we insist on perfect technology, it will never happen.

On-board sensing can be implemented in stages so we can learn as we go.

Recording for maintenance

↓

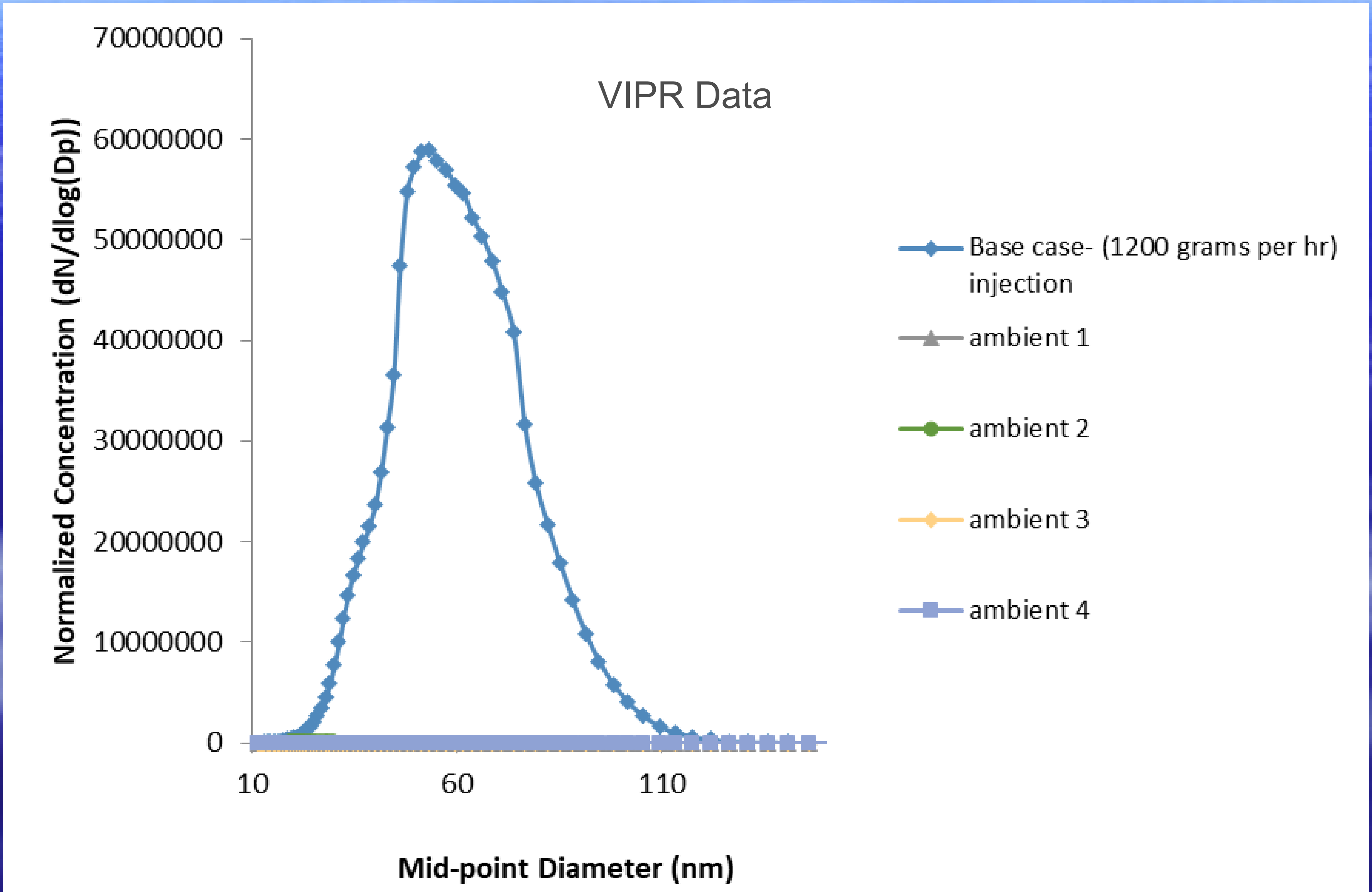
Displays and warnings in cockpit

You have to take the first step or you never get anywhere.

Questions

Further Discussion

Ultrafine Particles



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DeoxoTM Ozone and Ozone/VOC Converters: Essential for Cabin Clean Air

Victor Leung

Aircraft Cabin Air Conference
London, UK
September 2019

CLEAN AIR SOLUTIONS FOR AVIATION

- Introduction to BASF
- Deoxo™ ozone and ozone/VOC converters
- Converter life-cycle
- Converter maintenance

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BASF Overview

- We create chemistry for a sustainable future.
  - We source responsibly
  - We produce safely for people and the environment
  - We produce efficiently
  - We drive sustainable solutions
  - We value people and treat them with respect
- We are one of the world's leading companies in reporting on climate protection and sustainable water management
- Sales (2018): €62.7B
- Employees (2018): 122,404
- 6 Verbund sites and 355 other production sites

SUSTAINABLE DEVELOPMENT GOALS

FTSE4Good

CDP DISCLOSURE INSIGHT ACTION A LIST 2018 CLIMATE CHANGE

MSCI

ISS ESG ethix•climate•oekom

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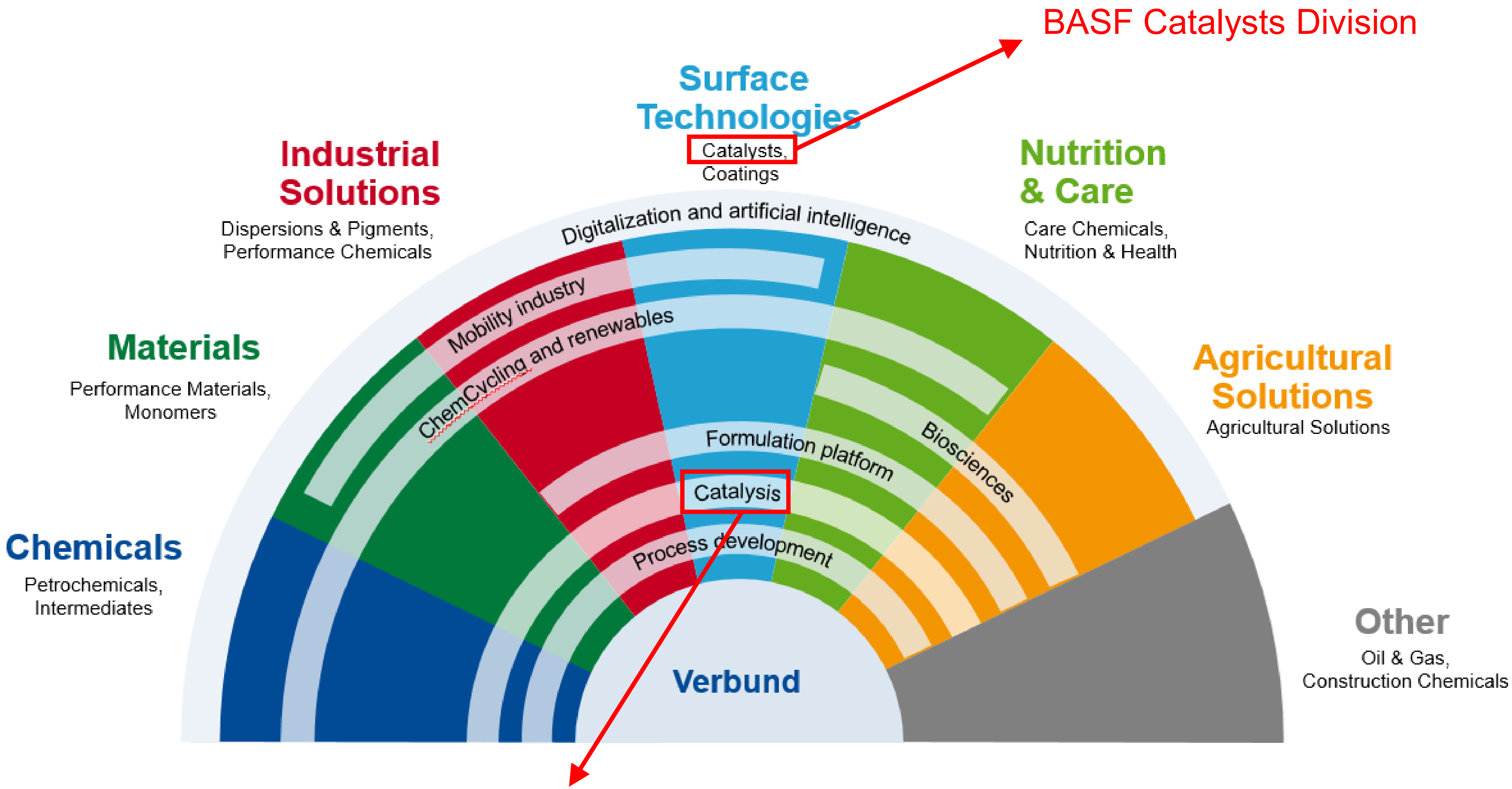
BASF Business Segments



Catalysis is one of the core technologies
that binds together the business segments within BASF

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BASF Catalysts Division
STRATEGIC BUSINESS UNITS

Mobile Emissions Catalysts

Emissions-control catalysts for cars, trucks, motorcycles

Chemical Catalysts

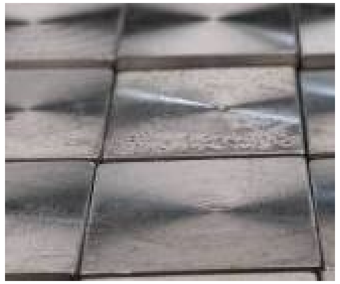
Chemical catalysts plus adsorbents

Refinery Catalysts

FCC catalysts and additives for oil refining

Battery Materials

Current and next-gen battery materials development



Precious & Base Metal Services

'Full-loop' metals distribution, financial services, recycling

Clean Air Solutions

Clean Air Solutions is committed to providing innovative solutions to the most complex emissions control problems for stationary, aerospace and indoor air.

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Clean Air Solutions
SERVED INDUSTRIES


Aircraft & Aerospace


Power Generation / Utilities


Industrial Manufacturing


Industrial Engines


Food Service


Indoor Air Quality

Matching chemistry & catalysis to solve sophisticated customer emissions challenges across a broad variety of industries & segments

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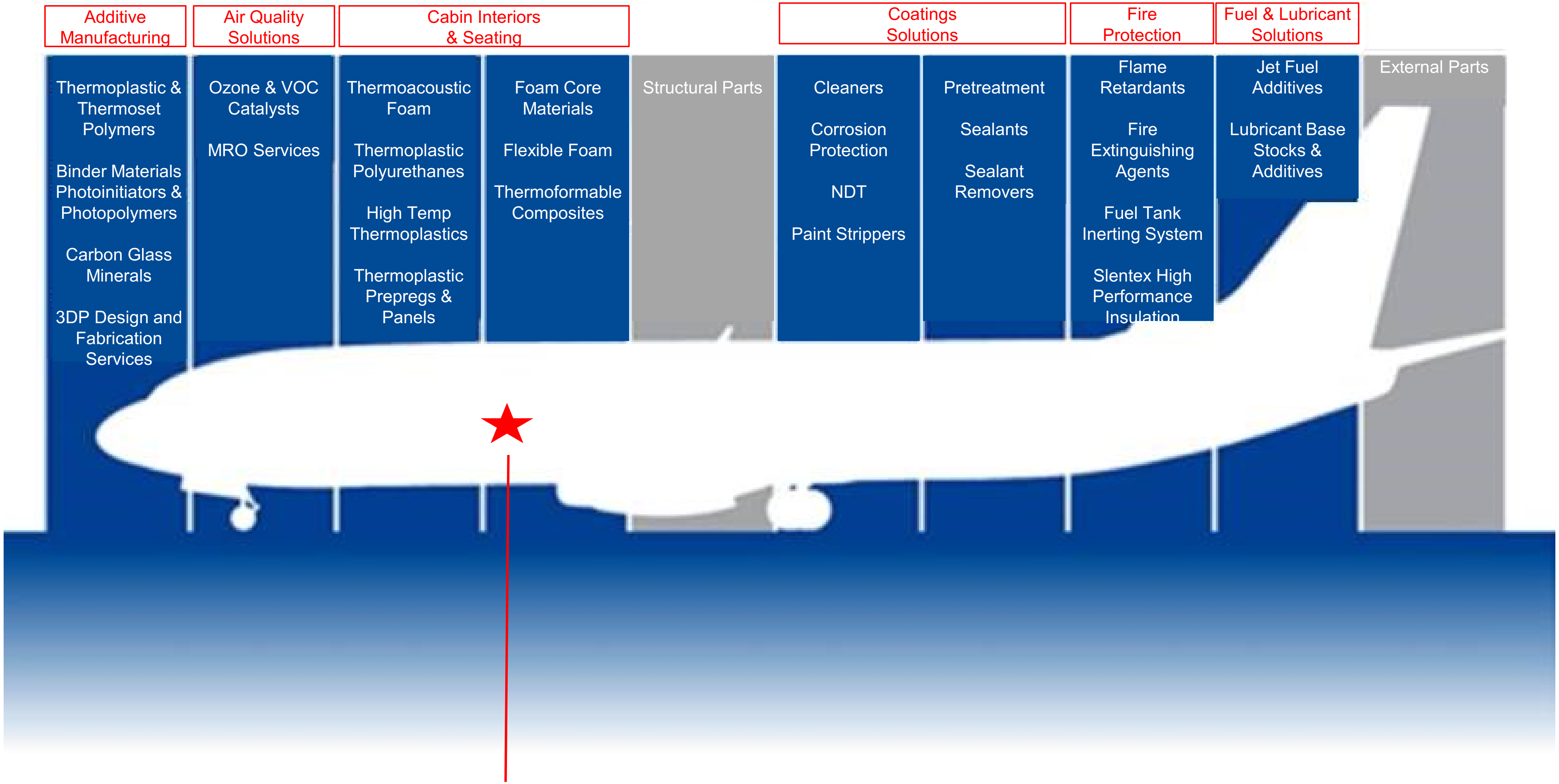
BASF PROVIDES AEROSPACE MATERIALS…



…AND TECHNOLOGY FOR CABIN AIR QUALITY

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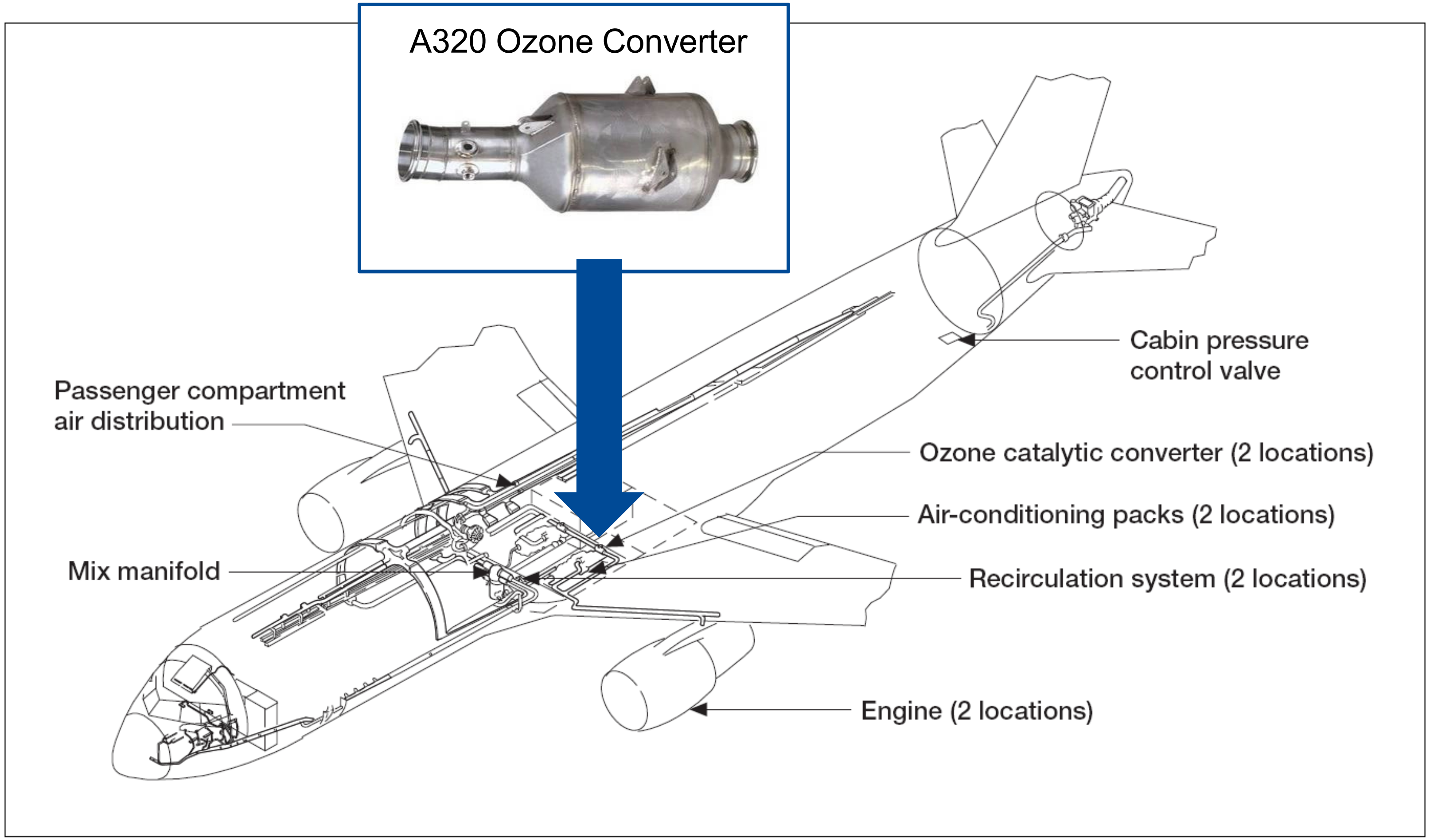
CONVERTER INSTALLED IN AIR CONDITIONING SYSTEM (ATA 21)



Engine Inlet ➞ Ozone Converter ➞ Air Conditioning Pack ➞ Mix Manifold ➞ Cabin

An A320 can be retrofitted with an ozone converter if it is not factory installed.

There is no disruption of existing ductwork and minimal installation time

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If you've flown over an ocean within the last 30 years…

…then you've likely breathed air
that has passed though a BASF ozone converter

A330/A340

Mandatory ozone equipment on wide-body aircraft

Optional on single-aisle aircraft

EJET E2

Standard equipment on latest regional jets

G650X

Enhances premium flight experience on business jets

A400M

Used on certain military aircraft to improve pilot performance

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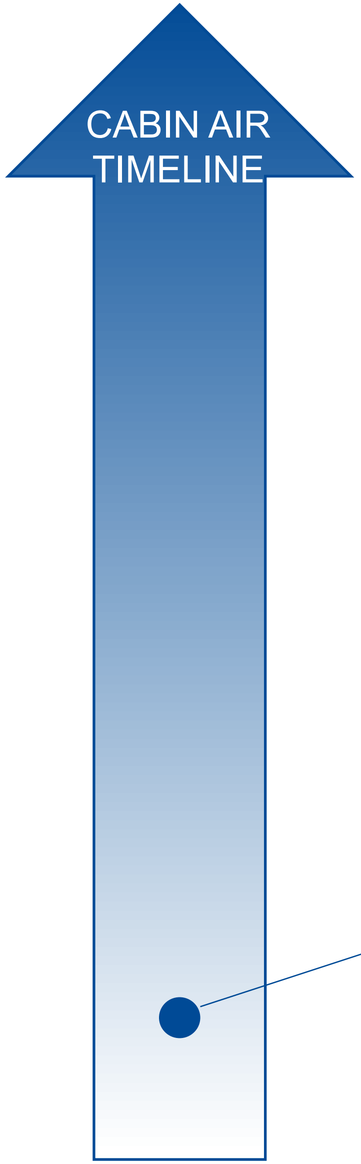


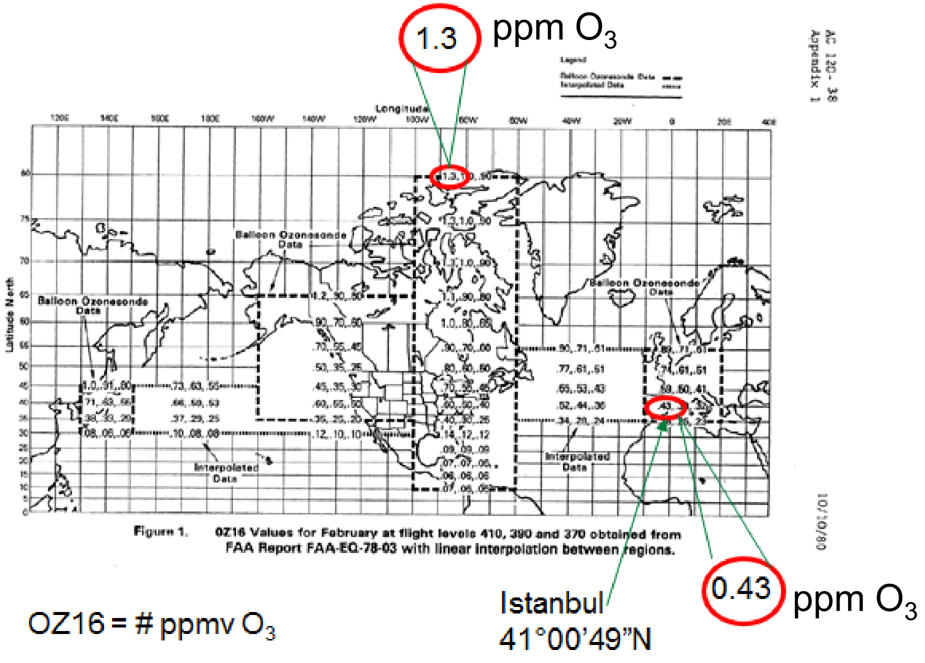
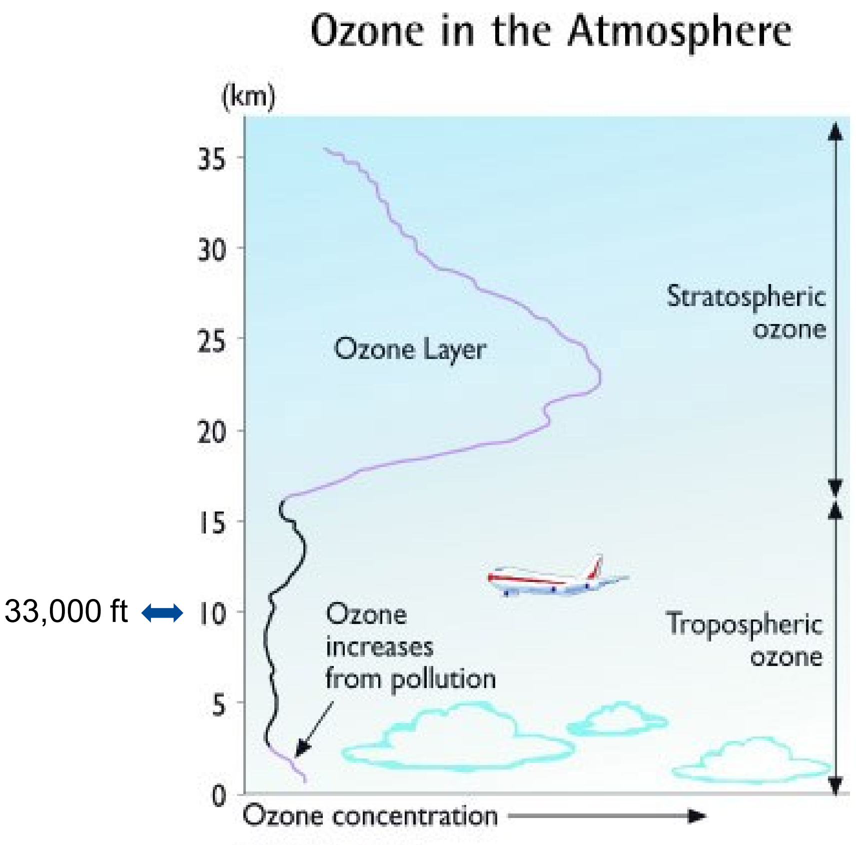


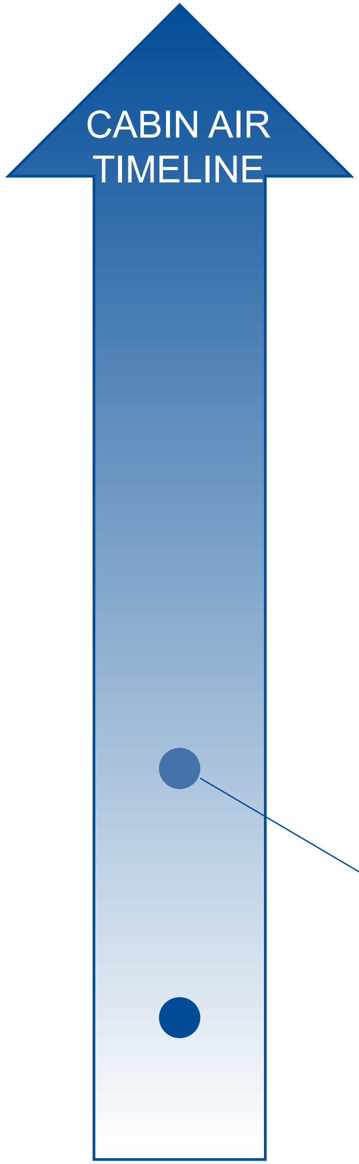
Figure 1. OZ16 Values for February at flight levels 410, 390 and 370 obtained from FAA Report FAA-EQ-78-03 with linear interpolation between regions.

OPEC oil embargo of 1973-74: higher fuel economies demanded of airplanes require them to fly at higher altitudes (> 27,000 ft ~8.2 km)

Atmospheric ozone concentration varies by altitude and latitude



©2004, ACIA



Cabin Ozone: A Potentially Serious 'Poison' At High Altitude

Patrick R. Veillette | *Business & Commercial Aviation* Mar 25, 2019

This article appears in the April 2019 issue of *Business & Commercial Aviation* with the title "Cabin Ozone."

Late 1970s – high ozone levels at these altitudes lead to observations of adverse health effects for crew and passengers

Prolonged exposure to high ozone concentrations has negative health impacts

- ✓ Breathing discomfort
  - Headaches
  - Eye, nose, and throat irritation
- ✓ Reduced lung function
  - Chest pains
- ✓ Adult onset asthma

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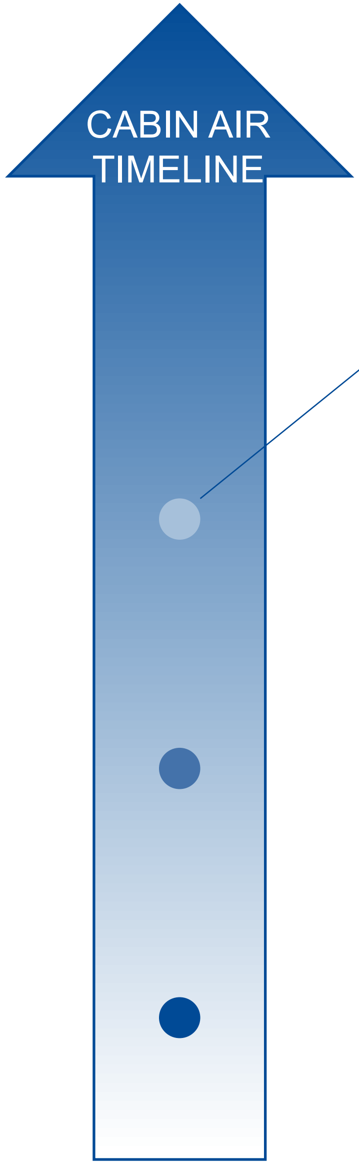

FAR 25.832 mandates maximum allowable cabin ozone level of 0.25 ppmv (SLE) at any time and a maximum time weighted average ozone concentration of 0.10 ppmv (SLE) during any 4 hour interval


DATE 10/10/80

ADVISORY CIRCULAR

DEPARTMENT OF TRANSPORTATION
Federal Aviation Administration
Washington, D.C.

FAR GUIDANCE MATERIAL

Subject: TRANSPORT CATEGORY AIRPLANES CABIN OZONE CONCENTRATIONS

PURPOSE. This advisory circular provides guidance concerning acceptable means ... for an air carrier to demonstrate compliance with the ... permissible cabin ozone (O_3) concentrations established by Section

AC: 120-38
10/10/1980

Note: SLE = Sea Level Equivalent

Methods of compliance:

- ✓ Modification of aircraft – install ozone converter technology
- ✓ Limit flight times (< 4 hours) and/or flight altitudes (< 18,000 ft)
- ✓ Statistical analysis that shows aircraft effectively meets the requirements by route selection and flight path
- ✓ Statistical analysis based on in-flight cabin air measurements for typical flight routes

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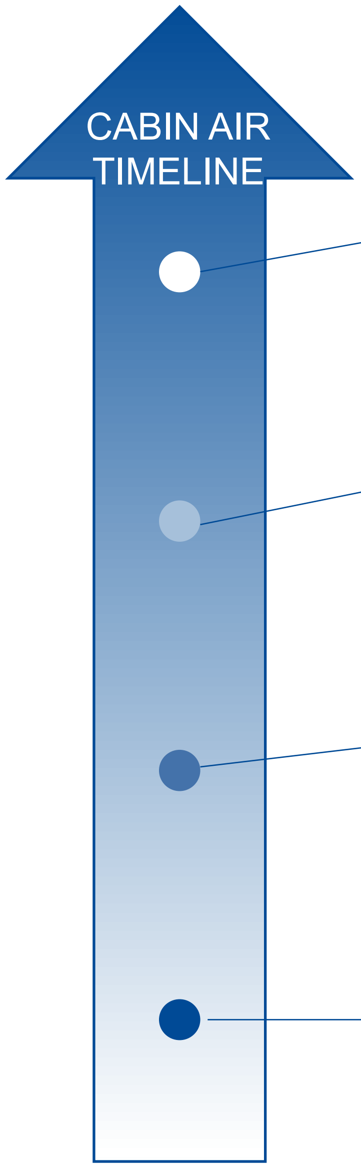
BASF HAS RESPONDED TO THE AEROSPACE MARKET FOR OVER 35 YEARS



2010s – BASF Clean Air Solutions technology development: formaldehyde catalyst, low temperature ozone catalyst, CO_2 sorbent

2004 – BASF (Engelhard) introduces ozone/VOC catalyst technology for aircraft cabin comfort

2000s – Industry development of Fuel Tank Inerting Systems (FTIS) relies on air separation membrane technology, which is protected by dedicated ozone converter.

1983 – First commercial application of ozone converter technology, pioneered by BASF (Engelhard) and field tested on Boeing 747

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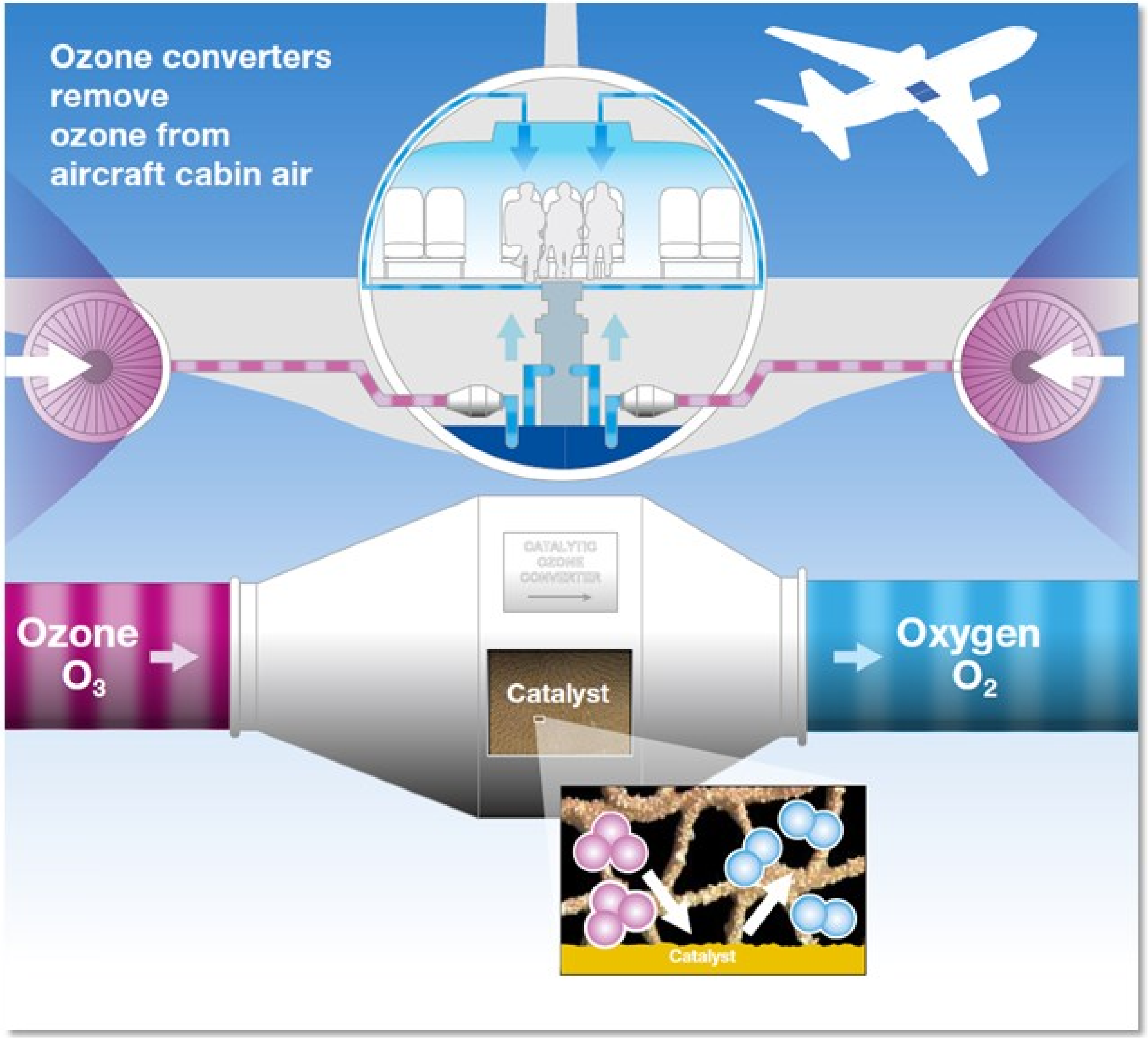


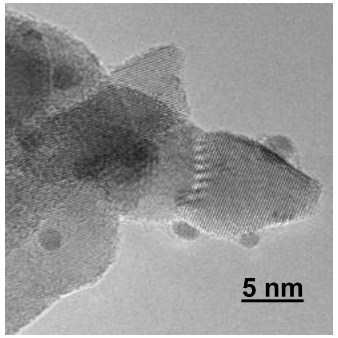
2☹$_3$ $\longrightarrow$ 3☺$_2$

Ozone decomposes to oxygen across catalyst

Catalyst is neither consumed nor altered by the chemical reaction

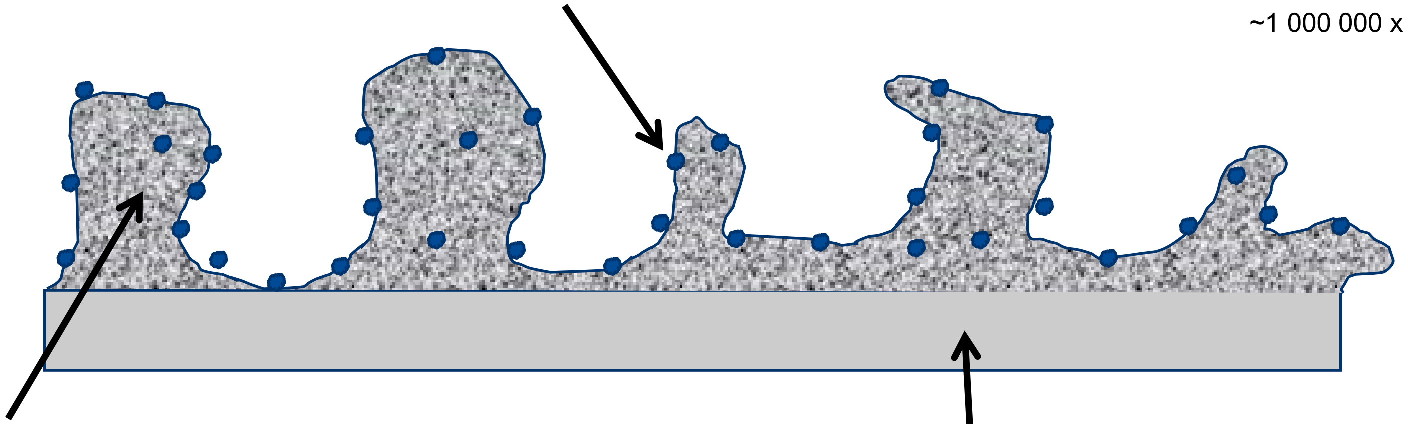
WHAT IS A CATALYST?
ACTIVE COMPONENT + WASHCOAT + SUBSTRATE

Active component (e.g. precious or base metal) dispersed through a high surface area washcoat applied to a substrate, such as a ceramic honeycomb block or a corrugated metal foil.



~1 000 000 x magnification

Active site (component) for catalysis



Carrier (washcoat) provides high surface area

Substrate

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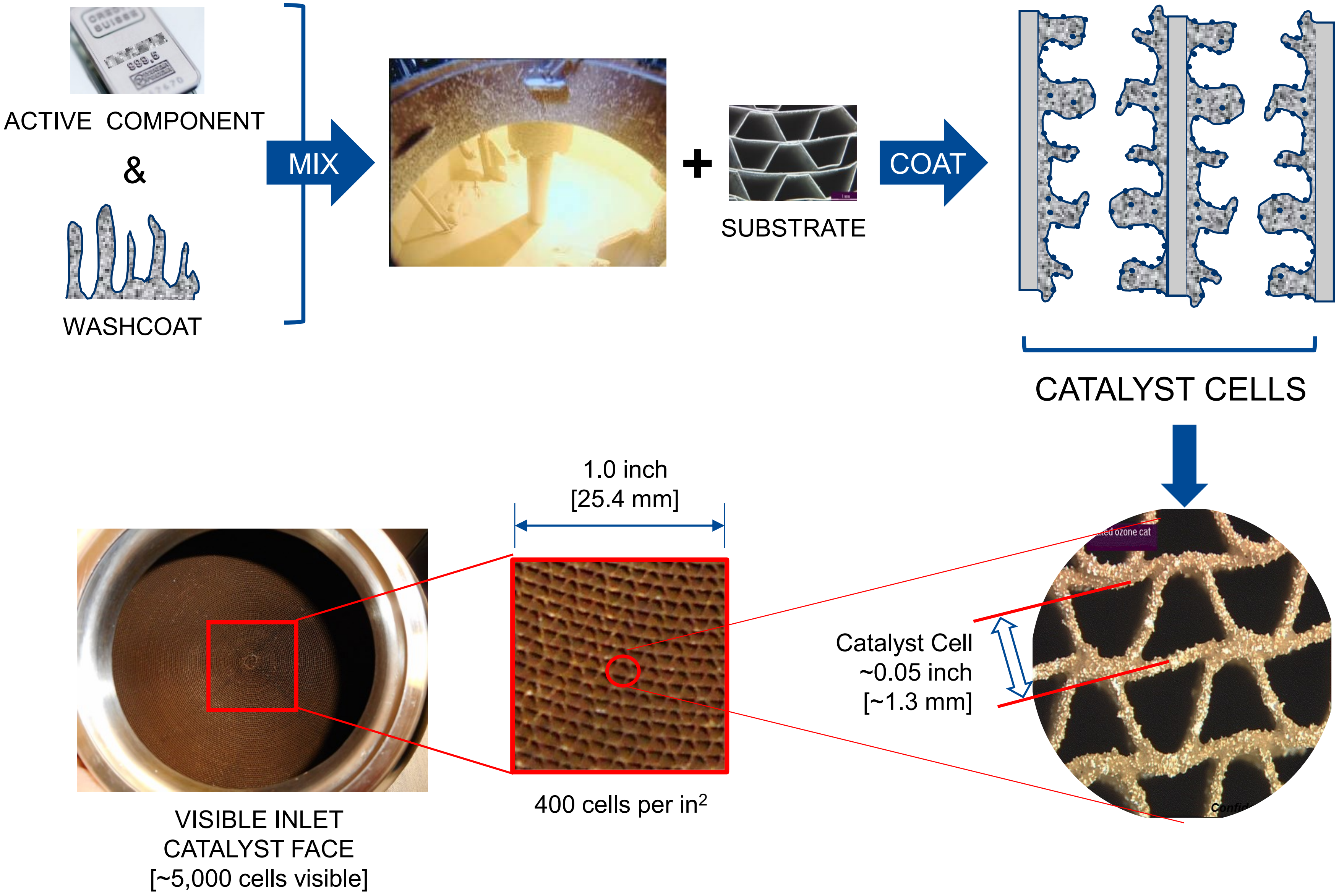

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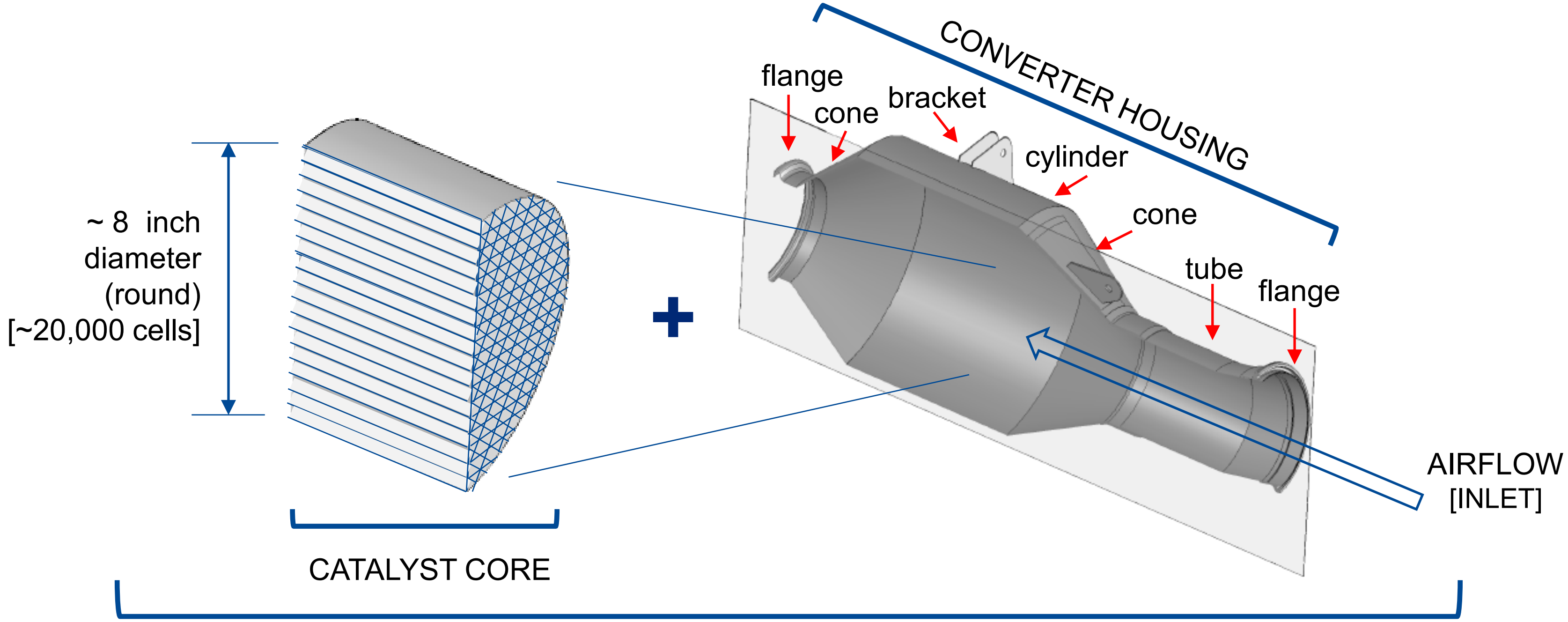
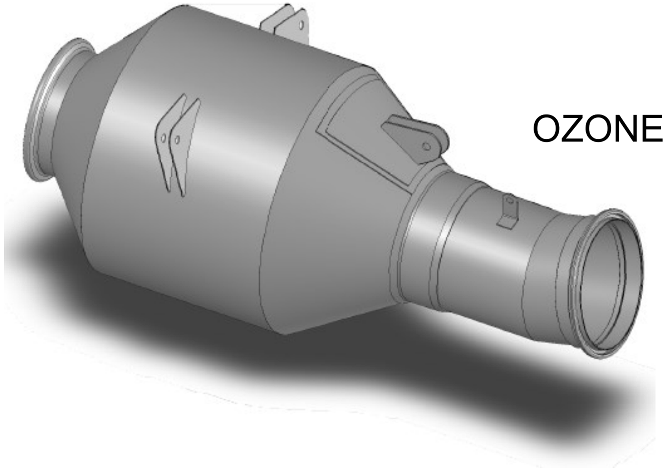
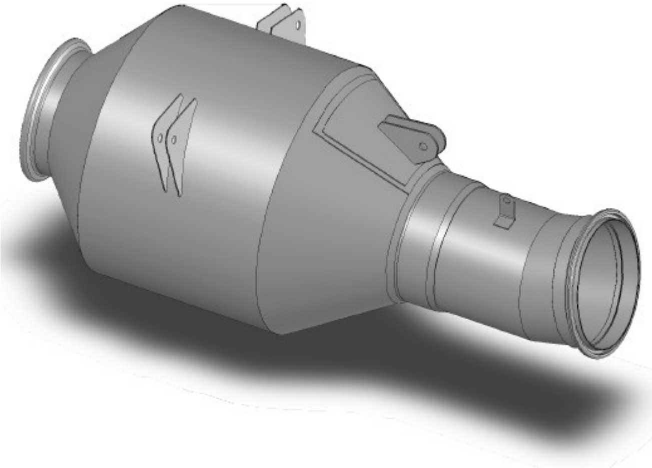




OZONE CONVERTER*

WHAT IS A CONVERTER?



Custom Engineered Technology

A Flying, Pressurized Chemical Reactor

~~Ozone Filter~~

Clean Air Solution for Aircraft Cabins

Converters are subject to aircraft industry and customer design qualification requirements:

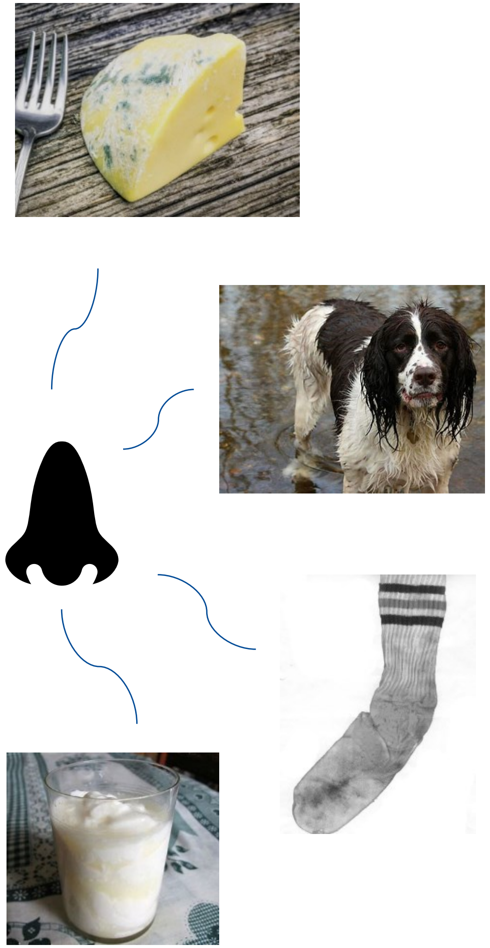
- ✓ Electrical bonding resistance
- ✓ Weight
- ✓ External leakage
- ✓ Proof pressure
- ✓ Burst pressure
- ✓ Ozone conversion, new
- ✓ Ozone conversion, end of life
- ✓ Total pressure loss
- ✓ Sand and dust
- ✓ Fungus resistance
- ✓ Salt fog
- ✓ Endurance & fatigue
- ✓ Interface loads
- ✓ Reliability
- ✓ High temperature
- ✓ Low temperature
- ✓ Temperature variation
- ✓ Altitude
- ✓ Humidity
- ✓ Fire & flammability
- ✓ Icing
- ✓ Operational acceleration
- ✓ Operational shocks
- ✓ Operational vibration
- ✓ Crash safety sustained
- ✓ Crash safety shocks
- ✓ Windmilling
- ✓ Explosion proofness
- ✓ Water proofness
- ✓ Fluid susceptibility

POTENTIAL SOURCES OF CABIN ODOR

- VOCs [Volatile Organic Compounds] enter the bleed air stream due to
  - Ingestion of other aircraft and/or airport vehicles engine fume exhaust while on ground or taxiing
  - Ingestion of de-icing fluids
  - Hydraulic fluid leaks
  - Engine oil leaks during operation (fume event)
  - Oil coated vent ducts (desorption)

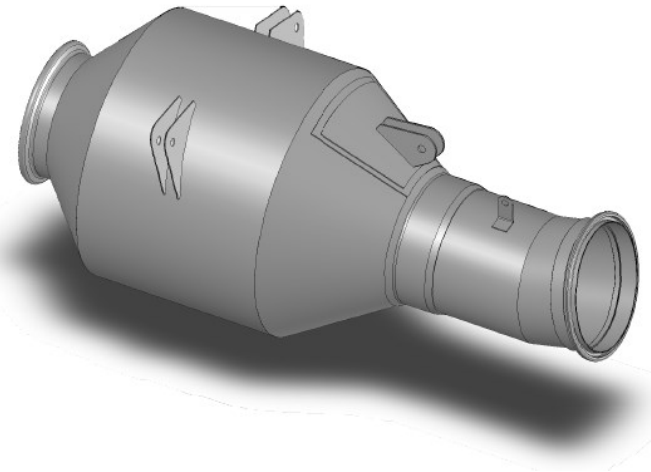
Odor is <u>the</u> most significant memorable environmental variable on an aircraft

Comfort pyramid per Bubb, H.
Komfort and Diskomfort. Ergonomie Aktuell Ausgabe 4. 2003



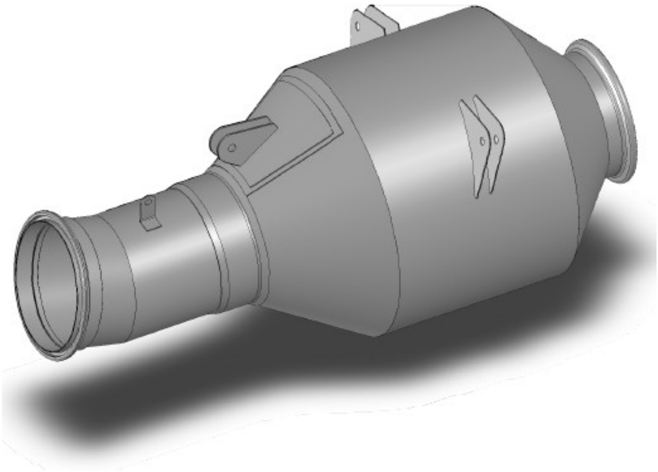
TO MITIGATE CABIN ODOR, BASF DEVELOPED THE OZONE/VOC CONVERTER

SAME PHYSICAL ITEM…



OZONE CONVERTER

$$2O_3 \longrightarrow 3O_2$$



OZONE/VOC CONVERTER

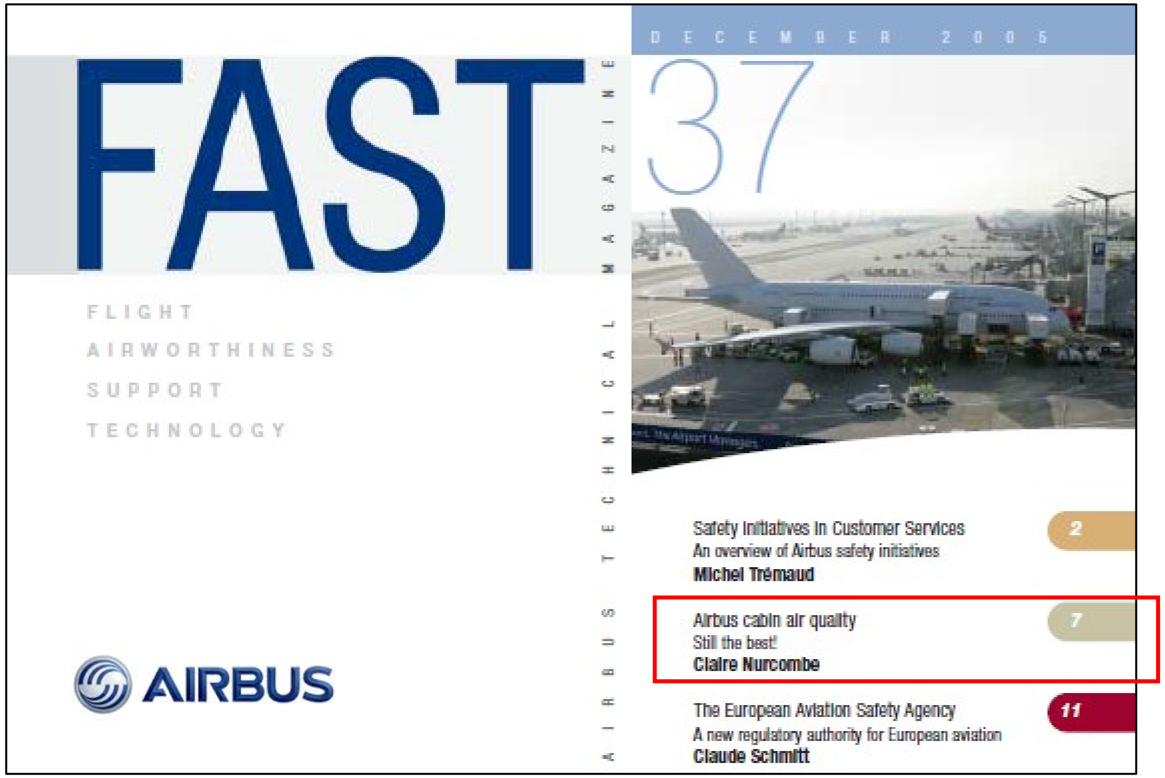
$$2O_3 \longrightarrow 3O_2$$

$$VOC + O_2 \longrightarrow CO_2 + H_2O$$

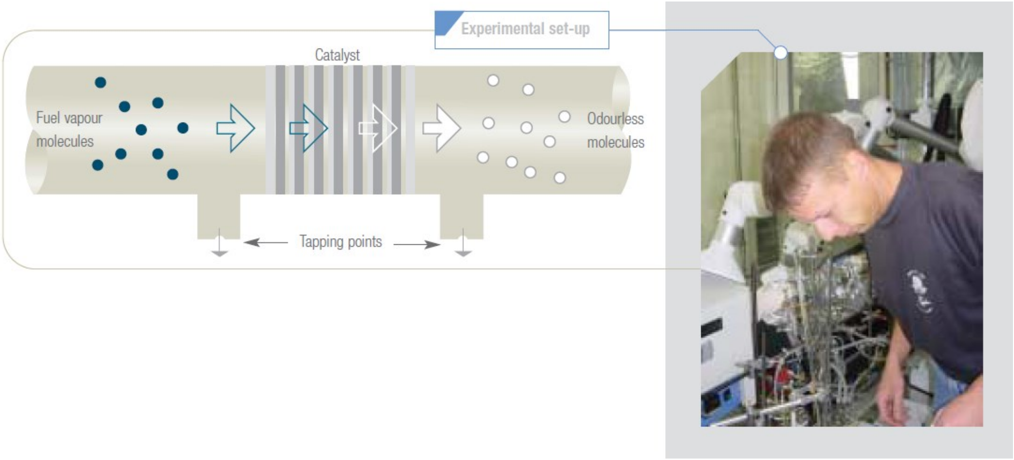
…BUT WITH ADDITIONAL CHEMISTRY*

An ozone converter can be "upgraded" to an ozone/VOC converter with no disruption to existing ductwork, no disruption to ozone conversion rates, and no disruption to existing maintenance service cycles

* - Currently available on Airbus platforms only



FAST
DECEMBER 2005
37
FLIGHT
AIRWORTHINESS
SUPPORT
TECHNOLOGY
AIRBUS TECHNICAL MAGAZINE
AIRBUS



BASF and Airbus worked together to demonstrate by test the efficacy of the ozone/VOC converter to mitigate odor in the aircraft cabin

EXPERIMENTS WITH JP1 JET FUEL – SUMMARY OF RESULTS

	Odor Intensity (0 to 6)	Hedonic odor tone (-4 to +4)	Acceptability [decipol] (0 to 31)	Panel members perceiving fuel odor [%]	Total HC (FID) [ppm]
Upstream	2.6	-0.8	8.7	80	3.0
Downstream	2.3	-0.8	8.4	77	3.0
Downstream w/ VOC catalyst	1.5	0.1	3.0	36	2.4

40% improvement

60% improvement

20% improvement

Hedonic odor tone is improved; downstream the odor is described as slight pleasant, while upstream it is described as a little unpleasant.

The number of panel members perceiving a fuel odor is much smaller downstream when the O_3/VOC catalyst is in place.

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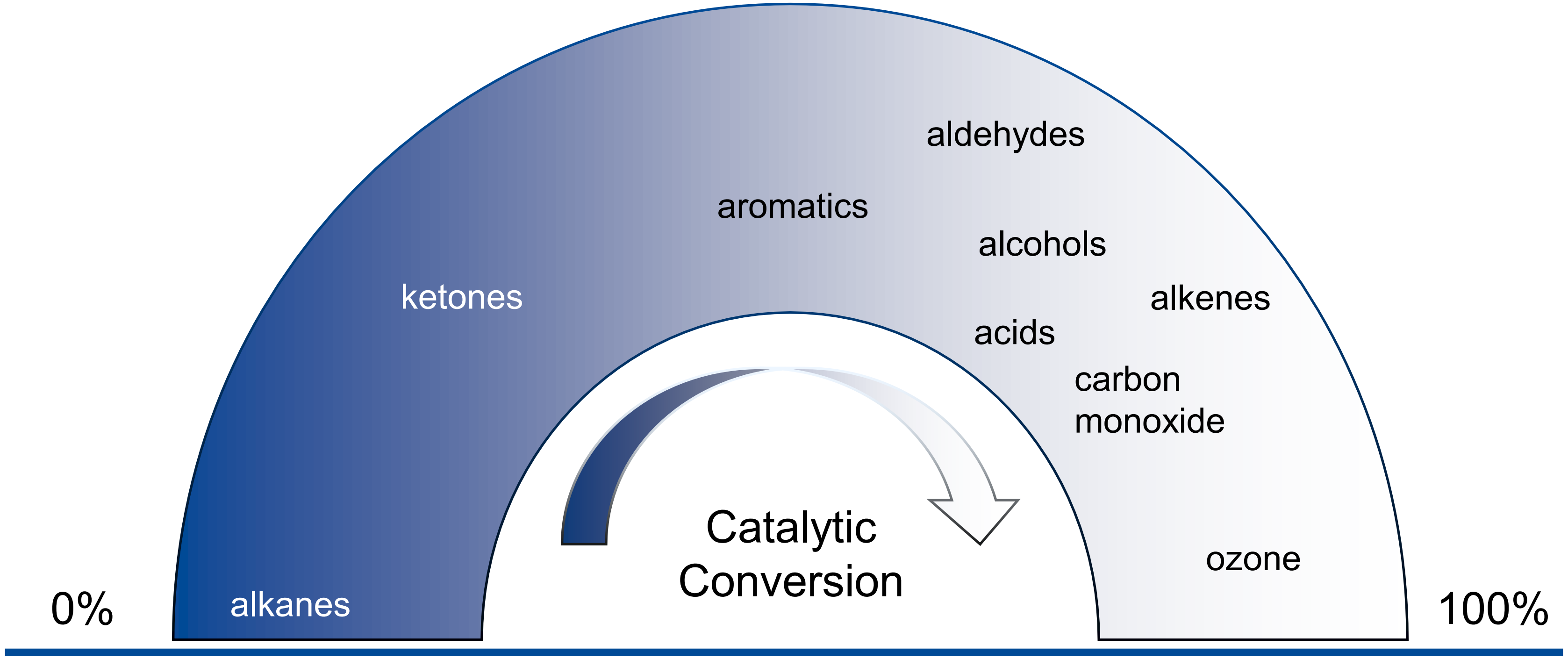
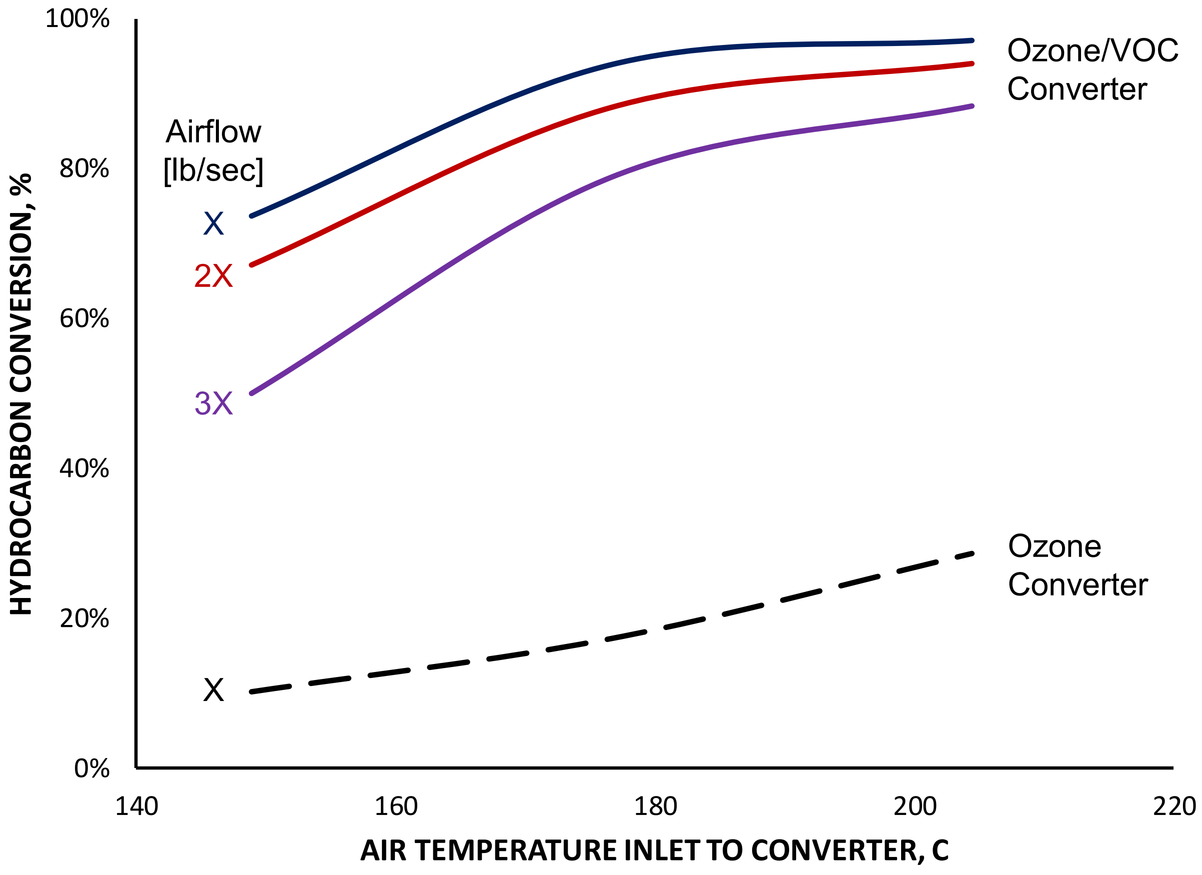
Ozone/VOC converter provides a spectrum of performance for VOC compounds



VOC conversion is compound, converter, catalyst, and operating condition specific

Ozone/VOC v. Ozone converter performance
BTEX hydrocarbon compound mixture



BTEX = Mixture of benzene, toluene, ethyl benzene, and xylene

Ozone/VOC converter provides significantly greater hydrocarbon conversion than ozone converter

Performance shown for initial converter performance
(0 flight hours)

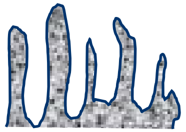
Deoxo™ Ozone and Ozone/VOC Converters

Deoxo™ Catalyst Benefits	Ozone Converter	Ozone / VOC Converter
Regulatory compliance with cabin air ozone concentration requirements	✓	✓
Lightweight, easy-to-install (retrofit), and superior catalyst life with proven performance	✓	✓
Reduces jet-fuel odor in the cabin, improving cabin comfort	n/a	✓

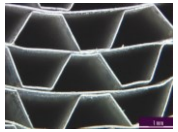
COMPLIANCE & COMFORT

ACTIVE COMPONENT

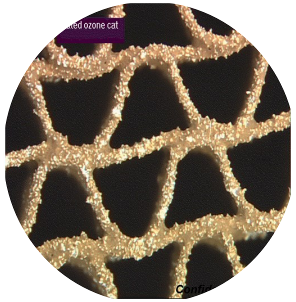
&



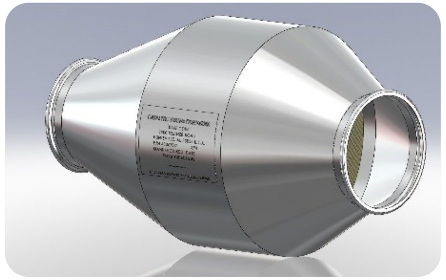
WASHCOAT



SUBSTRATE



CATALYST



CONVERTER

INSTALLED CONVERTERS ARE ONLY PART OF THE EQUATION …
PROPER MAINTENANCE IS ESSENTIAL

- Ozone converters are rotables and must be maintained properly to ensure effective performance and regulatory compliance with cabin air standards
- Poorly or improperly maintained converters do not guarantee continued performance
- As MRO, BASF has the breadth and depth of knowledge to maintain the catalyst performance in a manner that leverages the original design and thereby extends converter useful life

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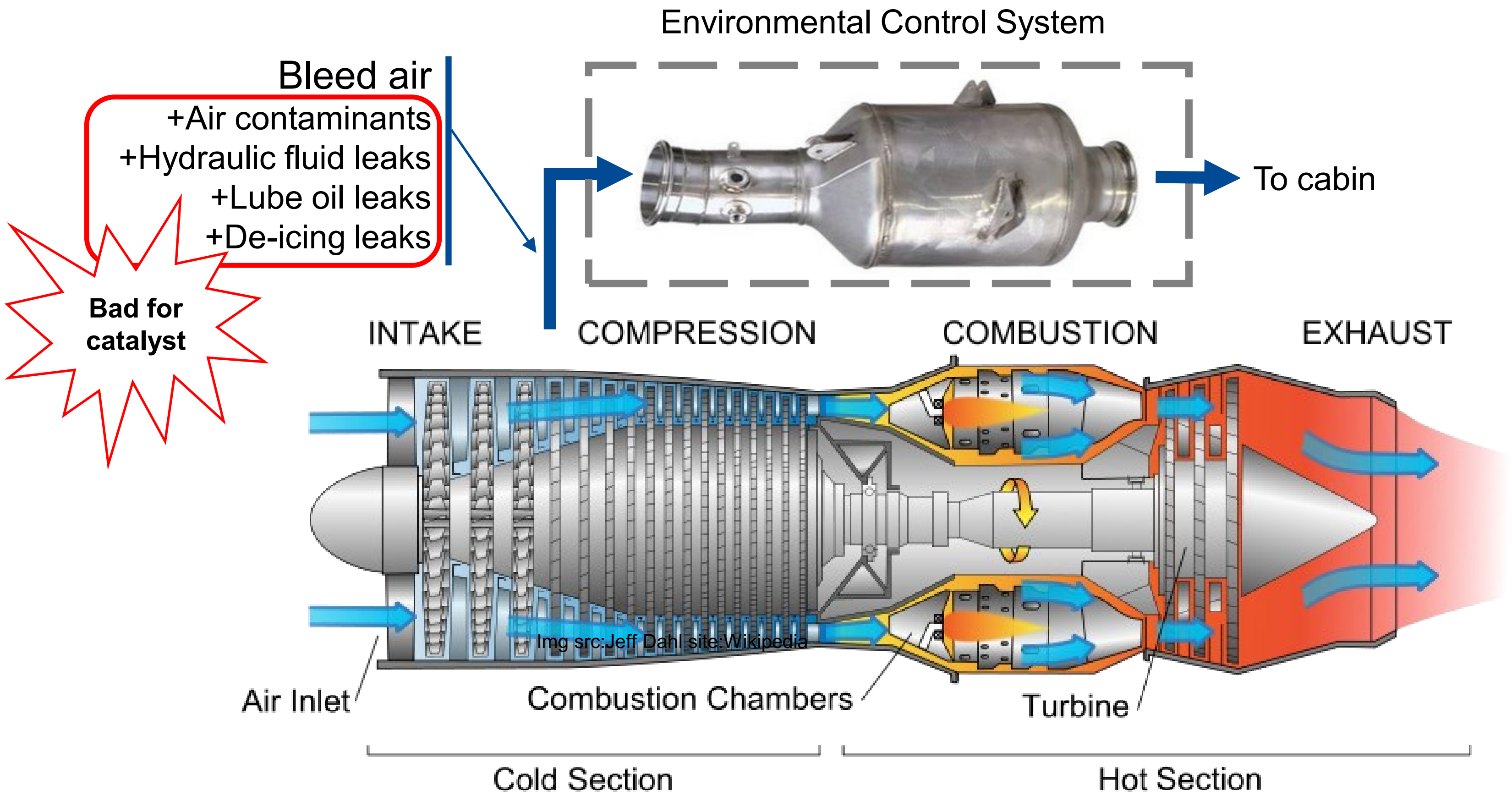
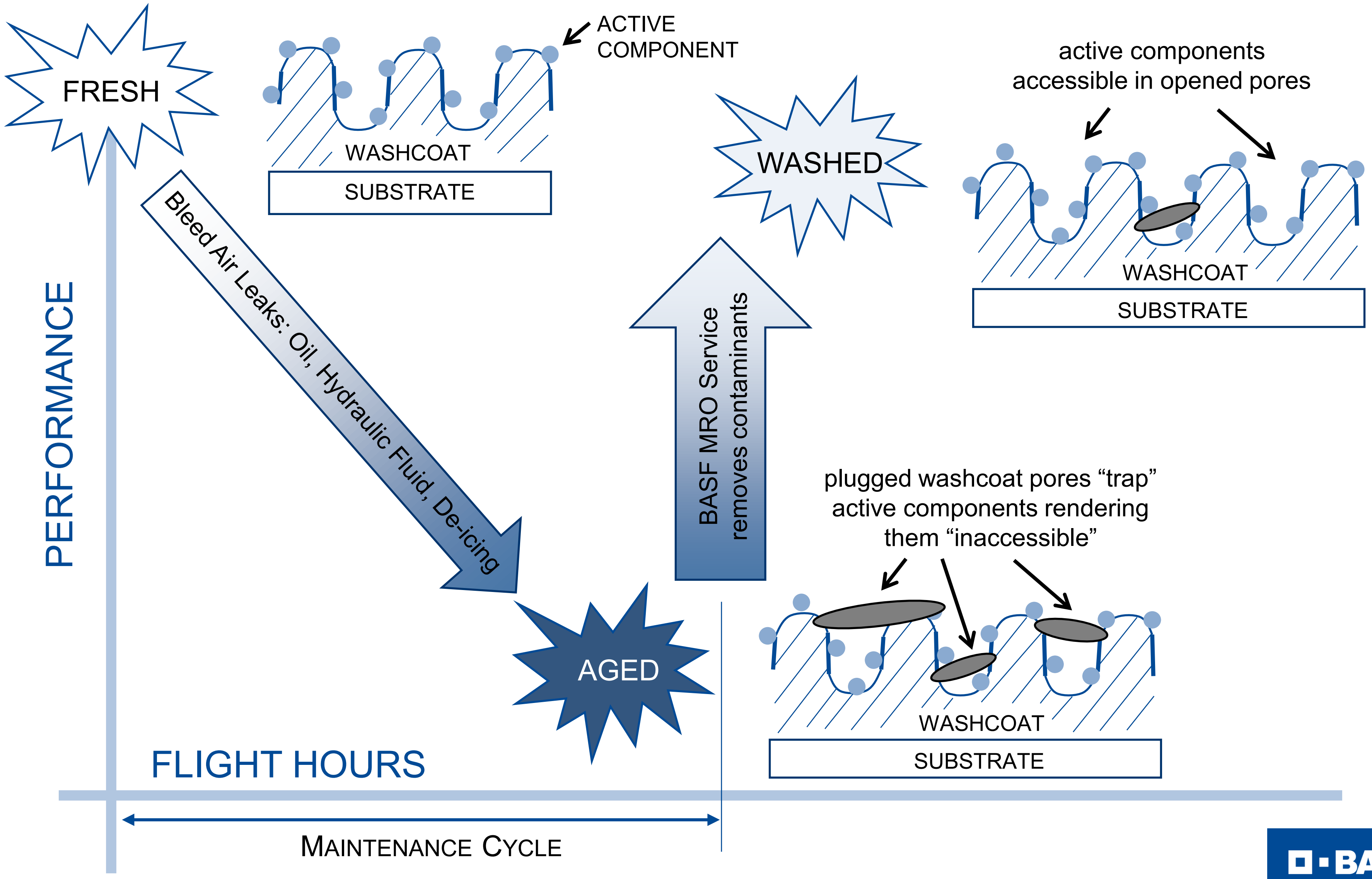
Catalyst contaminant exposure is intrinsic to Ozone (VOC) Converter application

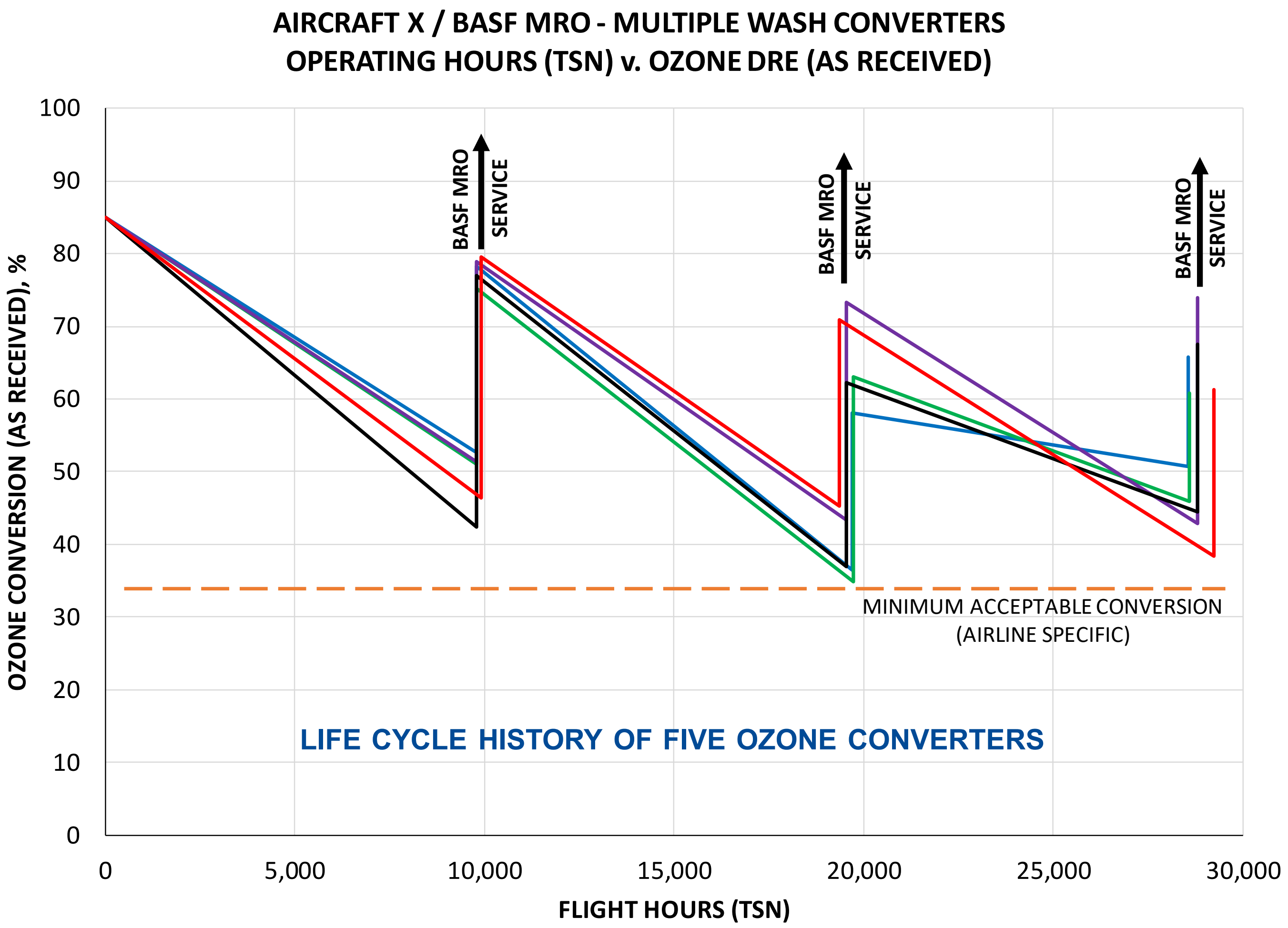


Img src:Jeff Dahl site:Wikipedia

CONTAMINANTS "AGE" THE ~~CONVERTER~~ CATALYST



CONTAMINANT REMOVAL RENEWS ~~CONVERTER~~ CATALYST ACTIVITY



BASF MRO converter [catalyst] service preserves the active component and pore structure of the catalyst.

This preserves the catalyst aging characteristics for reliable, predictable performance

When washing no longer restores sufficient activity, the converter can be “recored” – the aged catalyst core is replaced with fresh catalyst

Reference: BASF MRO Service Database (proprietary)
Aircraft X / Airline Y

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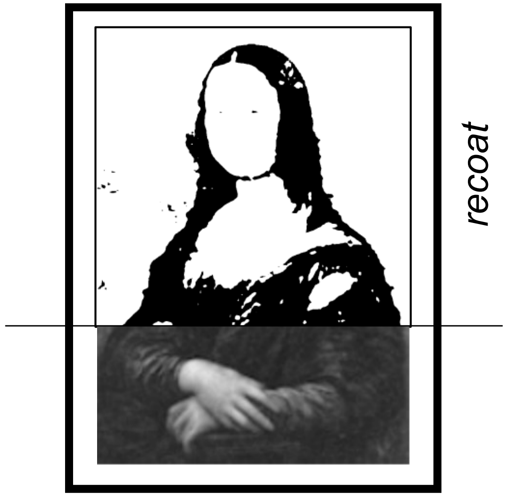
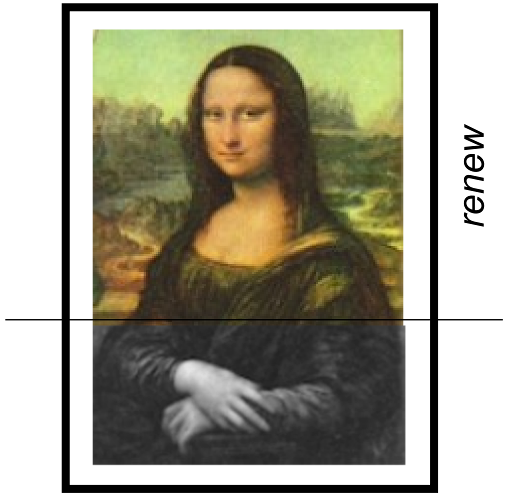
COMPARISON OF ~~CONVERTER~~ CATALYST SERVICE METHODS





STRIP & RECOAT

Not quite like the original, but close enough?

RENEW BY DEEP PORE CLEANING

BASF MRO

Preserves catalyst pore structure for enduring value and performance

OVERCOAT WITH DIFFERENT ACTIVE COMPONENT & WASHCOAT

Paints a different picture but it still fits the original's frame

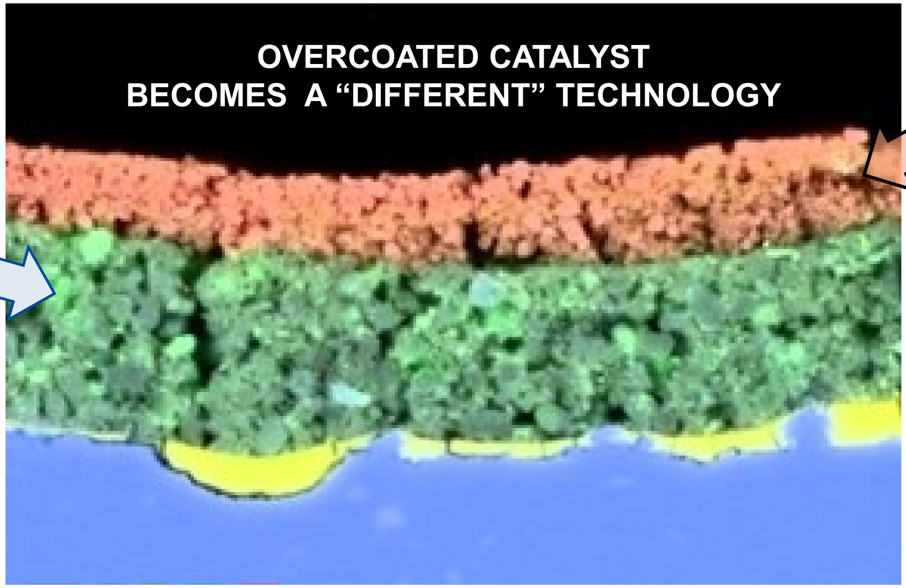
AN OVERCOAT CHANGES THE CATALYST SURFACE AND DILUTES THE INVESTMENT IN CLEAN AIR TECHNOLOGY

BASF Catalyst

Original technology

Precious metal
active component

Porous washcoat for
extended service life
in application



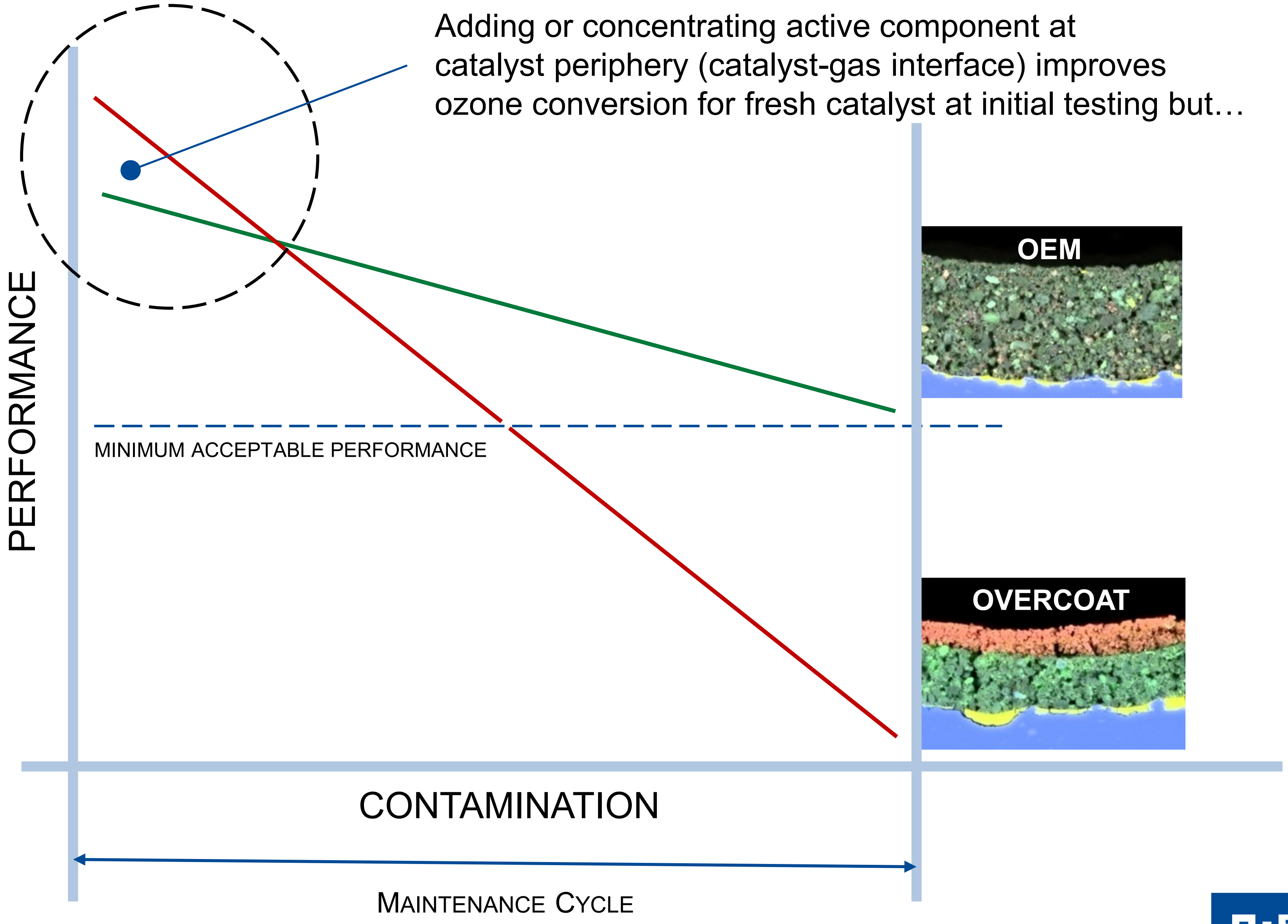
Third-Party Servicing:

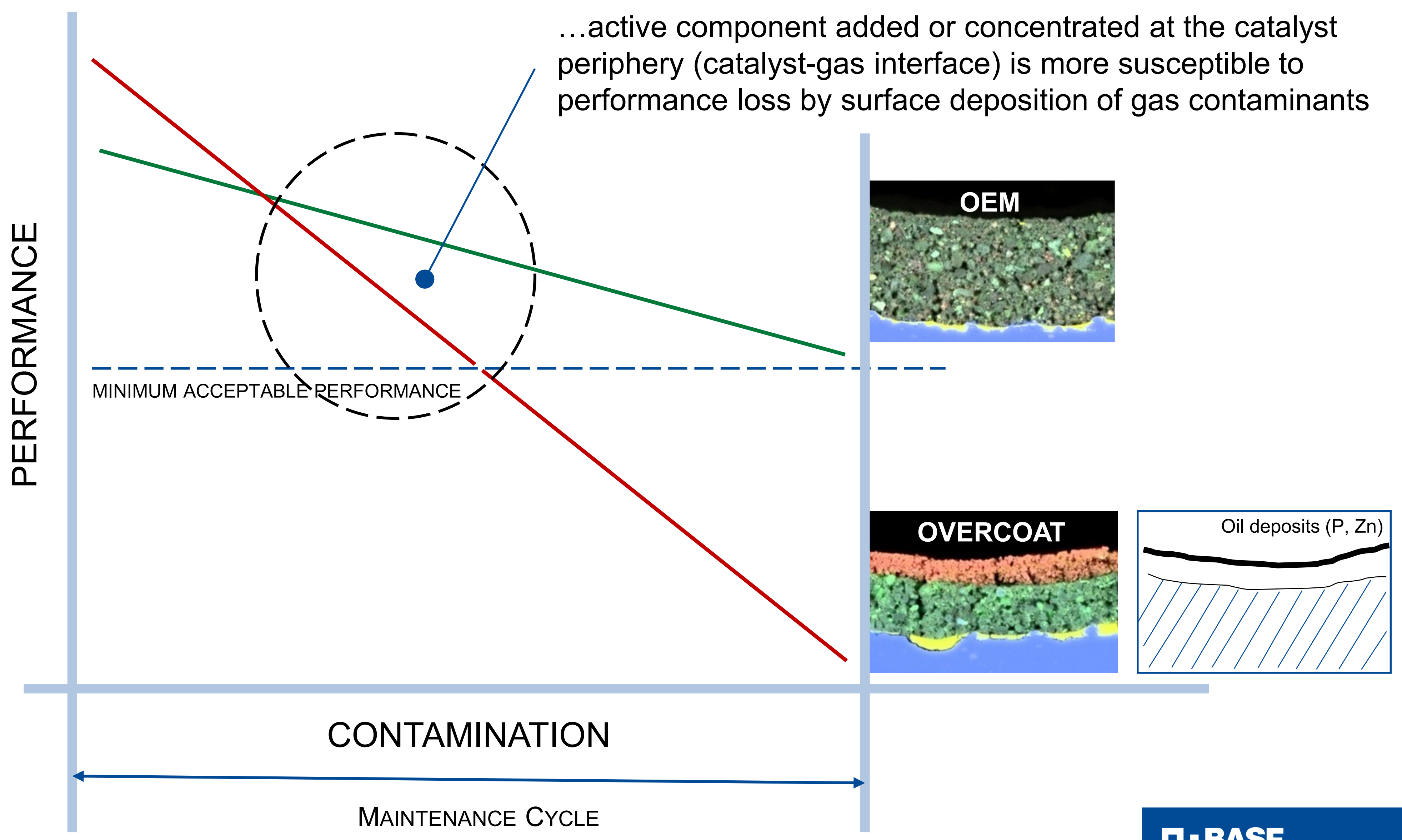
Overcoat technology

Base metal
active component

Dense washcoat
constricts access to
underlying original
catalyst layer

**DIFFERENT CATALYST SURFACE
EQUALS
DIFFERENT TECHNOLOGY**


Adding or concentrating active component at catalyst periphery (catalyst-gas interface) improves ozone conversion for fresh catalyst at initial testing but…
PERFORMANCE
MINIMUM ACCEPTABLE PERFORMANCE
OEM
OVERCOAT
CONTAMINATION
MAINTENANCE CYCLE



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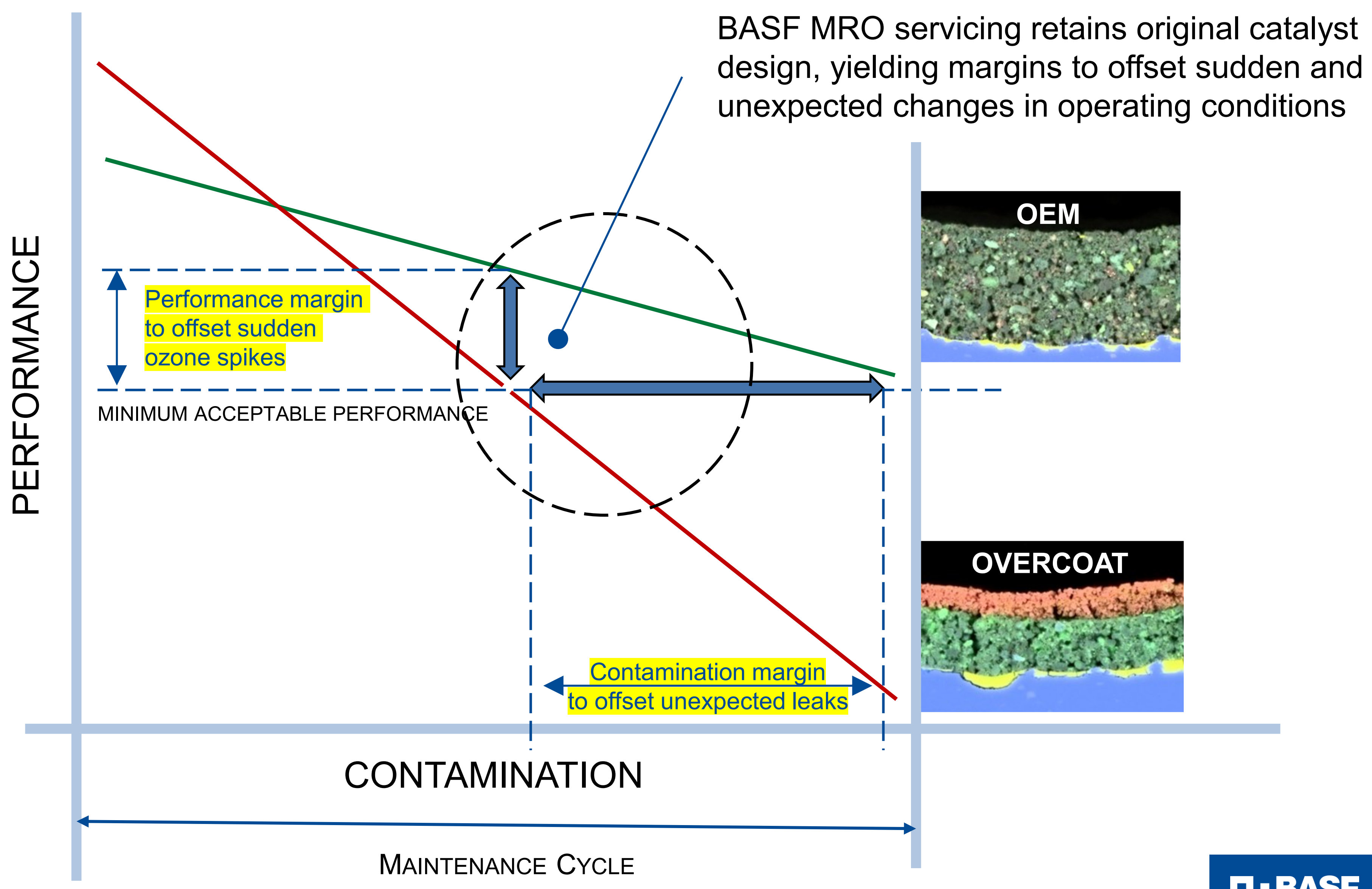

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WHY SHOULD YOU CARE WHO SERVICES THE CONVERTER?

PERFORMANCE

Operational margin:
MRO service by OEM

Because you want operational margins:

- ✓ There are no ozone sensors in the aircraft cabin to alert a converter performance failure
- ✓ Contamination is not a predictable event
- ✓ Converter maintenance is a pre-scheduled activity (C check)

The risk, and consequence, of converter non-performance is born by the aircraft occupants…

Operational margin:
MRO service by OEM

CONTAMINATION

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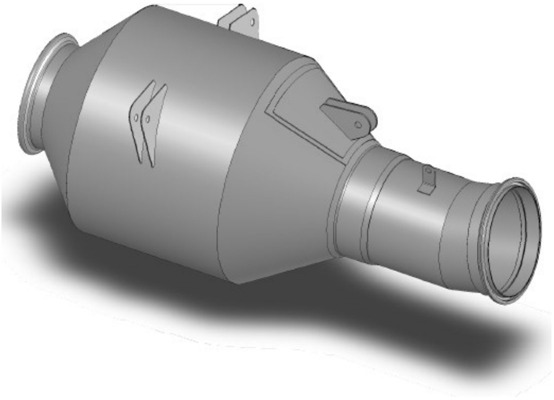
PROPERLY SERVICED, CONVERTERS ARE AN INVESTMENT IN CLEAN AIR THAT RETAINS VALUE OVER THE LIFE OF THE AIRCRAFT



BASF MRO Services

- ✓ Performance test
- ✓ Chemical wash to remove contaminants and renew pore structure of catalyst
- ✓ Converter recore to replace catalyst core within existing structure

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We create chemistry

THE AIRCRAFT IS YOUR WORKSPACE AND YOU DESERVE QUALITY CABIN AIR

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Summary

- BASF has been involved in aircraft cabin clean air issues for over 35 years; **we develop**ed the ozone and ozone/VOC **technology in response to market and customer needs**
- Having an ozone or ozone/VOC converter installed is only part of the equation; **converters must be properly maintained** to ensure continued performance
- **BASF** is very interested in working with all major stakeholders to further **develop solutions** for ever evolving aircraft cabin air issues
- We'd like to **thank you** for the opportunity to discuss these issues today; ultimately, each and every one of you is our end use customer

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Countess of Mar

Closing Speech

International

Aircraft Cabin Air Conference 2019

Imperial College London

17/18 September 2019

Ladies and Gentleman Good Afternoon

I am the Countess of Mar and a co-patron for the GCAQE.

I hope you will agree with me that the 30 speakers we have been privileged to listen to over the last 2 days have again clearly shown us that contaminated air on aircraft is very real and the problem must be resolved.

It is 10 years since the distinguished British Air Accident Investigation Department recommended that contaminated-air detection systems be fitted to passenger aircraft. Still no aircraft flies today with any warning systems fitted. It is not only unbelievable but clearly shows us that our aviation regulators are failing to show the leadership, respect and common sense this issue deserves.

It makes sense that a warning system on an aircraft to alert pilots and crew when the air contains hazardous chemicals should be a statutory requirement. Instead Her Majesty's Government hide behind the cloak of EASA when it comes to decision making.

Two years ago I stood here beside Captain Niels Goner. He and his co-pilot were totally incapacitated due to oil fume exposure on the descent to Malmo nearly 15 years ago. They were lucky to survive. The harsh reality is that the industry has been negligent in failing to act. Here, I applaud Eastman for the unambiguous labelling of their 2197 synthetic jet engine oil: “Do not breathe mist or vapour from heated product.” Why do not the other manufacturers follow their lead?

Contaminated air is not just a jet engine oil issue. Countless swab tests remind us this is also an issue of exposure to hydraulic fluids.

Hydraulic fluid cans come with a warning such “Suspected of causing cancer”. In doing so manufacturers have made the risks very clear but why has virtually no passenger or crew-member ever seen such warnings?

My interest in toxic chemical exposures, like that of many others, comes from personal experience; one I would much rather not have had.

I was a sheep farmer in the days when the Government mandated dipping sheep in organophosphate sheep dips to remove parasites but, just as happens today with cabin air contamination, people were not warned.

The first I knew of their ability to cause irreversible damage three years after I first fell seriously ill. The effects have been much like those which I hear about in pilots and crew who have been affected. We are told that organophosphates like those found in engine oils and hydraulic fluids used in aviation are not as poisonous as those used in agrichemicals and veterinary medicines but these assertions are simply not credible. I live every day of my life with the consequences of those exposures thirty years ago.

The sheep dippers who first complained of suffering health effects were dismissed in much the same way suffers of asbestosis, smoking or thalidomide and, now, pilots and crew have been dismissed. The dangers of all but contaminated cabin air have now been recognized, albeit after long periods of denial.

I have raised my concerns in the Lords about the adverse effects of organophosphates on human, plant and animal health through oral questions, questions for written answer, debates and correspondence with Ministers. Since I was made aware of the issues of contaminated air in aircraft, I have also asked hundreds of questions about this important health and flight safety issue and, I hate to say it, I have been consistently fobbed off by Ministers.

I have frequently been told by Government Ministers and the aviation industry that all the chemicals measured in aircraft are below the exposure standard but, for the most prevalent isomers of the organophosphate TCP in engine oils, the meta and para isomers, there are no exposure standards. I also note that in the fine print of many of these countless industry funded reports, it's clearly stated that there were no reported contaminated air events during the research. Does this mean that there are never any contaminated air events in aircraft or does it make the research pointless? I think of Toyber's Dictum – "The absence of evidence is not evidence of absence", or as Professor Andrew Watterson, my favourite public health expert put it many years ago – "If you don't look, you won't find."

The exposure standard debate is an interesting one. We hear that the chemicals crews are exposed to are below the exposure standard yet most of the chemicals have no exposure standard and exposure standards don't apply to passengers, especially not the unborn or elderly so why this constant denial? To seek to clarify this matter, I asked Her

Majesty's Government a Parliamentary Question over 10 years ago: It was very clear. What is the exposure standard for the complex mixture of chemicals people are exposed to on an aircraft when they are exposed to oil fumes and the Government reply was equally clear. None.

Yet over ten years later we still hear people claim everything is below these exposure standards that don't actually exist or apply. This raises an interesting further question: Is the misinformation agenda such as that Prof Michaels discussed this morning, creating confusion deliberately to delay taking effective action or is it simply ignorance? One can only conclude that aviation is another industry that Prof Michaels will be adding to his increasingly list of industries seeking to misinform on some aspects of this debate.

This may seem harsh or negative but its fact. Just like with asbestosis, smoking or thalidomide, those industries also played the corporate denial game rather than fix the problem.

In my 44 years as a member of the House of Lords, I have found that most issues go through several phases. First there is consistent denial that a problem exists. Then, if there is a problem, it has to be the fault of the person complaining for not reading the label or failing to use the correct engineering solutions. Then the Government offers to sponsor research which, as we know only too well, finds that there is no problem. Eventually the burden of evidence becomes so great that preventative action has to be taken.

Where are we with the contaminated air issue today, 18 September 2019, some 65 years since the problem was first recognised? I would say we are slowly transitioning into the final phase – lets fix this problem but let's not necessarily accept or admit that it exists.

The only real solution to this problem lies in the design architecture of the Boeing 787 and not to use 'bleed air' at all, I would very much like to applaud some of those who have played a key role in being part of the solution.

I particularly applaud Pall Aerospace for their extensive research & development in seeking to develop a new total cabin air filtration system. I first heard them talk about designing solutions in 2005, so well done them for all their efforts and persistence.

I congratulate those airlines that have shown the leadership to be part of this new phase and to start flight trials of the new Pall system. Airlines looking to finally install much needed ‘bleed air’ filtration. I have no doubt your marketing teams will soon turn this leadership into increased revenue as competitors lag behind in vision or duty of care to their crews and passengers

I also cheer those pilots and crew whose own careers and health have been adversely affected by contaminated air exposure and who have played a huge part in driving the industry to the much-needed solutions. There are so many of you but Dr Susan Michaelis, who I am proud to call my friend, must be at the very top of that long list.

I would like to highlight the work of the GCAQE, the largest coalition of unions dealing with this issue. They organized this conference and have been the main voice of the workers who experience these issues every day. Their board of 6, under the Chair of Daniel Tandoi, embraces 6 different nationalities, showing the global nature of the problem and those seeking to resolve it.

Finally, I have a message for all airline chief executives and airline board members around the globe. New filtration systems are now available. Every individual passenger and crew-member deserves to breathe clean air on board. I am yet to meet a shareholder who would disagree, so please, do the right thing, show leadership and bring this 6-decade old problem to an end.

Thank you

Aircraft Cabin Air Conference 2019

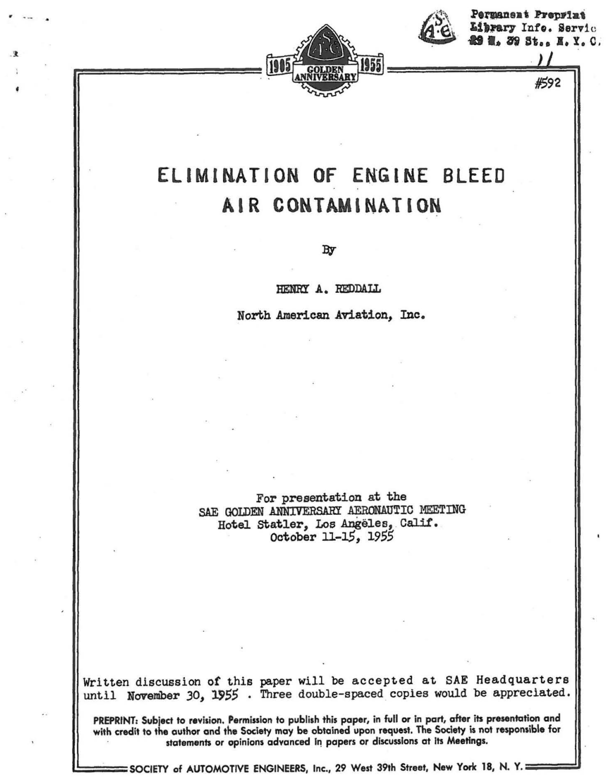
Contaminated Cabin Air

A Flight Safety Issue

Nick McHugh

In the Opposite Direction.

Elimination of Engine Bleed Air Contamination, Henry Reddall.



1905 GOLDEN ANNIVERSARY 1955

#592

ELIMINATION OF ENGINE BLEED
AIR CONTAMINATION

By

HENRY A. REDDALL

North American Aviation, Inc.

For presentation at the
SAE GOLDEN ANNIVERSARY AERONAUTIC MEETING
Hotel Statler, Los Angeles, Calif.
October 11-15, 1955

Written discussion of this paper will be accepted at SAE Headquarters until November 30, 1955 . Three double-spaced copies would be appreciated.

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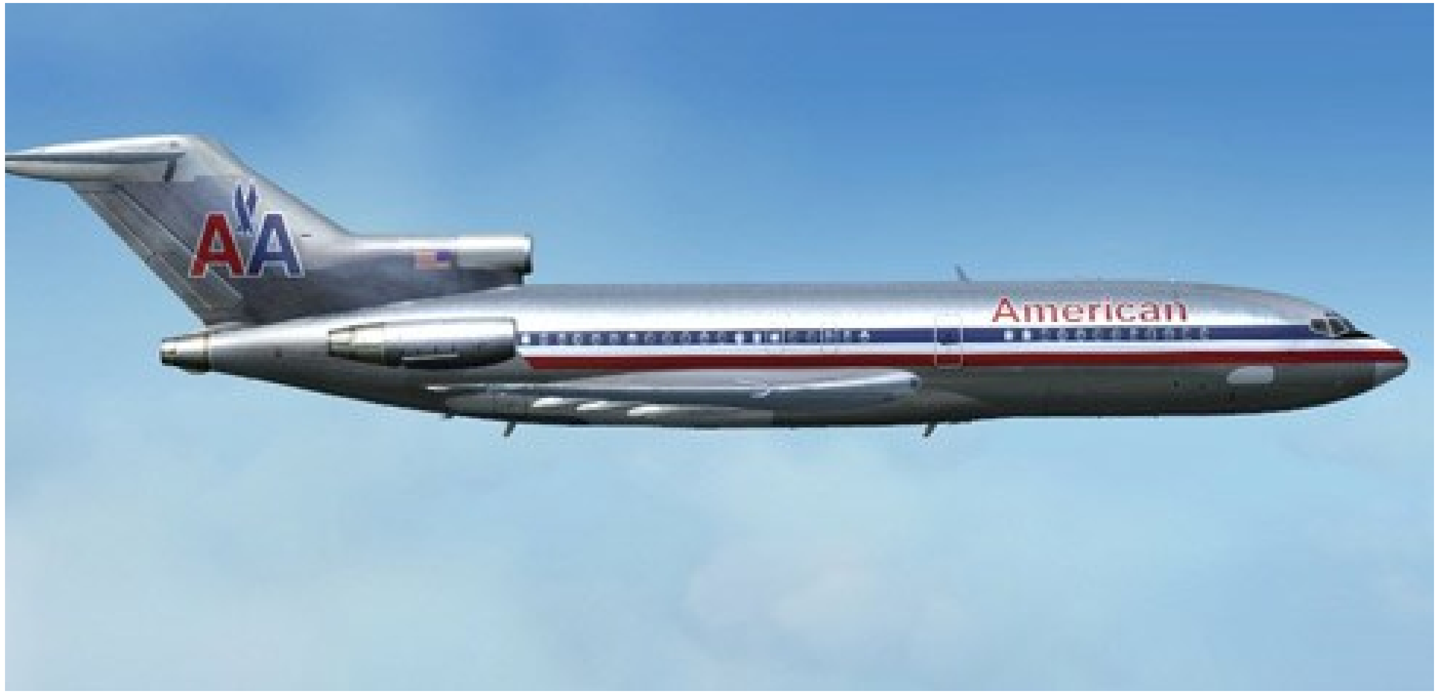
SOCIETY of AUTOMOTIVE ENGINEERS, Inc., 29 West 39th Street, New York 18, N. Y.


BOEING
BOEING
707
N70700


DOUGLAS DC-

Convair


ROYAL AIR FORCE



Boeing 727

So What Changed.

- ADVANCES IN AIRCRAFT MANUFACTURING TECHNOLOGY.
- ADVANCES IN ENGINE SEAL TECHNOLOGY.
- ADVANCES IN OIL FORMULATION AND PRODUCTION.
- COSTS.
- SHAREHOLDER VALUE.
- THE AGE OF BLEED AIR.

- History.
- Airmanship.
- Some Science.
- Closer look at the facts.
- Conclusions/Recommendations.

Overview

Self.

Aircraft.

Environment.

Risk.

Aerotoxic Syndrome.

Cholinergic Syndrome.

Centre for Disease Control.

Similiaraties

Self

Centre for Disease Control and Prevention (CDC)

Centers for Disease Control and Prevention

Emergency Preparedness and Response

Nerve Agent and Organophosphate Pesticide Poisoning

TOXIC SYNDROME DESCRIPTION

The purpose of this document is to enable health care workers and public health officials to recognize an unknown or suspected exposure to a nerve agent or an organophosphate (OP) pesticide. Nerve agents are chemical warfare agents that have the same mechanism of action as OP organophosphate pesticides insecticides. They are potent inhibitors of acetylcholinesterase . Inhibition of acetylcholinesterase leads , thereby leading to an accumulation of acetylcholine in the central and peripheral nervous system. Excess acetylcholine produces a predictable cholinergic syndrome consisting of copious respiratory and oral secretions, diarrhea and vomiting, sweating, altered mental status, autonomic instability, and generalized weakness that can progress to paralysis and respiratory arrest.

The amount and route of exposure to the nerve agent or OP pesticide, the type of nerve agent or pesticide, and the premorbid condition of the person exposed person will contribute to the time of onset and the severity of illness. For example, inhalation of a nerve agent or an OP pesticide leads to a quicker onset of poisoning with more severe symptoms when compared to with dermal exposure s, given the same amount of agent.

Signs and symptoms

The following is a more comprehensive list of signs and symptoms that may be encountered in a person exposed to a nerve agent or OP pesticide. Signs and symptoms are not listed in order of presentation or specificity. Also, partial presentations (an absence of some of the following signs/symptoms) do not necessarily imply less severe disease.

Central nervous system signs and symptoms

- Miosis (unilateral or bilateral)
- Headache
- Restlessness
- Convulsions
- Loss of consciousness
- Coma

Respiratory signs and symptoms

- Rhinorrhea (perfuse watery runny nose)
- Bronchorrhea (excessive bronchial secretions)
- Wheezing
- Dyspnea (shortness of breath)
- Chest tightness
- Hyperpnea (increased respiratory rate/depth) – early (increased respiratory rate/depth)
- Bradypnea (decreased respiratory rate) – late (decreased respiratory rate)

Environment

Hazards of our own making.

Complex chemical compounds and UFP’s

One chemical at a time/trigger limits

Dibectly and indibectly, sepabately and collectively.

Aircraft.

RAnti wear TCP and complex mixtures of isomers, ester based stock, anti oxidants and other proprietary ingredients.

ROil Change and engine ‘on wing time’.

RVapor-Phase lubricants / High temperatures and the Creation of Aerosol Nanoparticles under Bearing shear stress. (Bearing Squeeze oil.)

RThermal degradation of small volumes of oil, and assured sequelae.

Uncontaminated Ducting

Contaminated Ducting

EASA CS 25.831

European Aviation Safety Agency

Certification Specifications

and

Acceptable Means of Compliance

for

Large Aeroplanes

CS-25

Amendment 18

22 June 2016[1]

[1] For the date of entry into force of Amendment 18, please refer to Decision 2016/010/R in the Official Publication of the Agency.

Risk to Operations

NO DETECTORS FOR CO^2 CO OR O^3

CREW INCAPACITATION, AND ACUTE OVER CHRONIC EXPOSURE THRESHOLD.

WHEN IS SMOKE NOT SMOKE ? SELECTING THE CORRECT CHECKLIST.

DESENSITIZED SMELL AFTER 3 MINUTES.

COMPLEXITY OF SMOKE/FUME/SMELL CHECKLISTS AND THE RISKS ASSOCIATED WITH SMOKE EVAC PROCEDURE.

TRAINING.

LAND AS SOON A POSSIBLE OVER OCEANIC AND LARGE LAND MASS.

Recommendations

- Meaningful Steps.
- Reporting.
- Cabin Air Quality Sensors.
- Bleed Free future Aircraft.
- Medical Assesment Protocols
- Enhanced Training (Recognise Characterize, Respond)
- Long term Health effects.

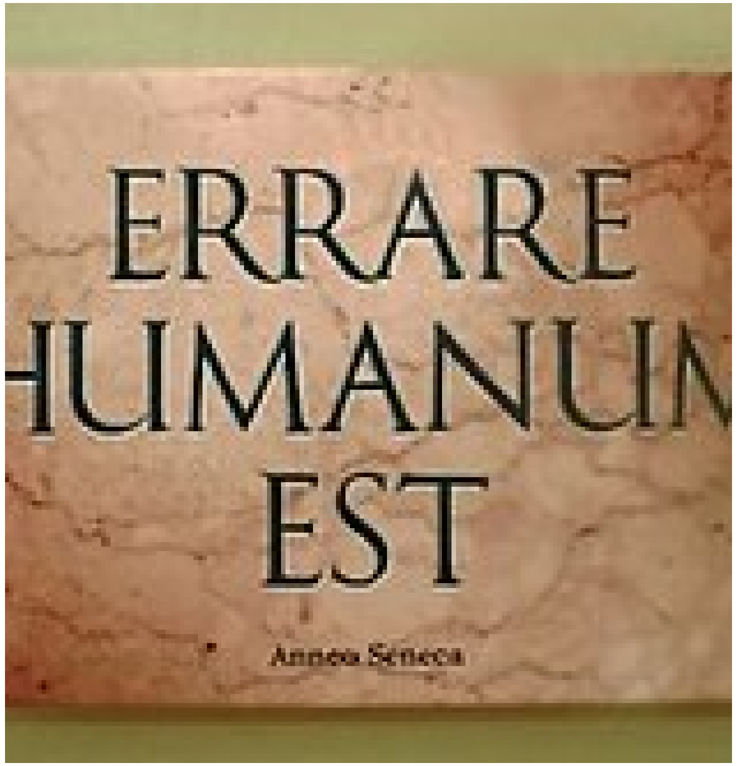
Conclusion

LONG TERM HEALTH

GENERAL FORESEEABILITY OF INJURY OR IMPAIRMENT.

ULTRA FINE PARTICLES AND THE BLOOD BRAIN BARRIER.

Lucius Seneca



- Errare humanum est, sed perseverare diabolicum."
- To err is human, but to persist in error is diabolical.

The Regulatory Implications of Bleed Air Supply Contamination

Susan Michaelis PhD, MSc, ATPL

University of Stirling / Michaelis Aviation Consulting

Aircraft Cabin Air Conference
Imperial College London
17-18 September, 2019

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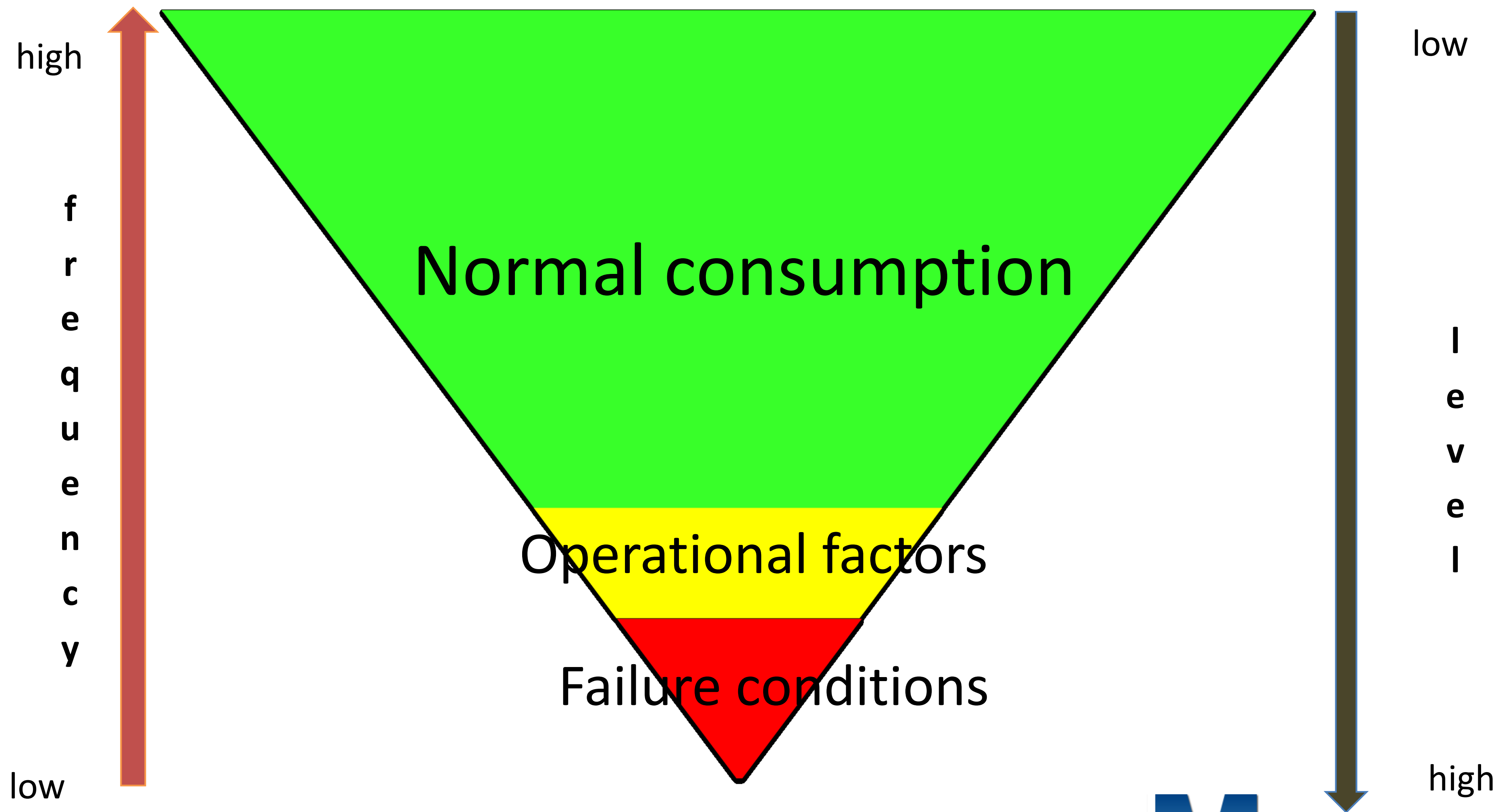
Oil Consumption



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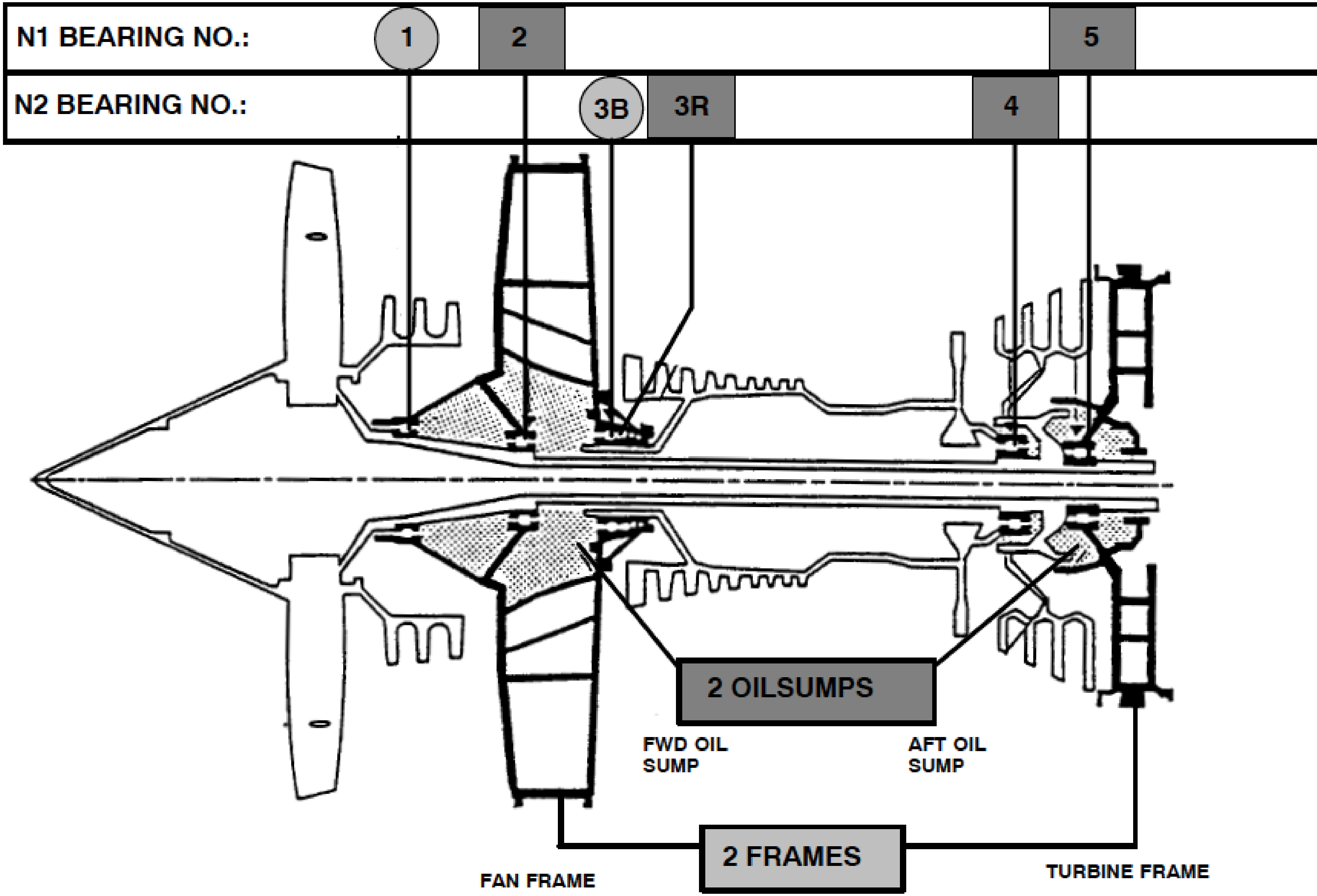
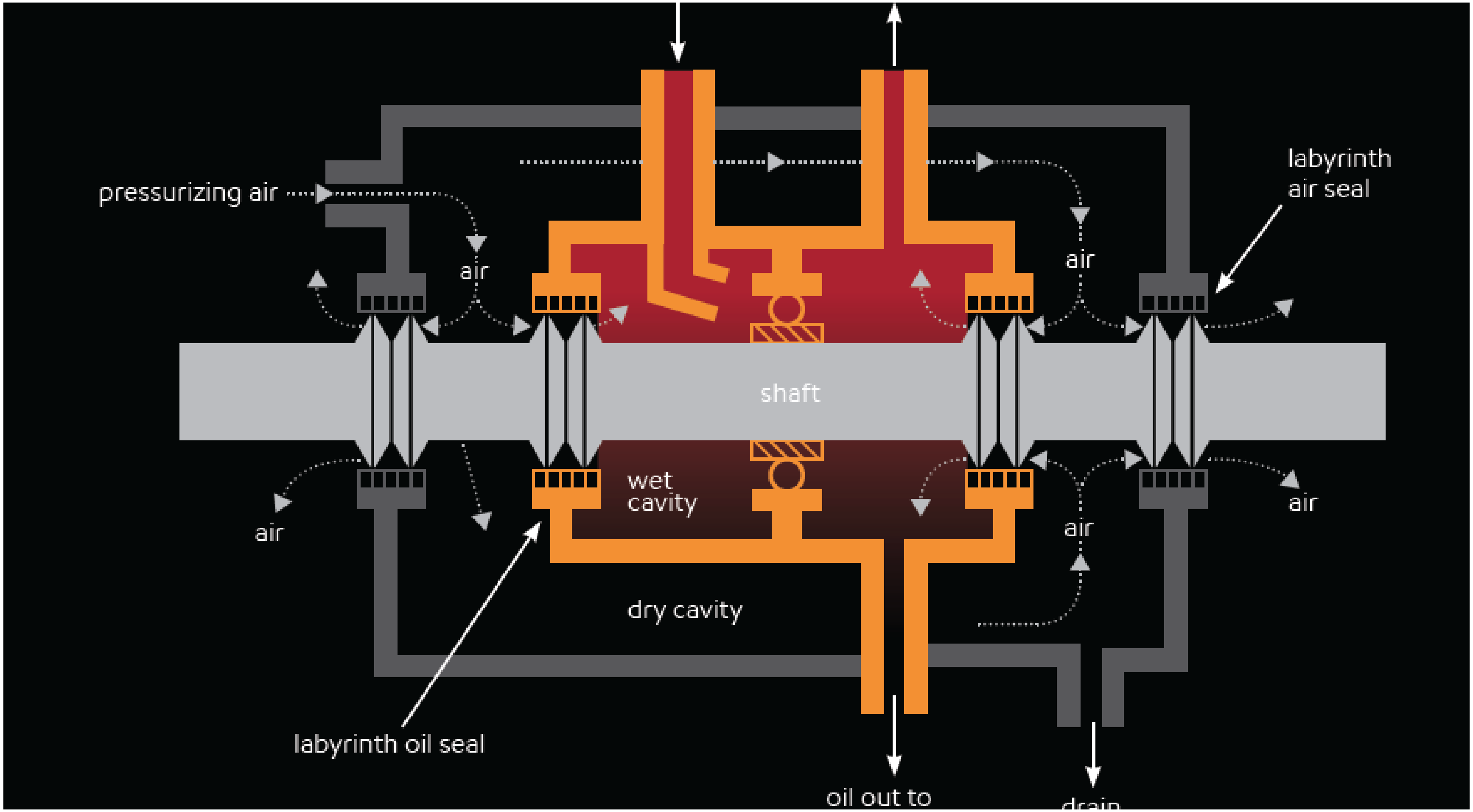


Figure 11 Engine Construction

Lufthansa (1999)
https://www.metabunk.org/attachments/docslide-us_a-320-engine-pdf.16733

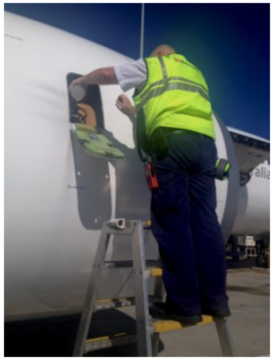
Oil Bearing Chamber



https://www.exxonmobil.com/en/aviation/knowledge-library/resources/jet-engine-oil-system-2

Normal Oil Consumption

- Normal "permissible" oil consumption via:
  - breather/deoiler - vent system
  - past seals → core airflow
  - oil leaks

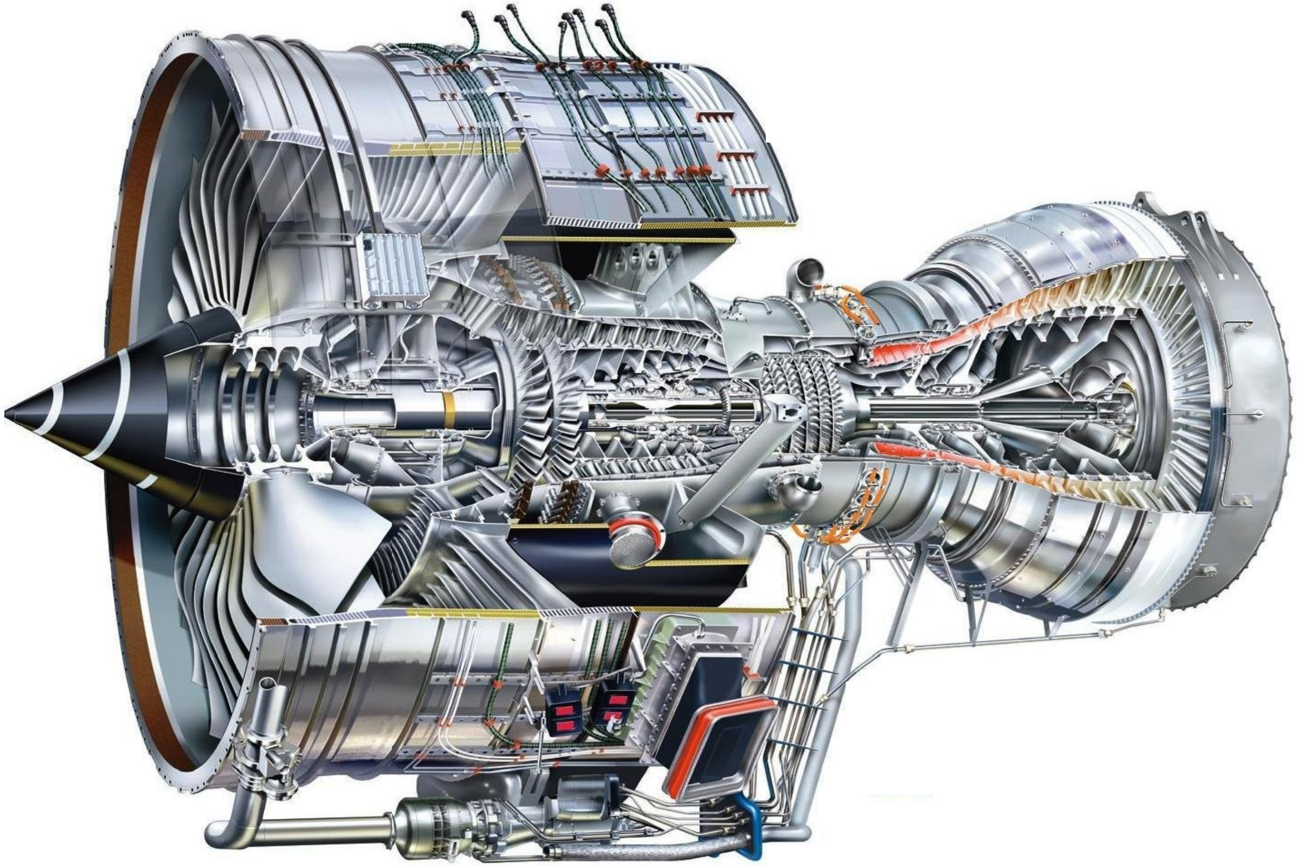


- Rate of loss affected by various factors
  - style of seal, balance ratio, lubricating regime, operating conditions (speed, temp, pressures), component condition, wear life, distortion…

All dynamic seals are designed to leak

https://www.exxonmobil.com/en/aviation/knowledge-library/resources/categories/tech-topics
https://gavinpublishers.com/admin/assets/articles_pdf/1537165462new_article_pdf69025564.pdf

Seals and Bearings / Air Off-Take



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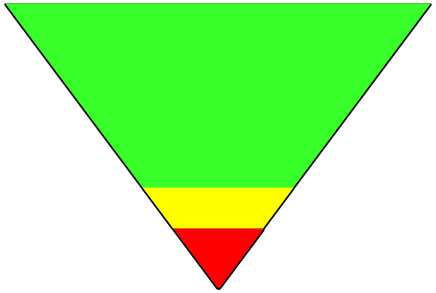
Oil Leaks



1. Normal operations

- All dynamic seals leak very low levels (not absolute design)
  - Rely on pressurised air: seals have a clearance / lubricated surface
- Increased leakage:
  - Pressure changes (transients) → Power air supply config changes
  - Thermal mechanical changes in engine
  - Low internal pressure – e.g. start up, taxiing, descent
  - Oil hydrolysis (reaction with water) and thermal oxidation → release of carboxylic acids which can escape from oil system (associated with strong odour “dirty sock”)

2. Operational: e.g. wearing seal; oil overfill
3. Failure conditions: bearing seal failure or component…

Misconceptions About Oil Leakage

1. Higher pressure in gas path than inside bearing chamber – keeps oil in bearing chamber ×
2. Seals only leak when failure occurs ×
3. Reverse pressures to be avoided – prevents leakage ×

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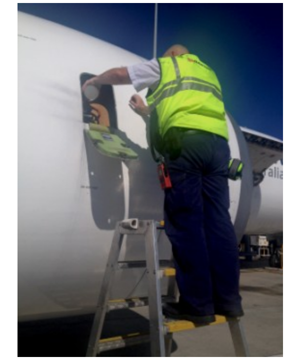
"Sealing bearing chambers at near ambient pressure is difficult" (Chupp 2006)
NASA/TM—2006-214341

Recognition of Oil Leakage in Normal Conditions



- Oil replenishment (‘top up’) maintains oil additives (Johnson 2018)
- Oils designed to work in engine, <u>limiting</u> exposure (ExxonMobil, 2018)
- Bleed system pressure fluctuations cause bearing seals to leak allowing oil to migrate into the cabin bleed air (ExxonMobil, 2018)
- “Shaft seals- must function as SEALS - NOT flow restrictors” (Bill, 1991)
- “A zero seal leakage is an oxymoron” (Chupp, 2006)
- Most engines might have a certain low level turbine oil leak rate (permanent oil entries) (EASA 2017)

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Two Ways of Addressing This Problem

1. Engineering failure analysis – <u>currently used</u>
   – Analysis, ground flight testing or simulator tests
   – Engineering judgement, previous experience, sound design & test philosophies.

2. Thorough assessment of the system in use in both <u>normal</u> and failure modes.

Do not place reliance on reporting system due acknowledged under-reporting

Method 1 – Brief Outline of Regulations, Standards & AMC

- 25.831- air does not cause undue discomfort, harm.
- 25.1309 & AMC
  - System works as intended
  - Air supply system does not cause impaired crew efficiency/ discomfort > 1 in 100,000 flight hours.
- CS-E/APU… Engine/APU & AMC safety analysis
  - Oil… in bleed air does not degrade crew performance

    > 1 in 100,000 engine/APU hours

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Method 2 – Assessment of Whole System

- Oil leaks at low levels in normal operations – permissible oil consumption – *see previous*
- Oils and other hazardous substances enter the bleed air – *see next*

Oils Cause Adverse Effects

- Oil MSDS/labels:
- Global chemical hazards system / e.g. EU classification *hazardous substances databases
  - *Oils: Damage to unborn/fertility; damage to organs (single repeat exposures): skin, respiratory sensitization; eye, respiratory, skin irritation; harmful in contact with skin; eye damage
  - * Hydraulic/deicing fluids: Above + harmful if inhaled; genetic effects; suspected to cause cancer; drowsiness, dizziness
- Manufacturers recognizes adverse effects, hazards,
  - Shell (1999); Boeing (2007); ExxonMobil (2017), Rolls Royce (2003)…
- Reports (where available) show Acute (short-term) effects/ impairment at > ~ 30%

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ExxonMobil

Product Name: MOBIL JET OIL II
Revision Date: 06 Sep 2017
Page 1 of 11

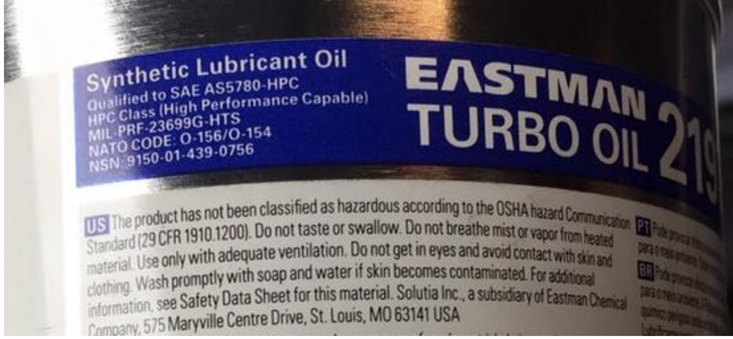
SAFETY DATA SHEET

SECTION 1	PRODUCT AND COMPANY IDENTIFICATION

PRODUCT

Product Name: **MOBIL JET OIL II**
Product Description: Synthetic Esters and Additives
Product Code: 201550101020, 430207-00, 970570
Intended Use: Aviation lubricating oil, Turbine oil

Oils



Mobil Jet Oil II

- May cause damage to organs through prolonged or repeated exposure. (Blood, Kidney); suspected to damage fertility;
- Symptoms of acute exposure to decomposition products: headache; nausea; eye nose & throat irritation;
- Not expected under normal conditions of use.

Eastman 2197

- Do not breathe mist or vapor from heated material;
- Inhalation of thermal decomposition products may lead to adverse effects;

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Oils Are Hazardous

- *"Jet oils do not pose a hazard when used as intended… Mobil jet oils are intended to be used in the lubrication of engine oil systems"*- (ExxonMobil 2018)
- *"We do not believe that Mobil jet turbine oils pose any significant toxicological risk to individuals* <u>*accidentally*</u> *exposed to aerosols or vapors in aircraft cabins. Such exposures are not what we would refer to as "normal use*" (Mobil, Australian Senate Inquiry, 1999/2000)
- *"Ortho –TCP is a known hazard; but exposure is controlled."* - (ExxonMobil 2018)
- *"Oil leaking from an engine entering the customer off-take is "classified as HAZARDOUS""* (Rolls Royce 2003)
- *"Oil vapors and coking smells are obnoxious at best and health hazards at worst to the customer*" (NASA, 1995)

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Where Are We Up To?

Design guarantees low levels of oil in normal operation – all flights

- Confirmed by many cabin air quality studies over 20 years+ / swab tests, ducting…
- So does this design meet the airworthiness standards?

Lets have a further look …

Are the Regulations / Standards & AMC Being Met?

25.831 – Ventilation Air

a) There must be a sufficient uncontaminated "fresh" air to enable crew to perform duties without undue discomfort / fatigue
b) Air must be free of harmful / hazardous concentrations of gasses and vapours

Are the Regulations / Standards & AMC Being Met?

25.831 – Ventilation Air

Is there enough uncontaminated air to not cause undue discomfort – **NO**

Is air free of concentrations of gasses/vapours causing harm – **NO**

Adverse / harmful effects are expected and being routinely documented

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Are the Regulations / Standards & AMC Being Met?

25.1309 & AMC – Equipment Systems … Design Requirements

- Do the systems and equipment perform intended function under foreseeable operating conditions?
- 'Major' failure conditions must be remote* (CS) - *Unlikely to occur in each aircraft during total life, but may occur several times during life of an number of aircraft.
- Impaired crew efficiency / discomfort to pilots must not occur more than 1 per 100,000 flight hours (10^{-5}- 10^{-7}) (AMC)

Oil leakage is a 'probable' & above or expected condition

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Are the Regulations / Standards & AMC Being Met?

25.1309 & AMC – Equipment Systems … Design equirements

- NO: Oil from the engine lubrication system enters the bleed air (not intended purpose) under foreseeable conditions
- NO: Impairment (‘Major’ failure) to crew efficiency is occurring > than 1 in 100,000 flight hours
- NO: oil leakage into the bleed air supply will occur to all aircraft

‘Oil leakage is probable’ & **expected condition**

‘Permissible oil consumption’

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Are the Regulations / Standards & AMC Being Met?

Engine/APU - CS E -510 / FAR 33.75 & APU & AMC…- Failure/ safety analysis

- Hazardous engine effects must be ‘extremely remote’ occurring less than 1 in 10 million / engine hours (10^{-7}) (CS)
  - Includes toxic products in bleed air sufficient to incapacitate crew/pax (CS)
- Major engine effects must be – ‘remote’ occurring less than 1 in 100,000/engine hours (10^{-5}) (CS)
  - Toxic products in bleed air sufficient to degrade crew performance (AMC)
  - Toxic products include degradation of oil leaking into compressor airflow (AMC)

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Are the Regulations / Standards & AMC Being Met?

CS E 510 & AMC & CS APU 210 & AMC… Failure analysis…

- **NO:** Degraded crew performance ('Major' engine/APU effects) due to oil leakage into compressor airflow/bleed air for cabin is occurring at > 1 in 100,000 engine/APU hours

'Oil leakage is probable' & **expected condition**

'Permissible oil consumption'

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Other Regulations /Standards Not Being Met

- FAR/CS 25.1309(c) - Information concerning unsafe system operating conditions must be provided to the crew to enable them to take appropriate corrective action – Warning system
- Unsafe condition – events occur more frequently than safety objectives allow that may impair crew efficiency, cause discomfort to occupants…
- Bleed air purity testing

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Certification - Michaelis MSc (2016)

- Certification: Must show compliance with all requirements
  - No requirement to follow a specific process
  - Interactive process between regulator and manufacturers
- Engine/APU: Focus on ‘hazardous’ engine effects – concentration of toxic products sufficient to incapacitate – Not AMC
- Airframe: No requirement for the air to be pristine free of contaminants (FAA); CO, CO2,O3, enough fresh air…
  - Manufacturers can choose to follow additional standards: e.g. ASHRAE, ASD-STAN (cancelled), SAE guidelines, NIOSH, CDC…

- Process is insufficient to ensure to ensure breathing air (bleed air) will not lead to impaired crew efficiency & degraded performance and adverse effects to occupants.
- There is a gap between the bleed air system regulatory process and the supply of clean air in aircraft. (Michaelis, 2016)
- Non binding
- Focus on <u>failure</u> conditions

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Where To Next?

- Future designs should be bleed-free;
- Air cleaning technology (filtration, catalytic convertors) to be provided for supply air (bleed and non bleed aircraft);
- Sensors to be fitted;
- Better designs: seals, improved oil reservoir, other design features;
- Improved clean air regulations/standards & compliance;
- Understanding low-level oil leakage occurs in normal operations, not just failure scenarios;
- Better procedures, training, education: crew, maintenance & management;
- Frequency seen in terms of <u>design</u>, NOT reporting.

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Thank you

Further information:

https://www.SusanMichaelis.com

susan@SusanMichaelis.com

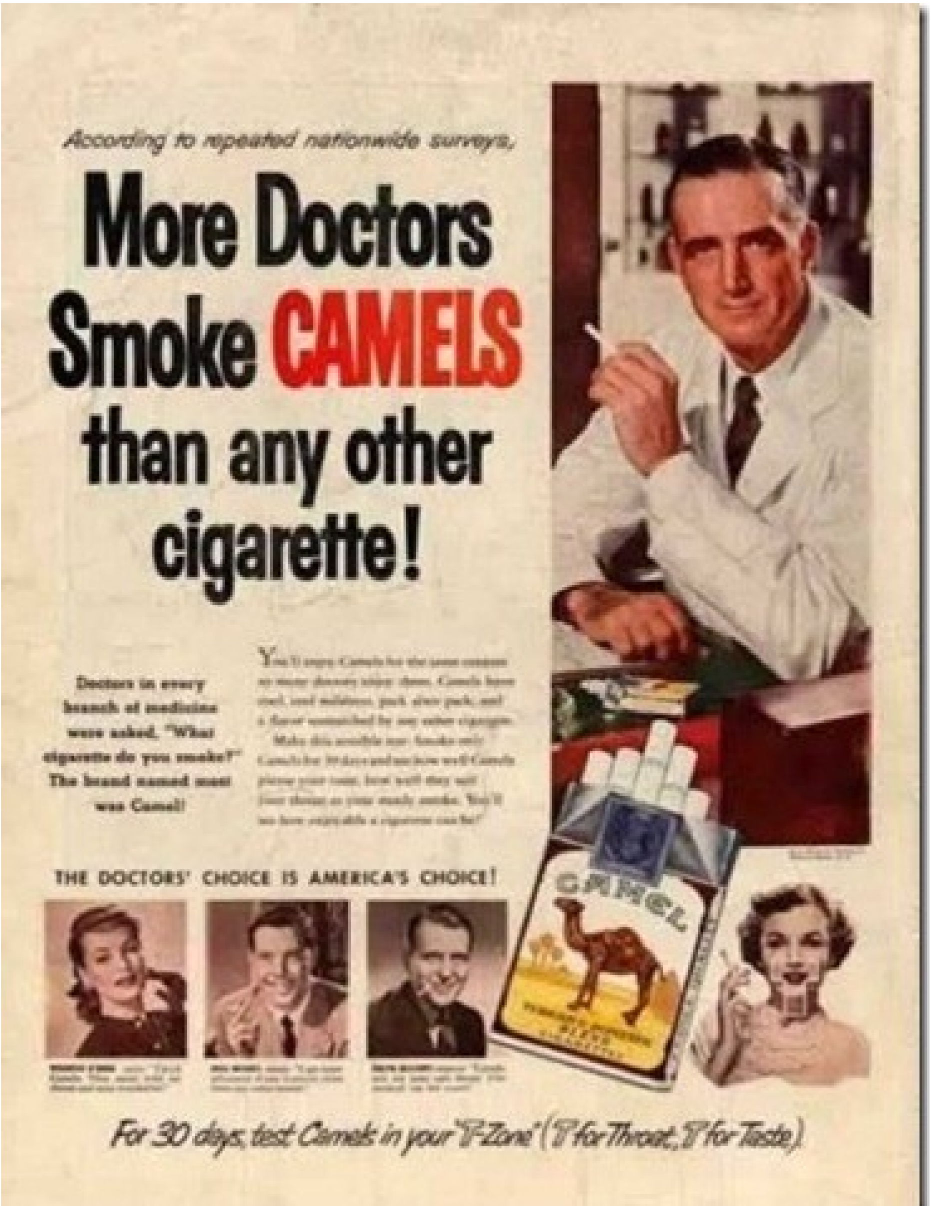
UNIVERSITY of STIRLING

The Triumph of Doubt: Dark Money and the Science of Deception

David Michaels, PhD, MPH
Department of Environmental and Occupational Health
Milken Institute School of Public Health
The George Washington University
Washington, DC USA

Aircraft Cabin Air Conference

September 18, 2019


According to repeated nationwide surveys,
More Doctors Smoke CAMELS than any other cigarette!
Doctors in every branch of medicine were asked, "What cigarette do you smoke?" The brand named most was Camel!
THE DOCTORS' CHOICE IS AMERICA'S CHOICE!
CAMEL
For 30 days, test Camels in your "T-Zone" (T for Throat, T for Taste)


MUCH MILDER
CHESTERFIELD IS BEST FOR ME!"
NOW...Scientific Evidence on Effects of Smoking!
A MEDICAL SPECIALIST is making regular bi-monthly examinations of a group of people from various walks of life. 45 percent of this group have smoked Chesterfield for an average of over ten years.
After ten months, the medical specialist reports that he observed...
no adverse effects on the nose, throat and sinuses of the group from smoking Chesterfield.
MUCH MILDER
CHESTERFIELD IS BEST FOR YOU
First and Only Premium Quality Cigarette in Both Regular and King-Size
Chesterfield
CIGARETTES
KING-SIZE CIGARETTES
CONTAINS TOBACCOS OF BETTER QUALITY AND HIGHER PRICE THAN ANY OTHER KING-SIZE CIGARETTE

Tobacco's Campaign to Manufacture Uncertainty

"Doubt is our product, since it is the best means of competing with the 'body of fact' that exists in the minds of the general public. It is also the means of establishing controversy."

-Brown & Williamson Document No. 332506, 1969

Reports on
Tobacco and Health Research

Vol. 5 No. 2 July-August 1963

IN THIS ISSUE

There is [illegible] of [illegible] regarding tobacco and health. Charges against tobacco are widely publicized, but less attention is given to [illegible] [illegible] opinions. This publication reports some of these materials.

Cancer Personality Pattern Is Reported To Begin in Childhood

New evidence of a personality pattern common to male lung cancer patients has been reported by a Scottish psychologist.* The pattern begins in childhood and does not appear to be related to smoking habits.

In a previous study, Dr. David M. Kissen of the University of Glasgow and an associate reported that male lung cancer patients have a significantly diminished outlet for emotional discharge. In addition, they said, such patients tend to bottle up or conceal

Verdict: 'Unproved'

Lung Specialist Cites 28 Reasons For Doubting Cigarette-Cancer Link

Although much has been written about possible causal relations of cigarette smoking to lung cancer, there is a good deal of evidence which does not fit this hypothesis, according to a California pulmonary specialist. In a review article digested below, he summarizes 28 reasons for his believing that cigarette smoking is not an important etiological agent in lung cancer, and that the real causes are unknown.

"There has been a virtual flood of literature 'associating' cigarette smoking with lung cancer," according to Dr. Leroy Hyde, chief of pulmonary disease service, Veterans Administra-

Test Results: Smoking Fails To Raise Cholesterol Levels

HILL AND KNOWLTON

Hill and Knowlton, Inc.
International Public Relations Counsel
420 Lexington Avenue
New York, New York 10017
212 697-5600

Case Histories

The following pages contain case histories detailing Hill and Knowlton's work on selected environmental, and occupational health issues:

- Siting a Municipal Waste Incinerator
- Vinyl Chloride and Cancer
- Asbestos and Human Health
- Dioxin and Public Health
- Fluorocarbons and Ozone Depletion
- Saccharin and the FDA
- Toxic Wastes Threaten Major Manufacturing Facility
- Groundwater Contamination Harms Company Reputation

Fluorocarbons and Ozone Depletion

Problem/Situation

Scientific allegations that fluorocarbons released from aerosol spray cans were a threat to the earth's ozone layer had become a cause celebre in the media and government. Despite the fact that there was no real scientific proof of the charges, and that it would be years before facts could be assembled, the media fastened on the threat of increased skin cancer and the doomsday aspects of the story. Public concern and fear about the future caused fluorocarbon users to look to alternatives. Hill and Knowlton was asked by Du Pont to help calm fears, get better reporting of the issues, and gain up to two or three years before the government took action to ban fluorocarbons.

The Nobel Prize in Chemistry 1995

"for their work in atmospheric chemistry, particularly concerning the formation and decomposition of ozone"

Paul J. Crutzen

Mario J. Molina

F. Sherwood Rowland

The Nobel Prize in Chemistry 1995
Press Release
Presentation Speech
Illustrated Presentation

Paul J. Crutzen
Autobiography
Curriculum Vitae
Nobel Lecture
Interview
Other Resources

Mario J. Molina
Autobiography
Nobel Lecture
Other Resources

F. Sherwood Rowland
Autobiography
Nobel Lecture
Banquet Speech
Other Resources

WINNING THE GLOBAL WARMING DEBATE – AN OVERVIEW

Please keep in mind the following communication recommendations as you address global warming in general, particularly as Democrats and opinion leaders attack President Bush over Kyoto.

1. ***The scientific debate remains open.*** Voters believe that there is ***no consensus*** about global warming within the scientific community. Should the public come to believe that the scientific issues are settled, their views about global warming will change accordingly. Therefore, ***you need to continue to make the lack of scientific certainty a primary issue in the debate***, and defer to scientists and other experts in the field.

2. ***Americans want a free and open discussion.*** Even though Democrats savaged President Bush for formally withdrawing from the Kyoto accord, the truth is that none of them would have actually voted to ratify the treaty, and they were all glad to see it die. Emphasize the importance of ***"acting only with all the facts in hand"*** and ***"making the right decision, not the quick decision."***

3. ***Technology and innovation are the key in arguments on both sides.*** Global warming alarmists use American superiority in technology and innovation quite effectively in responding to accusations that international agreements such as the Kyoto accord could cost the United States billions. Rather than condemning corporate America the way most environmentalists have done in the past, they attack their us for lacking faith in our collective ability to meet any economic challenges presented by environmental changes we make. This should be our argument. ***We*** need to emphasize how ***voluntary*** innovation and experimentation are preferable to bureaucratic or international intervention and regulation.

4. ***The "international fairness" issue is the emotional home run.*** Given the chance, Americans will demand that all nations be part of any international global warming treaty. Nations such as China, Mexico and India would have to sign such an agreement for the majority of Americans to support it.

5. ***The economic argument should be secondary.*** Many of you will want to focus on the higher prices and lost jobs that would result from complying with Kyoto, but you can do better. Yes, when put in specific terms (food and fuel prices, for example) on an individual-by-individual basis, this argument does resonate. Yes, the fact that Kyoto would hurt the economic well being of seniors and the poor is of particular concern. However, the economic argument is less effective than each of the arguments listed above.

"The scientific debate remains open. Voters believe that there is ***no consensus*** about global warming within the scientific community. Should the public come to believe that the scientific issues are settled, their view about global warming will change accordingly. Therefore, ***you need to continue to make the lack of scientific certainty a primary issue in the debate***…" (emphasis in original)

Marketing “Product Defense”

ASBESTOS, TOBACCO, PHARMACEUTICALS - WE’RE ALL NEXT!

- Scare science
- The loss of presumptive innocence
- Where will the liability end?

Presented by
Mr. Joseph Huggard
The Weinberg Group LLC
18 June 2003

2

The Enronization of Science

- Scientists hired to defend products in regulatory and legal arenas

- Their value is their ability to influence regulation and litigation, *not* to provide valid science

- Produce science of questionable value

Selected Glassdoor Reviews by Product Defense Firm Employees

- “This is a law consulting company, not a science consulting company. Don’t expect to be a ‘scientist.’” [Cardno ChemRisk]

- “Some of the principal scientists have questionable ethics (and have been called out for it).” [Gradient]

- “Sometimes you will be working for the evil do-ers and trying to make it seem like they did nothing wrong.” [Exponent]

The Center for
Public Integrity

SCIENCE FOR SALE

Published — February 16, 2016
Updated — Today at 7:01 am EST

FORD SPENT $40 MILLION TO RESHAPE ASBESTOS SCIENCE

THE TRIUMPH OF DOUBT

DARK MONEY AND THE SCIENCE OF DECEPTION

DAVID MICHAELS

Manufactured Uncertainty Threatens Public Health

- Clean Air
- Clean Water
- Lead Exposure to Children

Manufactured Uncertainty Threatens Public Health

- Sugar
- Sugar-Sweetened Beverages
- Alcoholic Beverages

Manufactured Uncertainty Threatens Public Health

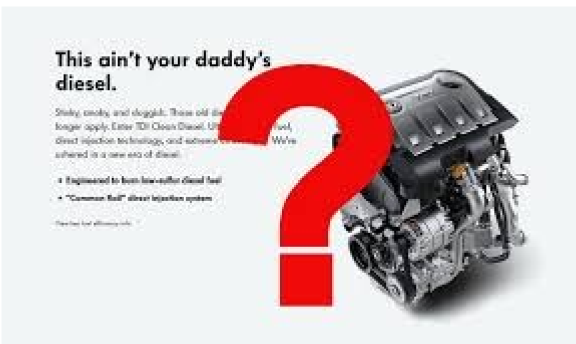
- Glyphosate

- Talc

The Work of Mercenary Scientists Hurts the Credibility of All Scientists

2012: The World Health Association/
International Agency for Research on Cancer
Classifies Diesel Engine Exhaust
as Carcinogenic to Humans


Meet the Volkswagen
TDI Clean Diesel
Family.


This ain't your daddy's diesel.


Old Wives' Tale #6
Diesel is Dirty


Drive cleaner.
Clean Diesel


Smoke less.
Polo BlueMotion. Only 102g CO_2/km.

From: Stertz, Brad
To: Kata, Leonard (EEO); Johnson, Stuart (EEO)
CC: Jacuzzi, Joe
Sent: 6/12/2012 7:41:47 PM
Subject: FW: Diesel WHO report reaction?

Hi Stuart and Len,

Any guidance you might be able to give regarding this WHO assertion that diesel is a carcinogen would help us with counter messaging. This would include studies that might contradict the WHO report below. We also have requests in with Ingolstadt.

Best regards,

Brad Stertz
Corporate Communications Manager

Audi of America, Inc.
2200 Ferdinand Porsche Drive
Herndon, VA 20171
United States of America
Office: +1-703-364-7440
Mobile: +1-703-344-1320
Fax: +1-703-364-7076
mailto: brad.stertz@audi.com
http://www.audiusa.com
http://www.audiusanews.com

Lovelace

Lovelace Respiratory Research Institute

and Family of Companies

2013: German Auto Industry Trade Association Signs Contract with Lovelace

EUGT

Europäische Forschungsvereinigung für Umwelt und Gesundheit im Transportsektor e.V.

EUGT e.V. Fritschestraße 35 10627 Berlin

EUGT e.V.
Fritschestraße 35
10627 Berlin

t: 030 3101 2252
f: 030 3101 2253

w: www.eugt.org
e: info@eugt.org

AGREEMENT

between the

Europäische Forschungsvereinigung für Umwelt und Gesundheit im Transportsektor e.V. (EUGT)

(European Research Group on Environment an Health in the Transport Sector, registered association)

Fritschestrasse 35
D-10627 Berlin

Herein after 'Research Association'
- abbreviated as 'EUGT' -

and

Lovelace Respiratory Research Institute (LRRI)

2425 Ridgecrest Drive SE
Albuquerque, New Mexico 87108

represented by
Lori Orona
Project management:

Herein after 'Researcher'

EUGT e.V. Fritschestraße 35 10627 Berlin

EUGT
Europäische
Forschungsvereinigung
für Umwelt und Gesundheit
im Transportsektor e.V.

EUGT e.V.
Fritschestraße 35
10627 Berlin
t: 030 3101 2252
f: 030 3101 2253
w: www.eugt.org
e: info@eugt.org

AGREEMENT

EUGT shall contribute the amount of **$718,572.00 US-$** (in words: seven hundred eighteen thousand five hundred seventy two $) incl. all taxes to the Researcher. Payment shall be effected to the below-mentioned account of LRRI within 14 days after the first invoice.

The contribution will be made in three installments. For this purpose LRRI will submit an invoice for 50% of the sum after this Agreement has become effective, an invoice for 40% upon completion of the in-life portion of the Research, and an invoice for 10% once the final report on the Research becomes available to EUGT. Work will begin once the initial contribution has been received.

4. Confidentiality

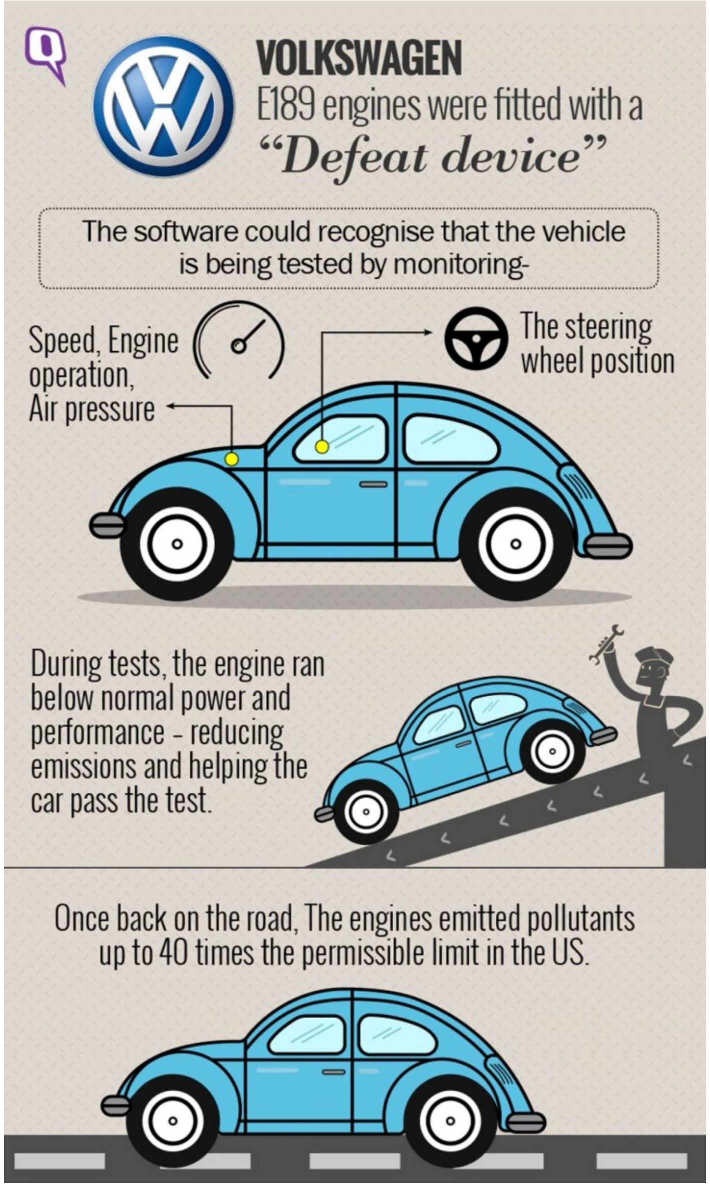
The contracting partners obligate themselves to treat as confidential, and to keep secret vis-à-vis outside parties, and further not to exploit, all documents marked as secret as well as all other information made mutually available. The contracting partners are obligated to maintain the same confidentiality during the performance of the work, and for up to five years after its conclusion, with respect to both the research work to be performed and its results.


King


DRIVING


King

James Liang, “Leader of Diesel Competence”, VW Group of America



James Liang, “Leader of Diesel Competence”, VW Group of America

2015: Lovelace Scientists Realize that VW Rigged the Study

From: Irshad, Hammad
To: McDonald, Jacob; Brower, Jeremy; Kuehl, Philip
Subject: RE: EPA accuses Volkswagen, Audi of evading emission laws (Diesel)
Date: Friday, September 18, 2015 7:25:44 PM

<1% of OTDE in the tunnel. I believe in our car that system was ON by default.

Table 2. Comparison of NO, NO_X and NO_2 concentration in the dilution tunnel for three test atmospheres

	Tunnel NO (ppm)	Tunnel NO_X (ppm)	Tunnel NO_2 (ppm)
AIR	0.06	0.06	0.00
NTDE	0.60	0.92	0.31
OTDE	146.22	169.77	23.49

From: McDonald, Jacob
Sent: Friday, September 18, 2015 12:43 PM
To: Brower, Jeremy; Kuehl, Philip; Irshad, Hammad
Subject: RE: EPA accuses Volkswagen, Audi of evading emission laws (Diesel)

Yep they were low. This seems crazy

From: Brower, Jeremy
Sent: Friday, September 18, 2015 12:31 PM

2016: Lovelace scientists desperately try to salvage the study

From: McDonald, Jacob
Sent: Mon 8/29/2016 5:47 PM (GMT-04:00)
To: 'Matthew J Campen'
Cc:
Bcc:
Subject: FY14-050_EUGT NHP Diesel Report_23Nov2015
Attachments: FY14-050_EUGT NHP Diesel Report_23Nov2015.docx

Here are the results in a draft report. The lavage data are garbage because I didn't realize this until it was too late the guys did the baselines the day before the actual exposure lavages so there was inflammation from the baselines.....

The blood showed nothing by standard clin path as expected.

The analysis on the bronchial brushings was kind of interesting.

I need to publish a paper and basically I will have to throw out the lavage data and then I have three figures....and a bunch of aerosol stuff....so I am trying to see if I can squeeze out something else that may be interesting and says "old dieslel bad, new diesel good' so I can win the nobel prize.

2016: Lovelace scientists submit abstract, with no mention of the VW

2016 Society of Toxicology Annual Meeting
Late-Breaking Abstracts

ABSTRACT FINAL ID: 3601 Poster Board: P293
TITLE: Exposures to Old Technology Diesel Emissions to Evaluate Biological Response in Non-Human Primates

AUTHORS (FIRST INITIAL, LAST NAME) & INSTITUTIONS: J. Brower, H. Irshad, M. Doyle-Eisele, Y. Tesfaigzi, J. McDonald. *Lovelace Respiratory Research Institute, Albuquerque, NM.*
KEYWORDS: Exposure, Environmental; Inhalation Toxicology; Lung; Pulmonary or Respiratory System; Diesel

ABSTRACT BODY: The adverse health effects of exposure to standard diesel vehicle emissions (DE) are a major concern among urban populations. Studies investigating the biological effects of diesel exposure date back more than 30 years, but combustion technology is constantly improving. We intended to establish a non-human primate model of acute DE exposure in order to test future hypotheses related to exhaust fractionation and comparisons with alternative fuel technologies. This study evaluated the biological responses of female cynomolgus macaques after acute (4 hour) whole body exposure to filtered air (FA) or whole DE.

What Needs To Change?

- Research must be directed by independent, unconflicted scientists.
- Polluters and producers of hazardous chemicals must pay for the research, but not control it.

What Else Needs To Change?

- Regulate toxic chemicals by class, not one by one.
- Chemicals are not innocent until proven guilty:

  End the Presumption of Innocence!

Thank You for Listening

Cabin Air Quality Sensor

Rick Mlcak
GCAQE

Aircraft Cabin Air Conference

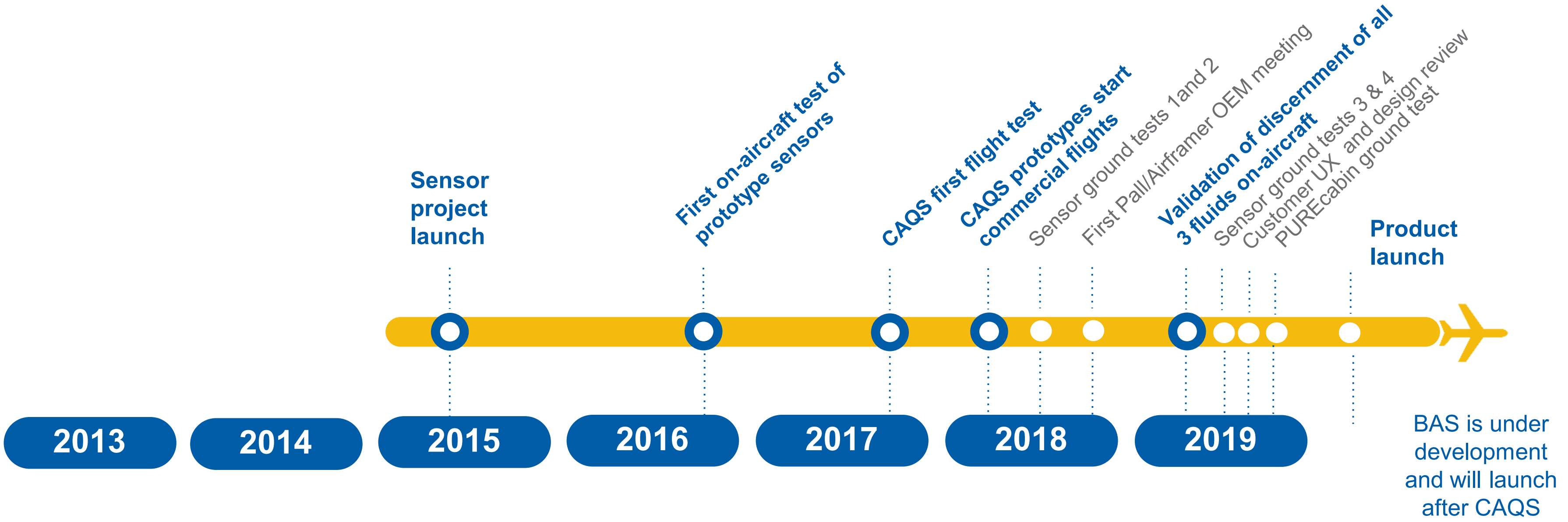
September, 2019

***PURE**cabin* Concept

***CSI** – sensing and identifying the odor*

How we Finished the 2017 Conference

Project Timeline



Solutions take partners: Airlines, OEMs, and Pall.

PALL Aerospace

Defining the Specification

Sensor Functionality

Detection Limits and Techniques

- Detect contaminant events at or below human olfaction levels
- Determine whether contaminants are increasing, stable or decreasing
- Identify contaminant sources by their response fingerprint or "smell"

Event Classification

- Turbine oil, hydraulic fluid, de-icing fluid, other
- Separate sensor for CO

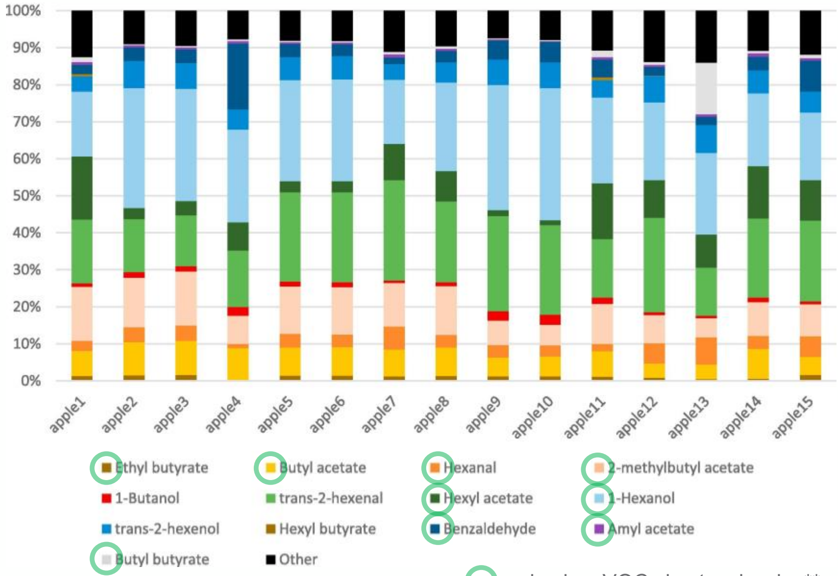
Background Levels

- Detect changes from "*normal*" indicating need for preventive maintenance or corrective measures
- Identify "dirty" aircraft requiring service

Identification: Smell vs. Marker Compounds

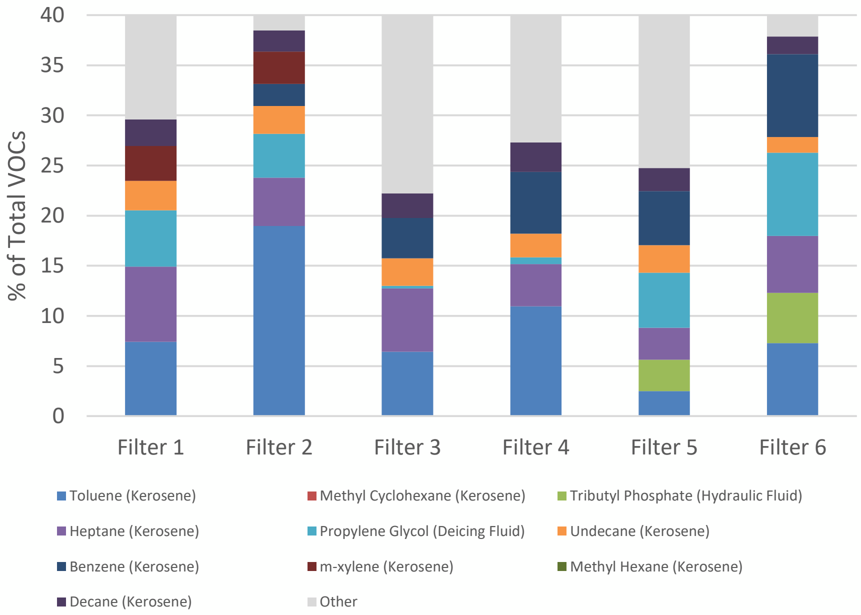
Odors are identified by concentration ratios

There are over 300 compounds in the smell of an apple…*



- also key VOCs in strawberries**

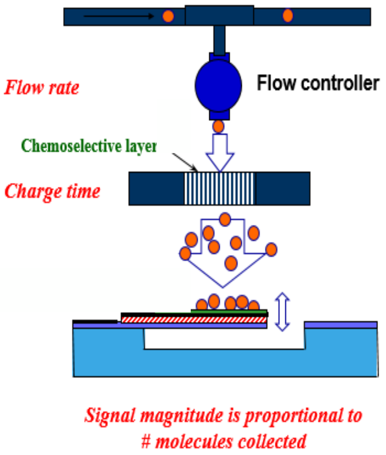
GCMS measured chemical concentrations desorbed from cockpit filter



*https://www.sciencedirect.com/science/article/pii/S030881461831923X#b0035; **https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3921181/

Why can't humans do it?

Technology Recap

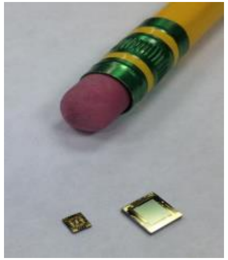


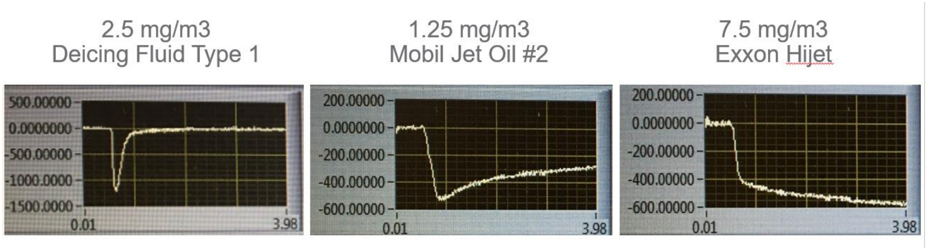
Analyte in carrier gas

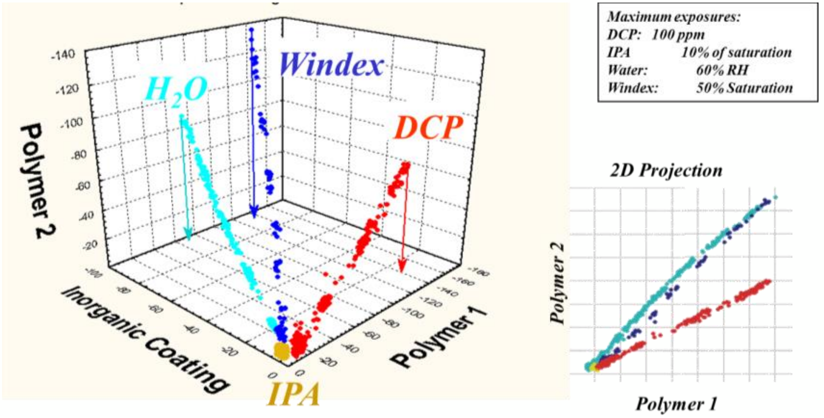
Preconcentrator collects analyte(s) of interest, and "flash desorbs" them when heated

Analyte is collected on resonator surface

Concentration is determined from change in resonant frequency





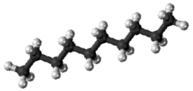


Conditions and Qualities of Aircraft Fluid Contaminants

Quality	Mobil jet oil	Skydrol PE-5
flash point (°C)	270	160
fire point (°C)	285	177
autoignition temp (°C)	404	400

CONCENTRATIONS IN CABIN:

Total fluids
~1 to 10 mg/m^3



Markers
~ 1 to 50 µg/m^3

FORM IN CABIN AIR:

- → Mostly primary constituents (little is burned in bleed system)
- → Both aerosols and vapors due to low vapor pressures
- → Aerosols foul electronic noses and VOC sensors
- → Inlet filters (to protect against aerosols) generate residual false positive signals

Sensor must tolerate exposure to lube and hydraulic oils

→ *Requires and materials compatibility & fouling mitigation features*

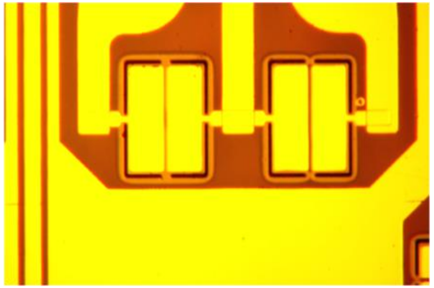
Managing the Environment

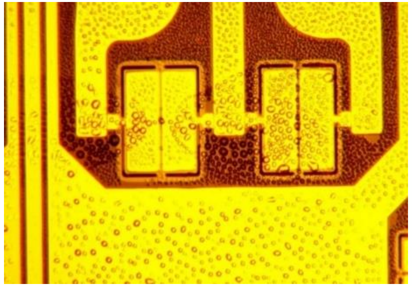
Oil Vapors & Ultrafine Particles (aerosols) can:

- Coat the surfaces of sensors
    - *Affect accuracy*
    - *Affect Life*
- 'Stick' to other surfaces
    - *Generate false positives*

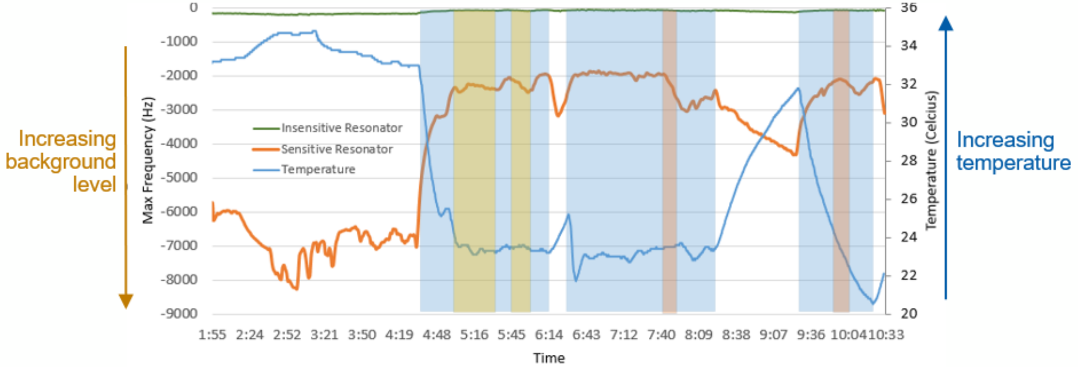
Aircraft background levels are variable and can generate false positives.

- *High background levels impacted by*
    - *Aircraft age*
    - *Temperature*
    - *ECS state*





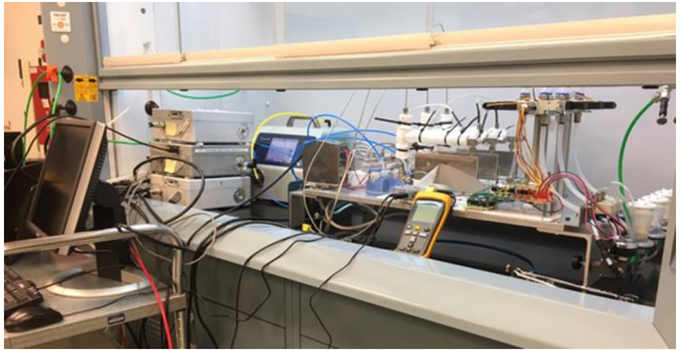
Sampling from cabin: background level is strongly correlated with cabin temperature



White = APU off. Blue = APU on. Beige: simulated de-icing fluid contamination.
Pink #1: simulated new BP2389 contamination. Pink #2: simulated used BP2389 contamination.

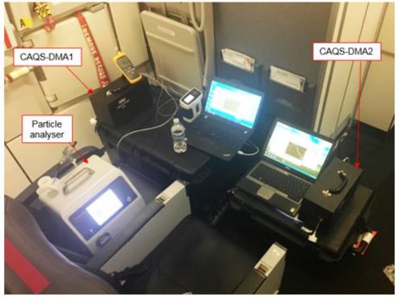
Sensor Evolution

Validating Laboratory and Aircraft Test Data



Measuring sensor performance in the laboratory

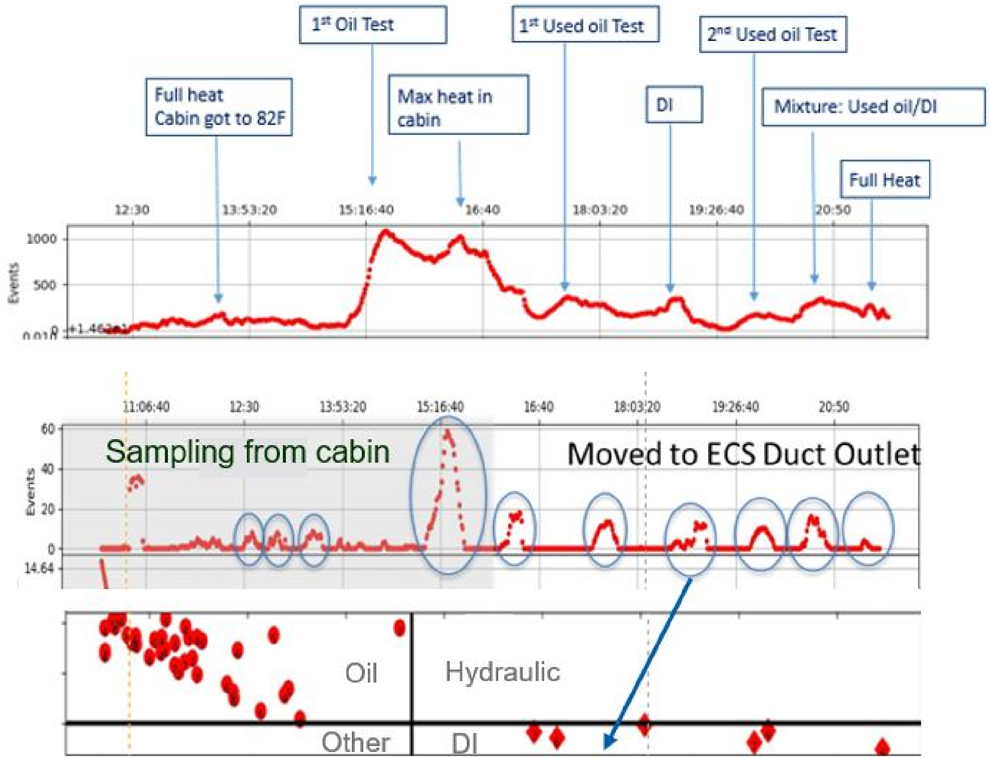
- Developing tests to compare laboratory challenges with actual aircraft environments



- Measuring performance on aircraft while passing contaminants through the ECS
- Comparing CAQS responses to human olfaction

PALL Aerospace

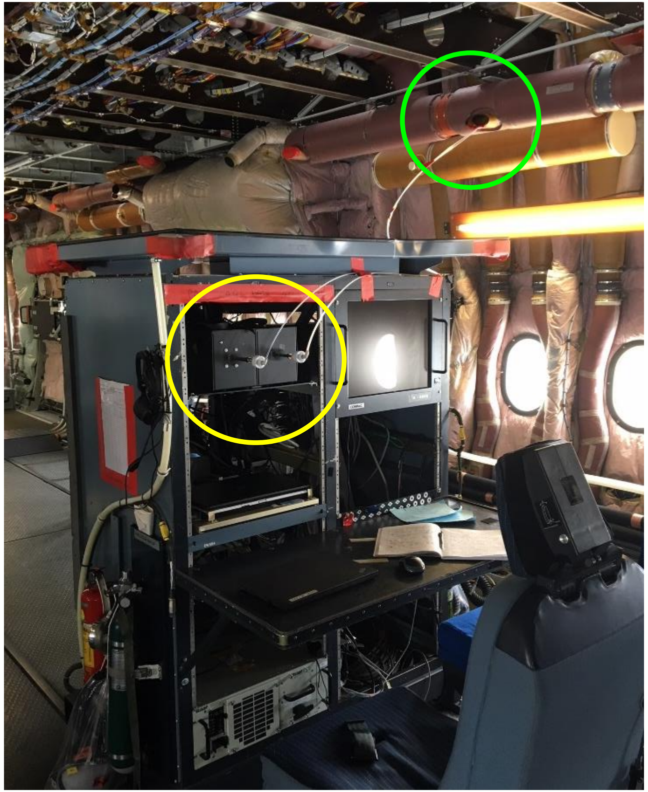
Constant Validation of Sensor Design Upgrades



- Oil and de-icing fluid are injected into APU inlet and passed through the ECS
- Background levels are measured during the trial
- Event Detection Algorithm identifies increases in contaminant events
  - Performance improved when sampling from ECS duct
- Classification Matrix identifies the contaminant by fluid type
  - 100% Recognition Accuracy of injected challenges

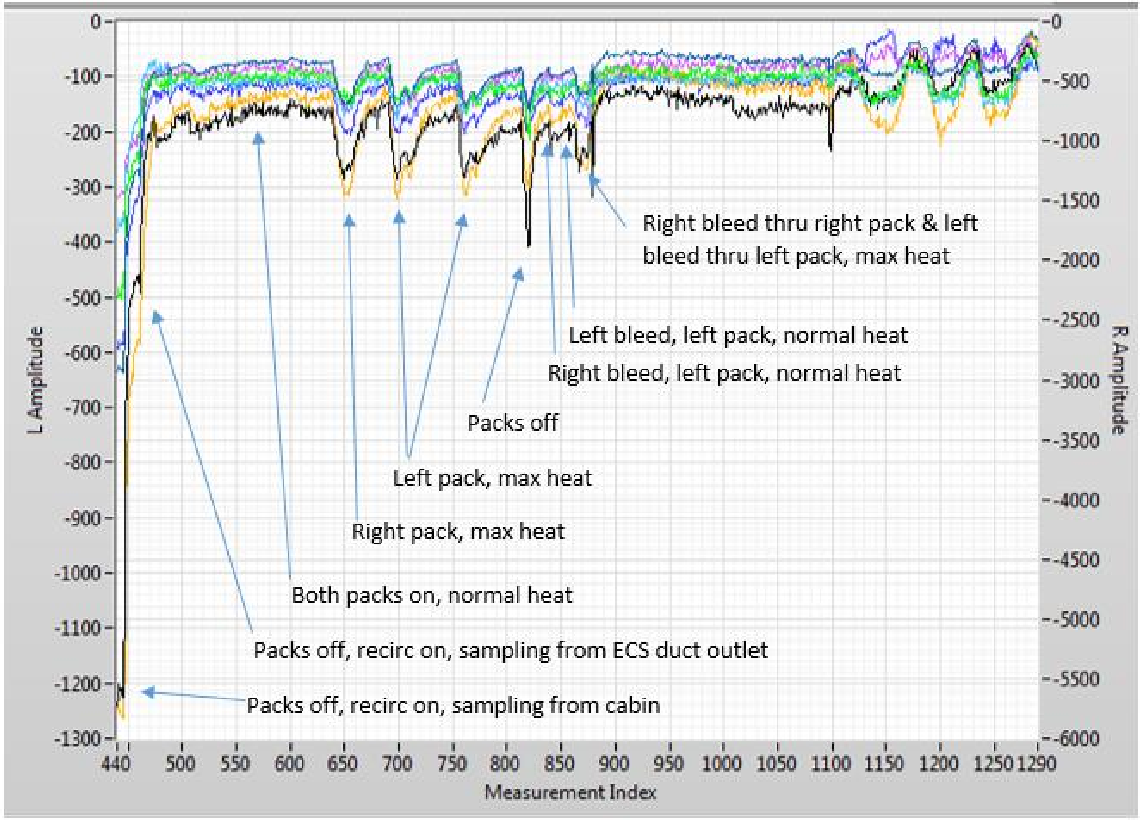
The Cabin Air Environment & Measurement Location

- Cabins are a large source of VOCs, from people, food, luggage, cleaning agents, carpets, seats, plastics, etc.
  - High background levels are measured with ESC off
- ECS supplies clean air to the cabin, *except* during upset conditions:
  - System/Mechanical fault introducing aircraft fluids in bleed air
  - Polluted outside air at intake
  - Faulty de-icing procedures
  - Fouled ECS (packs, ducts)
- CAQS measures contaminant levels in ECS-supplied air
  - Accelerates detection of upset conditions
  - Shields sensor from the chemically “noisy” cabin



Aircraft Ground Bleed Air Test & Functional Flight Check

Increasing background level



PALL Aerospace

CAQS Mark 1 – Launch MVP

CAQS MK1 Production Version

- Dimensions: 250 mm x 210 mm x 90mm
- Weight : 4.5kg
- Mounting : sensor supplied with tapped holes and installation kit
- Powered by aircraft electrical supply
  - 28VDC, 35W
- Data saved with time-date stamp
- Data transmitted over WiFi to standard devices

Launch Performance

Detection accuracy

- Achieving 100% accuracy (true positive rate) in the laboratory
- Assessing on-aircraft performance in ground & flight tests
- Will assess & optimize service accuracy using in-service performance data

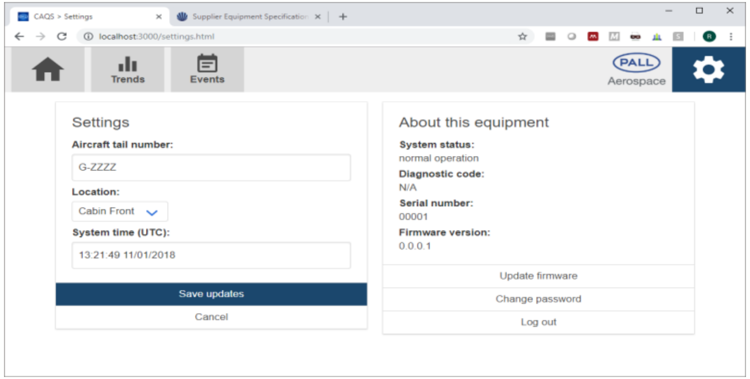
Monitoring “normal” aircraft background levels

- Initial release will record increasing & decreasing chemical background levels
- With in-service performance data we may learn to predict impending issues from changes in background levels

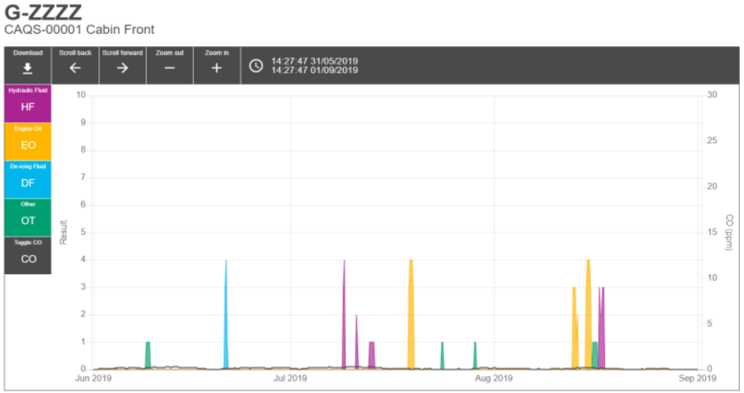
Lifetime, Maintenance & Calibration

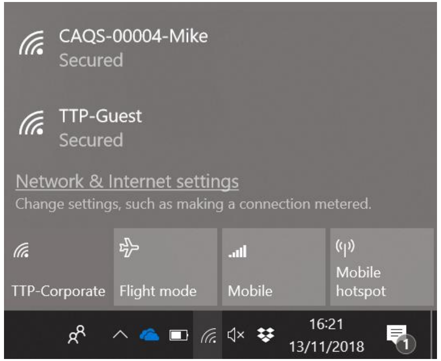
- Will be assessed during the early MK1 release
- Will enable Pall to implement a support strategy

User Interface



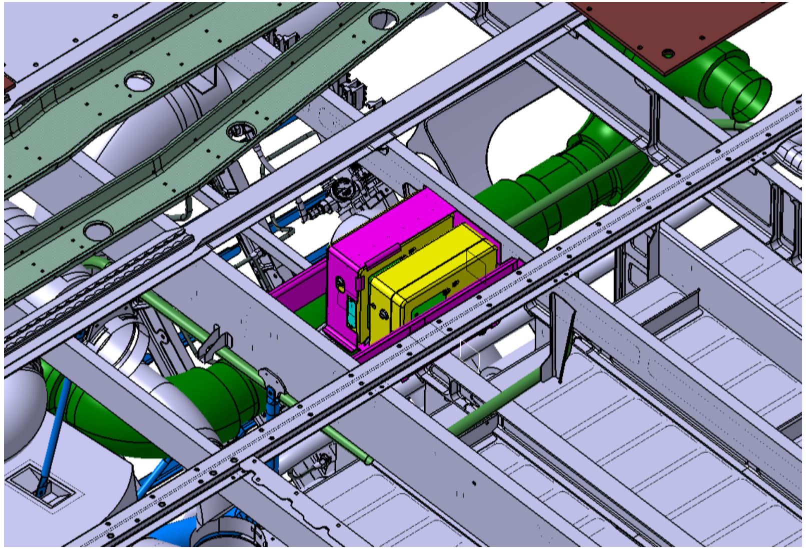
- Accessible by laptop or tablet through WIFI
- Data downloadable as csv
- Search criteria on file:
  - Serial number, aircraft type and number, data and time





Permanent Aircraft Installation

- OEM and airline support to determine optimal location
- Access through Avionics hatch



Schedule and Launch Plan

- 10 early-release CAQS MK1 available Q1 2020
- 3 to 6 month initial installation and FOC replacement
  - Assessment of:
    - Performance
    - Life
    - Reliability
  - Optimize algorithms using in-service data
  - Upload software upgrades
- Continuing CAQS MK1 Production & Release
  - 2nd batch Q2, 2020
  - 3rd batch Q3, 2020

THANK YOU

Pall Corporation

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Because of technological developments related to the products, systems and/or services described herein, the data and procedures are subject to change without notice. Please consult your Pall representative or visit www.pall.com to verify that this information remains valid. Pall Corporation has offices and plants throughout the world. For Pall representatives in your area, please visit our website.

Filtration. Separation. Solution.SM

17-09-2019

Dealing with Cabin Odor Events

Aircraft Cabin Air

International Conference 2019

Ricardo Pavia

TAP M&E Systems Engineering

A STAR ALLIANCE MEMBER

TAP MAINTENANCE & ENGINEERING

Topics

1. Pneumatic and Air Conditioning System

2. Cabin Air Quality troubleshooting
    - Causes of Cabin Odors
    - Dealing with a Cabin Odor Event
    - How to identify the Contamination Source?
    - COS Report
    - ECS Decontamination
    - Test and Release to Service

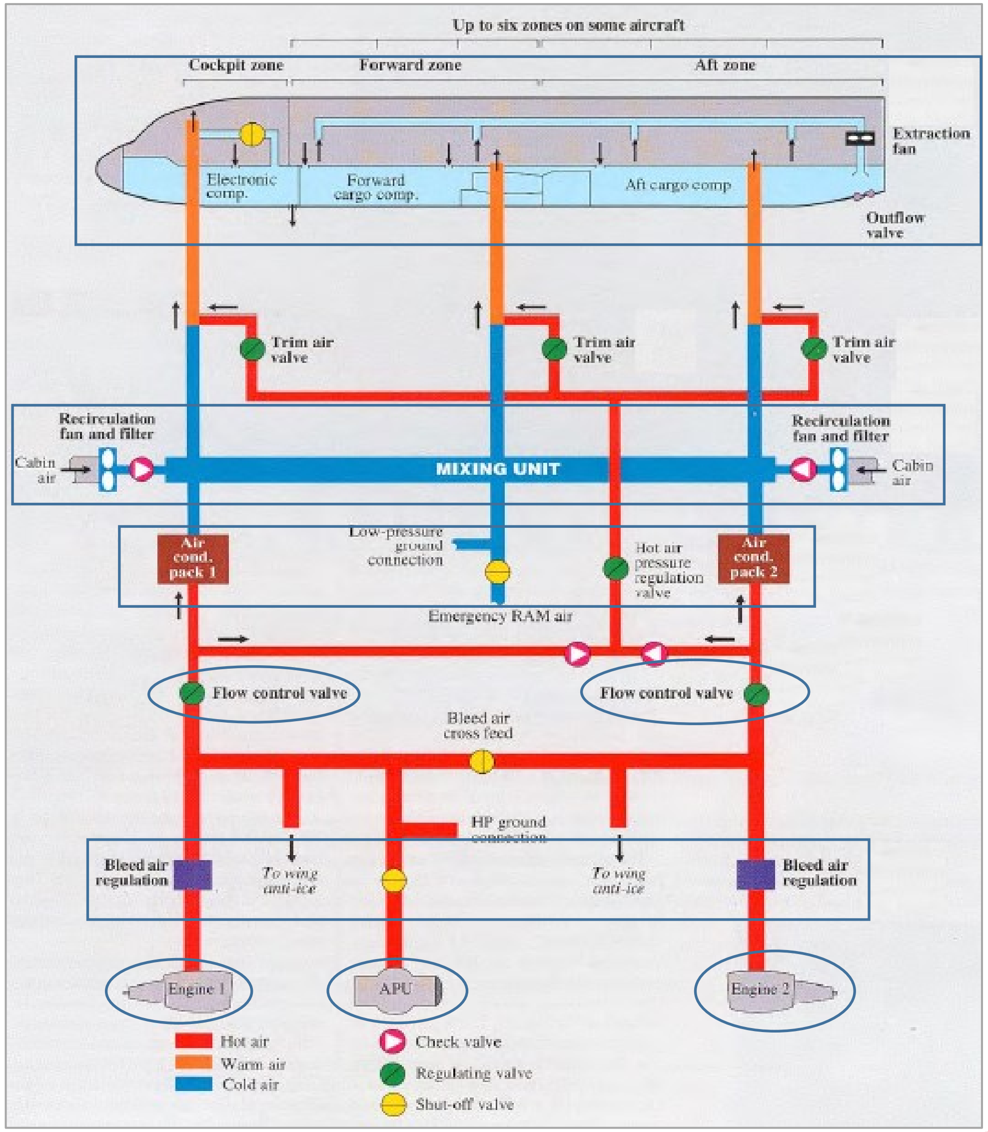
3. Challenges on Cabin Odor Events

MAINTENANCE
& ENGINEERING

1. Pneumatic and Air Conditioning System

Layout

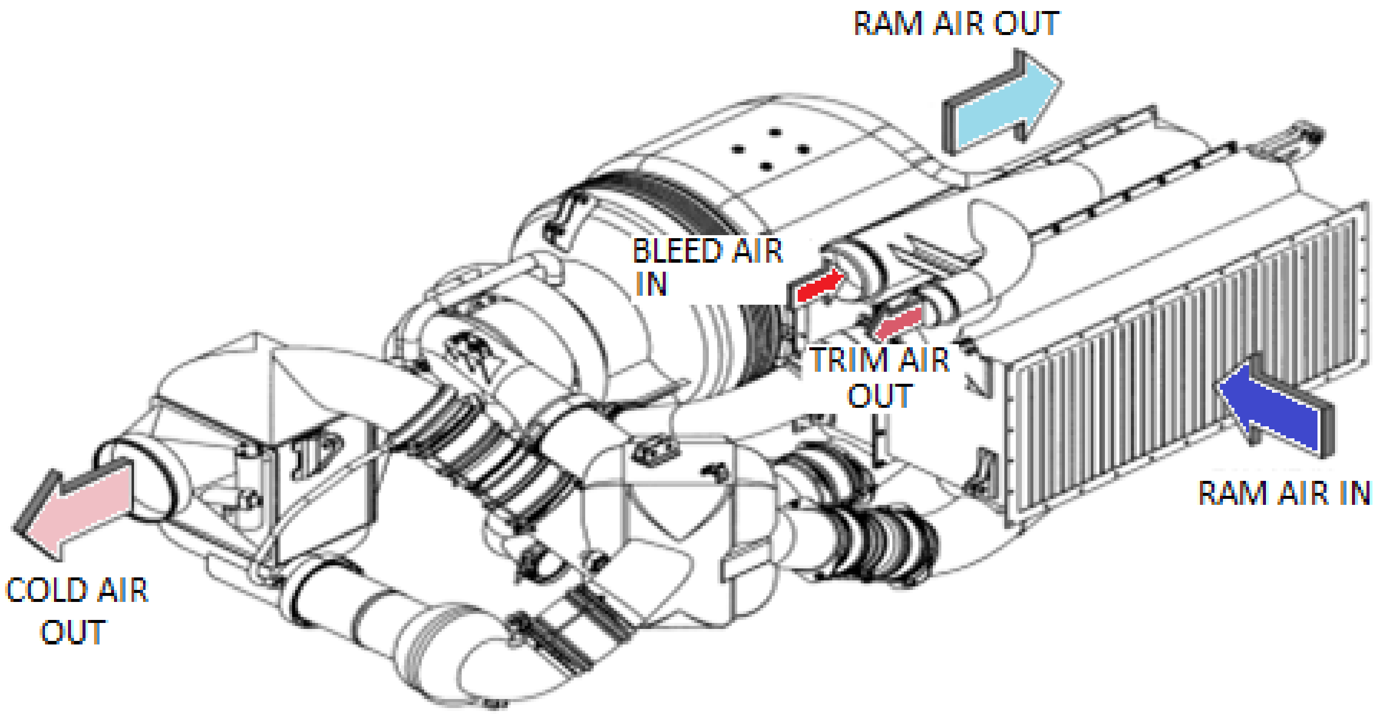
- ✓ The air is provided to cabin with a possibility of adding hot air if required
- ✓ Mixer Unit receive fresh air from the packs and the recirculation air from cabin
- ✓ Air Conditioning Packs are responsible to dehumidify and reduce the air temperature
- ✓ Part of the regulated air is provided to the Air Conditioning Packs
- ✓ The air is regulated in pressure and temperature by the pneumatic system
- ✓ Air is bled from Engines or APU in flight



Source: Airbus Fast 19

1. Pneumatic and Air Conditioning System

Air Conditioning Pack



- ❖ Apply a visual inspection for **oil traces** and **oil smell** on pack components

- ❖ **High complexity** to understand the affected contaminated components

AOG – Aircraft On Ground

If contaminated, a complete pack replacement could take **1 day** per each Air Conditioning Pack

2. Cabin Air Quality Troubleshooting

Causes of Cabin Odors

EXTERNAL Causes

Exhaust fumes from other aircrafts

Pollution

Birds

Pollens

Cleaning agent residues

De-icing fluid

Hydraulic fluid leaks

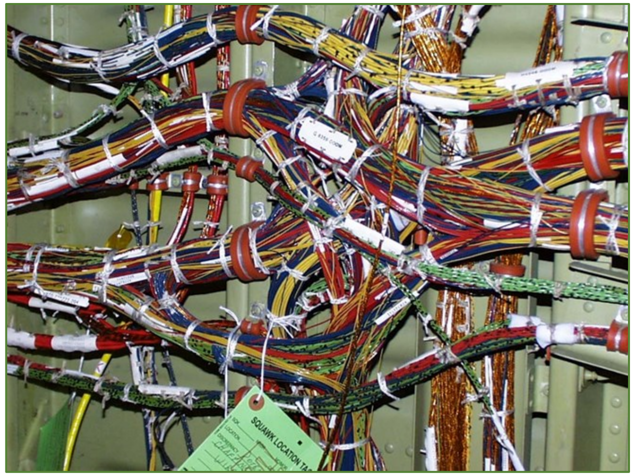
2. Cabin Air Quality Troubleshooting

Causes of Cabin Odors

INTERNAL Causes

Galley equipment (i.e. ovens, coffee makers, etc)

Toilet fluid spillage, leakage and also unapproved mixing of different disinfectant fluids in the toilet.



Damaged electrical wiring or components

APU or Engine oil leaks into the bleed system that leads to ECS contamination

Spillages within cargo compartments

2. Cabin Air Quality Troubleshooting

Dealing with a Cabin Odor Event

First Step – How to identify the Contamination Source?

- Analyze the Cabin Odor Sheet
- Identify the contamination source

Second Step – ECS Decontamination

- ECS Decontamination if applicable
- Replace the Engine or APU if applicable

Third Step – Test and Release to Service

- Test the ECS on ground for any odor at cabin
- Put the Aircraft back in service for flight

2. Cabin Air Quality Troubleshooting

How to identify the Contamination Source?

- COS report
- Visual and inspection for odor on APU and Engines for oil leakage
- ERU (Engine Run Up) to identify the correct source of odors
- Flight Crew co-operation on troubleshooting (if possible)
- MMEL for troubleshooting proposes (i.e. bleed OFF or ECS OFF)
- Aerotracer (equipment to measure the type of contamination)
- MMEL dispatch for later corrective actions when people, components and slot are not available.

Difficulty to identify the exact source of contamination

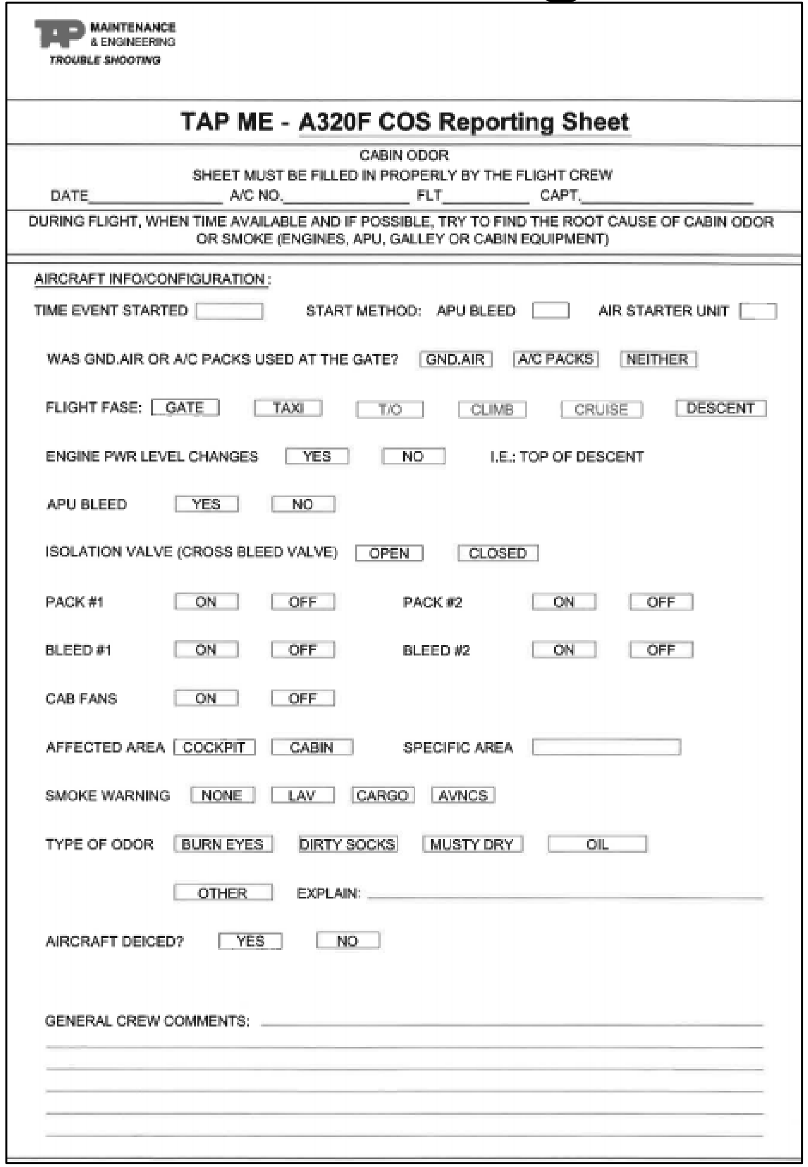
2. Cabin Air Quality Troubleshooting

COS Report

Importance of **COS** report filled by **Flight Crew**

Includes:

- Aircraft Configuration — Pre flight / Time of Event
- Pneumatic/Bleed Configuration
- Air Conditioning Configuration
- Description/Type of the Odor



TAP MAINTENANCE & ENGINEERING
TROUBLE SHOOTING

TAP ME - A320F COS Reporting Sheet

CABIN ODOR
SHEET MUST BE FILLED IN PROPERLY BY THE FLIGHT CREW

DATE______ A/C NO.______ FLT______ CAPT.______

DURING FLIGHT, WHEN TIME AVAILABLE AND IF POSSIBLE, TRY TO FIND THE ROOT CAUSE OF CABIN ODOR OR SMOKE (ENGINES, APU, GALLEY OR CABIN EQUIPMENT)

AIRCRAFT INFO/CONFIGURATION:

TIME EVENT STARTED [ ] START METHOD: APU BLEED [ ] AIR STARTER UNIT [ ]

WAS GND.AIR OR A/C PACKS USED AT THE GATE? [GND.AIR] [A/C PACKS] [NEITHER]

FLIGHT FASE: [GATE] [TAXI] [T/O] [CLIMB] [CRUISE] [DESCENT]

ENGINE PWR LEVEL CHANGES [YES] [NO] I.E.: TOP OF DESCENT

APU BLEED [YES] [NO]

ISOLATION VALVE (CROSS BLEED VALVE) [OPEN] [CLOSED]

PACK #1 [ON] [OFF] PACK #2 [ON] [OFF]

BLEED #1 [ON] [OFF] BLEED #2 [ON] [OFF]

CAB FANS [ON] [OFF]

AFFECTED AREA [COCKPIT] [CABIN] SPECIFIC AREA [ ]

SMOKE WARNING [NONE] [LAV] [CARGO] [AVNCS]

TYPE OF ODOR [BURN EYES] [DIRTY SOCKS] [MUSTY DRY] [OIL]

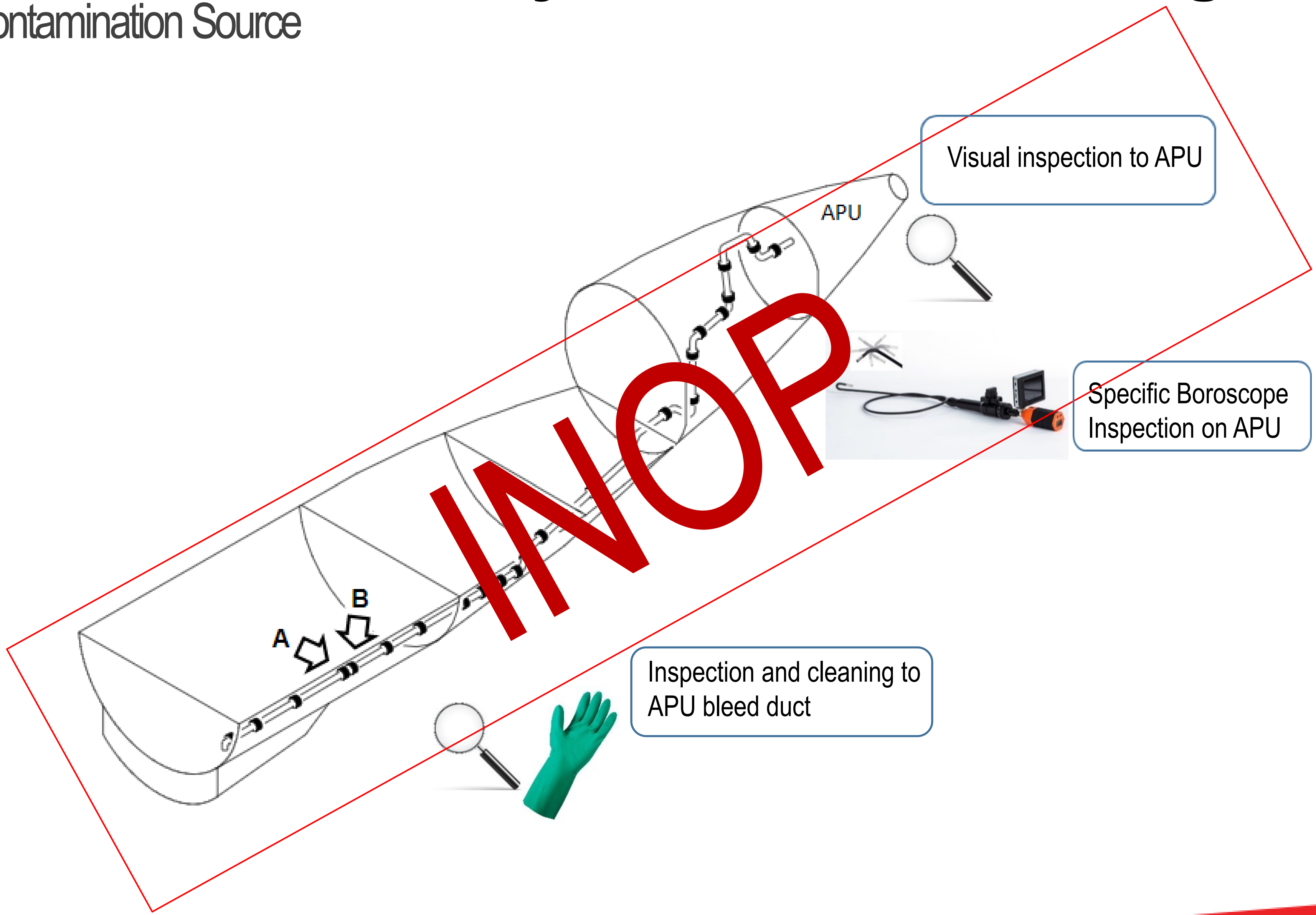
[OTHER] EXPLAIN: ______

AIRCRAFT DEICED? [YES] [NO]

GENERAL CREW COMMENTS: ______

2. Cabin Air Quality Troubleshooting

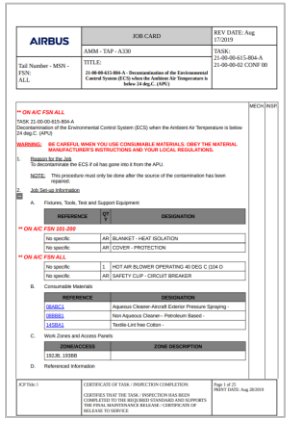
APU as Contamination Source



2. Cabin Air Quality Troubleshooting

ECS Decontamination

Initiate the AMM Decontamination procedures



AIRBUS	JOB CARD	REV DATE: Aug 17/2019
	AMM - TAP - A330	TASK: 21-00-00-615-804-A 21-00-00-02 CONF 00
Tail Number - MSN - FSN: ALL	TITLE: 21-00-00-615-804-A - Decontamination of the Environmental Control System (ECS) when the Ambient Air Temperature is below 24 deg.C. (APU)	

MECH. INSP

** ON A/C FSN ALL

TASK 21-00-00-615-804-A
Decontamination of the Environmental Control System (ECS) when the Ambient Air Temperature is below 24 deg.C. (APU)

WARNING: BE CAREFUL WHEN YOU USE CONSUMABLE MATERIALS. OBEY THE MATERIAL MANUFACTURER'S INSTRUCTIONS AND YOUR LOCAL REGULATIONS.

1. Reason for the Job
   To decontaminate the ECS if oil has gone into it from the APU.

   NOTE: This procedure must only be done after the source of the contamination has been repaired.

2. Job Set-up Information

   A. Fixtures, Tools, Test and Support Equipment

REFERENCE	QTY	DESIGNATION
** ON A/C FSN 101-200		
No specific	AR	BLANKET - HEAT ISOLATION
No specific	AR	COVER - PROTECTION
** ON A/C FSN ALL		
No specific	1	HOT AIR BLOWER OPERATING 40 DEG C (104 D
No specific	AR	SAFETY CLIP - CIRCUIT BREAKER

   B. Consumable Materials

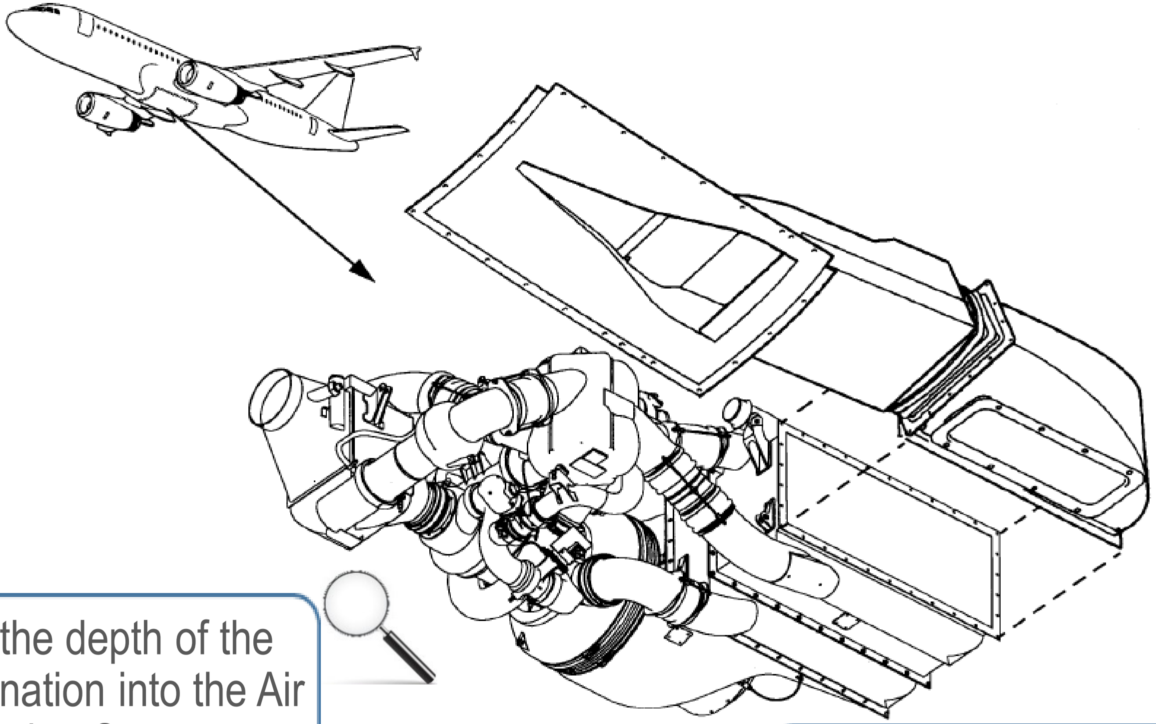
REFERENCE	DESIGNATION
08ABC1	Aqueous Cleaner-Aircraft Exterior Pressure Spraying -
08BBB1	Non Aqueous Cleaner - Petroleum Based -
14SBA1	Textile-Lint free Cotton -

   C. Work Zones and Access Panels

ZONE/ACCESS	ZONE DESCRIPTION
192JB, 193BB	

   D. Referenced Information

JCP Title:	CERTIFICATE OF TASK / INSPECTION COMPLETION: CERTIFIES THAT THE TASK / INSPECTION HAS BEEN COMPLETED TO THE REQUIRED STANDARD AND SUPPORTS THE FINAL MAINTENANCE RELEASE / CERTIFICATE OF RELEASE TO SERVICE	Page 1 of 25 PRINT DATE: Aug 20/2019



Assess the depth of the contamination into the Air Conditioning System

Components replacement and bleed ducts cleaning

High complexity and time to perform the recommended AMM task for Decontamination of the ECS

2. Cabin Air Quality Troubleshooting

Test and Release to Service

TEST

- ➢ Engine Run Up/APU on Ground
- ➢ Different Bleed and Pack configuration for smell identification at Cabin

RELEASE TO SERVICE

- ➢ No smell identification
- ➢ Put the Aircraft back in-service operation for flight

TAP PORTUGAL

Sheet *(Folha)* 1 of *(de)* 1

MAINTENANCE RELEASE *(Declaração de Aptidão para o Voo)*

☐ Check here in case of test flight *(Assinalar aqui em caso de voo de ensaio)*

AIRCRAFT *(Aeronave)*

MANUFACTURER *(Fabricante)* AIRBUS	MODEL *(Modelo)* A330-941
SERIAL NO. *(Nº. de Série)* 01897	NATIONALITY & REGISTRATION MARKS *(Nacionalidade e Matrícula)* PORTUGUESA CS-TUE
FLIGHT HOURS SINCE NEW *(Total de Horas de voo)* 729:43	CYCLES SINCE NEW *(Total de Ciclos)* 91

CUSTOMER/OPERATOR *(Cliente/Operador)*

NAME *(Nome)* TAP PORTUGAL	ADDRESS *(Morada)* AEROPORTO DE LISBOA

THE AIRCRAFT ABOVE IDENTIFIED WAS INSPECTED AND REPAIRED OR MODIFIED, EXCEPT AS OTHERWISE SPECIFIED, IN ACCORDANCE WITH PART 145 AND, IN RESPECT TO THE WORK PERFORMED, IS CONSIDERED READY FOR RELEASE TO SERVICE. (*A aeronave acima identificada foi inspeccionada e reparada ou modificada, excepto se de outra forma especificado, de acordo com a PARTE 145 e, relativamente aos trabalhos realizados, é considerada aprovada para serviço*)
DESCRIPTION OF WORK PERFORMED (*Descrição do trabalho efectuado*):

A1.1 Check; EO`s, RTR`s and NR`s.

PERTINENT DETAILS OF THE REPAIR ARE ON FILE AT THIS MAINTENANCE ORGANIZATION UNDER EVENT No. (O processo documental com os detalhes dos trabalhos efectuados encontra-se arquivado nesta Organização de Manutenção, sob o nº do evento): **AV 103639**
FOR SPECIAL REMARKS, INCLUDING DEFERRED ITEMS SEE _n_ ATTACHED SHEETS, TO THIS ORIGINAL CERTIFICATE
(As condições especiais em que é emitida esta declaração, incluídos itens diferidos, estão indicadas nas folhas anexas ao certificado original)

DATE *(Data)*: 20 de agosto de 2019

SIGNATURE AND PRINTED NAME OF AUTHORISED PERSON BY QUALITY ASSURANCE DEPARTMENT:
(Assinatura e nome legível de uma pessoa autorizada pela Direcção da Qualidade):

Sig *(Ass)*: ______ Name *(Nome)*: ______ TAP MA 726

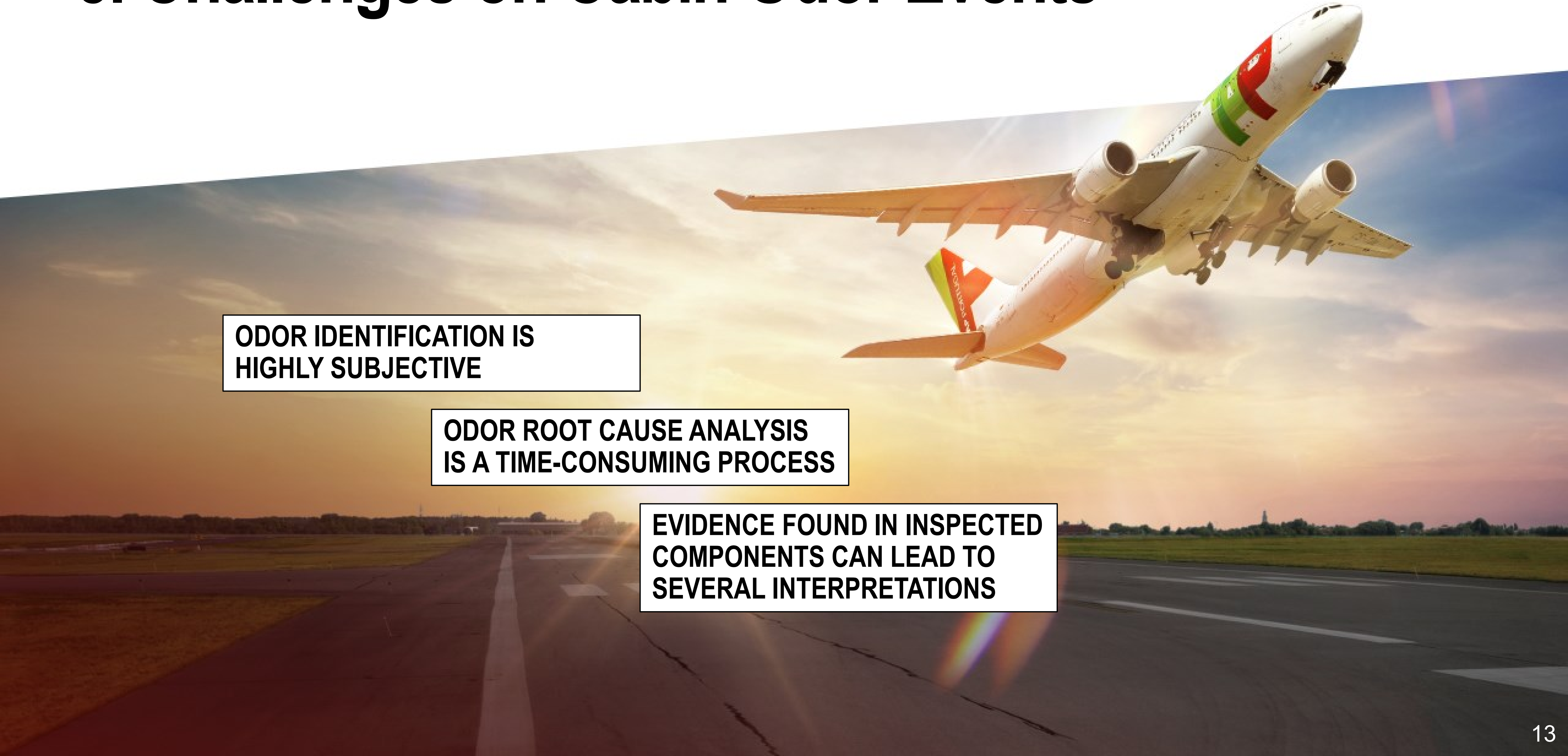
TAP PORTUGAL PART - 145 APPROVAL CERTIFICATE NO. PT.145.001

Maintenance & Engineering
Quality Assurance Department
P. O. Box 50194
1704-801 LISBOA - Portugal

Tel. No. 351 21 8416204
Fax No. 351 21 8415775
SITA Code LISMVTP
Telex 12231 TAP LIS P

TAP MOD ME 110 REV. 7, 26 NOV 2009

3. Challenges on Cabin Odor Events



ODOR IDENTIFICATION IS HIGHLY SUBJECTIVE

ODOR ROOT CAUSE ANALYSIS IS A TIME-CONSUMING PROCESS

EVIDENCE FOUND IN INSPECTED COMPONENTS CAN LEAD TO SEVERAL INTERPRETATIONS

Our vision

LEANER and FASTER troubleshooting for an air FREE of contaminants

TAP AIR PORTUGAL

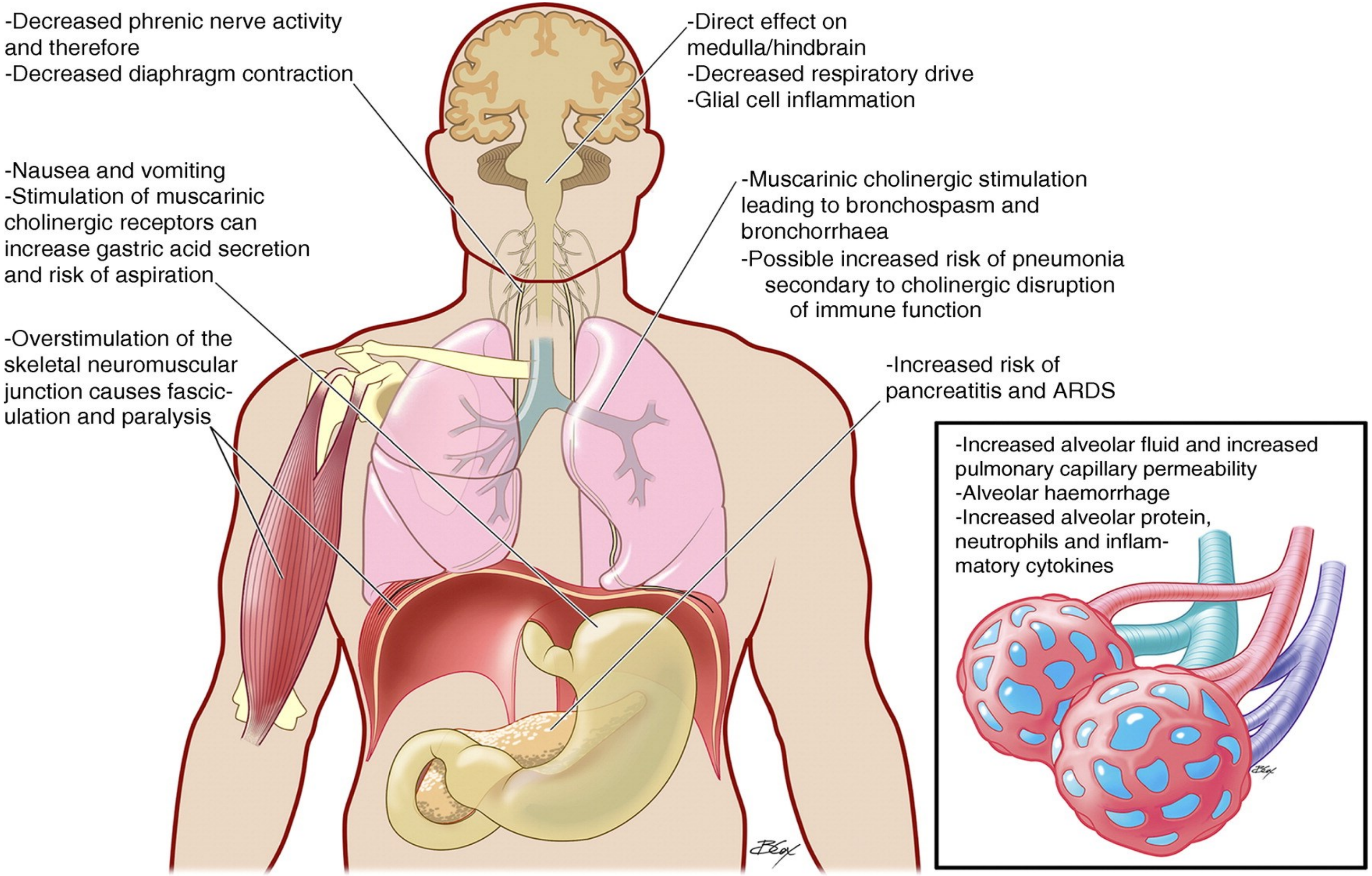
AIRCRAFT CABIN AIR
International Conference 2019

Respiratory disease caused by Aerotoxic Syndrome

J. Roig, MD, PhD, FCCP
Pulmonary Department
Clínica Creu Blanca
Barcelona

DR.JORDI ROIG
NEUMÓLOGO
www.drjordiroig.com

CreuBlanca



Hulse EJ. Respiratory Complications of Organophosphorus Nerve Agent and Insecticide Poisoning. Implications for Respiratory and Critical Care. AJRCCM 2014;190:1342-54

CASE 1

- 47-year-old male international airline pilot experienced 4 episodes of cabin air fume events, over 2 years during flights on Airbus aircraft
- 2 of them were smell episodes, the others were smoke events of unknown origin
- Difficulties with immediate memory recall and, occasionally, with the fluency of his speech
- Last event: the pilot developed mild cough and shortness of breath that persisted for several weeks.
- Past history: non remarkable; no prior medication; no other epidemiologic hints

CASE 1: one month later

- Severe cough, tiny whitish sputum, moderate dyspnea
- Physical exam: bilateral wheezing, O_2 saturation 93% (room air); afebrile
- Chest X-ray and CT scan: normal
- Sputum microbiology: negative
- Negative PCR test (Film Array Respiratory Panel 2) of nasopharyngeal secretions for

  Adenovirus, Influenza A & B virus, Parainfluenza, RSV, Rhinovirus/Enterovirus, *Chlamydia pneumoniae*, *Mycoplasma pneumoniae*, *Bordetella pertussis*, Metapneumovirus & Corona virus

CASE 1

- Spirometry: moderate airway obstruction with a strongly positive bronchodilator test. Diffusion capacity for carbon monoxide (D_{LCO}) was normal
- Steroids, leukotriene inhibitors, inhaled long acting muscarinic agents (LAMA) and long acting beta-adrenergic agents (LABA) were prescribed
- Respiratory symptoms slowly subsided during the following 6 months; but neurologic complaints even worsened
- At 3-month follow-up a diagnosis of Reactive Airway Dysfunction Syndrome (RADS) related to Aerotoxic Syndrome was done

Pulmonary Function Test	Actual	% Predicted
TLC, L	7.47	91
RV, L	2.82	111
FVC, L	5.09	101
FEV1, L	2.45	63
FEV1/FVC	48	63
$FEF_{25\text{-}75}$, L	0.94	25
D_{LCO}, mL/min/mm Hg	25.8	82

CASE 1: long-term follow-up

- Pain radiating down his arms and slight numbness and tingling in fingers
- Formal neurological examination: normal
- Blood tests: normal
  - Negative immunological studies (ACE, RF, ANA, ANCA)
- MRI examination and EMG: normal
- Neuronal injury :
  - Highly positive tests for autoantibodies against myelin basic protein (MBO), neurofilament proteins (NFP), microtubule associated tau proteins, tubulin, MBP and microtubule associated protein-2 (MAP-2)
  - Astrocytic markers brain injury: highly increased levels for autoantibodies against glial fibrillary acidic protein (GFAP) and glial calcium-binding protein S-100B

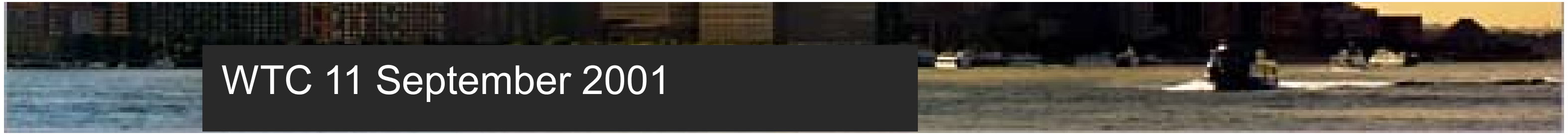
Reactive Airways Dysfunction Syndrome (RADS)

- ✓Respiratory symptoms after exposure to irritant fume, vapor,...
  - Cough, wheezing, shortness of breath, chest tightness
- ✓Onset < 24 hours of exposure + at least 3 months
- ✓Documented absence of previous respiratory complaints
- ✓Pulmonary function tests: Bronchial hyperreactivity
- ✓Single inhalation of a high concentration or irritating chemicals generated as aerosol or high levels of particulates **but...**

Banauch GI *et al*. Persistent hyperreactivity and reactive airway dysfunction in firefighters at the World Trade Center.

Am J Respir Crit Care Med 2003; 168: 54-62

RADS does not require a clinically severe inhalation injury necessitating medical care



Low dose RADS & Low Intensity Chronic Exposure Dysfunction Syndrome

- ✓ Related to “ irritant-induced asthma”
- ✓ Multiple exposures to low concentrations of irritants
- ✓ Intensity of exposure is less but may be of greater duration
- ✓ Onset of symptoms after several hours or days
- ✓ Chemical and physical nature of the irritating agent
- ✓ Concentration & simultaneous multiple agents
- ✓ Risk factors are incompletely characterized

CASE 2

- 34 year-old female international airline flight attendant exposed to a few, repetitive smell oil odors in the cabin of an Airbus 320 during takeoff and landing for 2 weeks
- Past History: unremarkable. No prior medication
- Nonspecific upper respiratory tract irritation, mild but progressive dry cough, and some skin itching
- After a strong odor episode, she developed a skin rash particularly involving both ears and trunk, the cough worsened, and she began to complain about mild dyspnea

CASE 2

- Blood test (few days after the last episode):
  - Serum cholinesterase of 18 U/L (normal value < 14)
  - Eosinophils count: normal
- Rash subsided after a course of steroid therapy but moderate shortness of breath and dry cough on exercise persisted
- Chest x-ray performed at the onset of the disease was normal

- Two months after the onset physical examination was unremarkable; CT scan was normal

CASE 2: follow-up

- Inhaled therapy (fluticasone furoate plus vilanterol)
  - Respiratory symptoms progressively subsided
  - Withdrawn after 6 months without any relapse

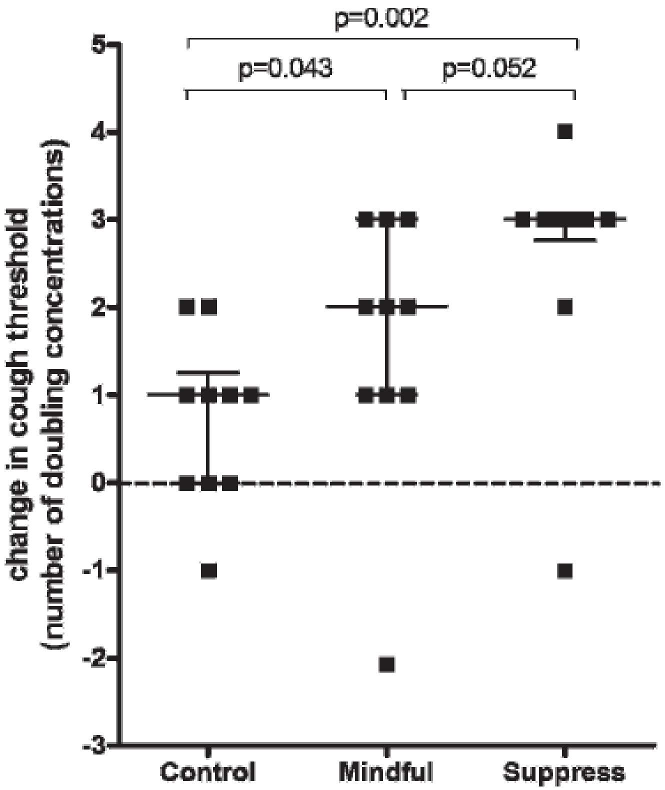
- Recurrent anxiety and emotional instability
- She gave up working as flight attendant
- Mind – body interventions were useful for recovery

Mindfulness

- ✓Mental training to cultivate present moment awareness
- ✓Meditation practice is the cornerstone of mindfulness
- ✓Non pharmacological approach to psychological symptoms related to illness such as anxiety, depression, self blame, catastrophic interpretations…

- ✓Mind & body have been useful in many respiratory conditions

The effect of mindfulness meditation on cough reflex sensitivity



Changes in cough reflex sensitivity to citric acid in healthy volunteers for the control, mindfulness intervention and voluntary cough suppression groups. Horizontal lines represent median values and error bars represent the interquartile range.

Young EC. Thorax 2017

CASE 3

- 56-year-old woman, international airline pilot, presented with symptoms of a long-term, unbearable, dry cough + upper respiratory tract irritation, related to exposure to a variety of environmental substances or odors
- Recurrent headaches, relapsing inflammation of eyelids, pains in her legs and shoulders, weakness, and tingling of her fingertips
- Onset of symptoms 9 years previously soon after a fume event on an Airbus A319
- 4 passengers also required medical assistance because of nausea and shortness of breath

CASE 3

- Physical Exam:
  - low BMI
  - skin abnormalities and eyelids irritation
  - dry cough on deep breathing; O_2 saturation 96% (room air)
- Neurological evaluation: unremarkable
- Blood tests: normal. Increase in myelin associated glycoprotein (MAG)
- Previous chest X rays were reported to be normal
- Spirometric values normal but significant bronchodilator response
- D_{LCO} normal. Interestingly, the breathing of gas mixture (helium) used to perform the diffusion test induced a severe cough episode

CASE 3

- A diagnosis of multiple chemical sensitivity and bronchial hyperreactivity related to Aerotoxic Syndrome was done
- Cough improved with daily inhaled therapy with fluticasone furoate plus vilanterol
- Non- respiratory symptoms persisted on long-term follow-up
- The patient had been forced many years before to cease flying with obvious negative psychological connotations

Multiple Chemical Sensitivity

Idiopathic environmental intolerance (IEI)

✓Nonspecific symptoms when exposed to low levels of chemicals, biologic or physical agents

✓Medical societies scepticism: psychiatric disorder?

✓No consistent objective diagnostic tests to define an illness...

✓Cough is the most frequently reported respiratory symptom

✓Psychological approach mandatory: mind & body interventions

✓Quick Environmental Exposure & Sensitivity Inventory (QUEESI questionnaire): TILT test (Toxicant-induced loss of tolerance)


There are presently 30 UK airline pilots grounded due to toxic air

AIRCRAFT CABIN AIR
International Conference 2019

Conclusions

- Respiratory symptoms rank second to neurological symptoms
- Respiratory symptoms have been often neglected since many clinicians are unaware of this condition
- Bronchial hyperresponsiveness is the hallmark of involvement
- Some cases are consistent with RADS – Irritant induced asthma
- Some cases may also be included in the spectrum of MCS / Idiopathic Environmental Intolerance

AIRCRAFT DESIGN AND SYSTEMS GROUP (AERO)

Hochschule für Angewandte Wissenschaften Hamburg

Hamburg University of Applied Sciences

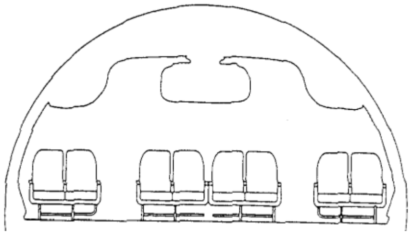
Cabin Air Contamination – A Summary of Engineering Arguments

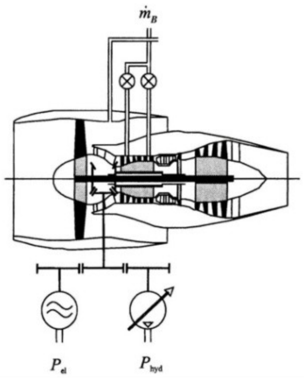
Dieter Scholz

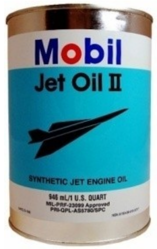
Hamburg University of Applied Sciences

International Aircraft Cabin Air Conference 2019

Imperial College London, 17/18.09.2019







Contents

Introduction

Definition: Fume Event

In a fume event, the cabin and/or cockpit of an aircraft is filled with fume. Air contamination is due to fluids such as engine oil, hydraulic fluid or anti-icing fluid. A Fume Event includes a Smell Event. Note: Other reasons for fume in the cabin are possible. The term "fume event", however, is generally used as defined here. Definition adapted from (Wikipedia 2019)

Definition: Smell Event

A fume event without visible fume or smoke, but with a distinct smell usually described as "dirty socks" from the butyric acid originating from a decomposition of the esters that are the base stock of the synthetic jet engine oil.

Definition: Cabin Air Contamination Event (CACE)

In a Cabin Air Contamination Event (CACE) the air in the cabin and/or cockpit of an aircraft is contaminated. Sensation of the contamination can be from vison (fume/smoke), olfaction (smell/odor), a combination of typical symptoms experienced by several passengers and/or or crew or by related measurements of CO, CO2, ozon or other "harmful or hazardous concentrations of gases or vapours" (CS-25.831).

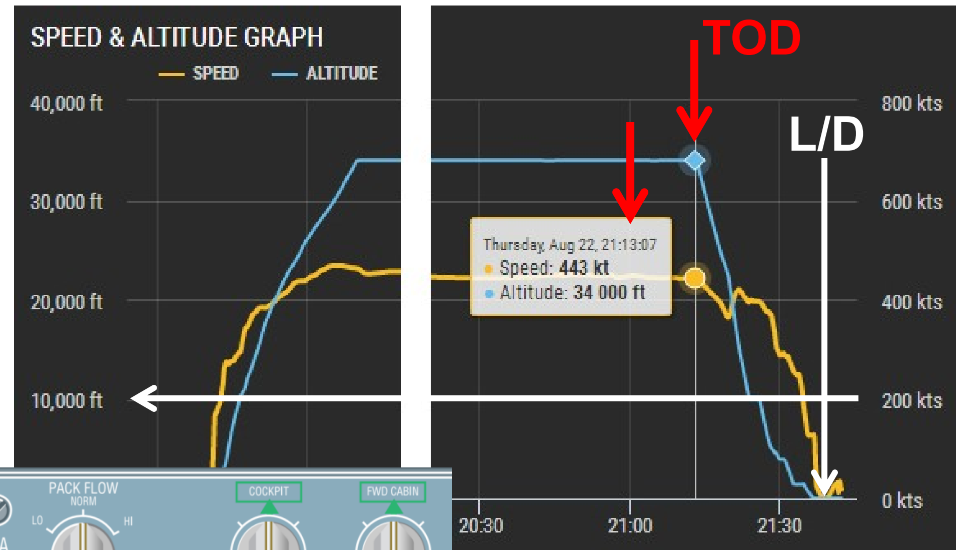
2019-08-22: Hawaiian Airlines, A321neo
Emergency Landing and Evacuation; Smoke on Board

Oakland to Honolulu, Flight HA47, A321neo, N218HA

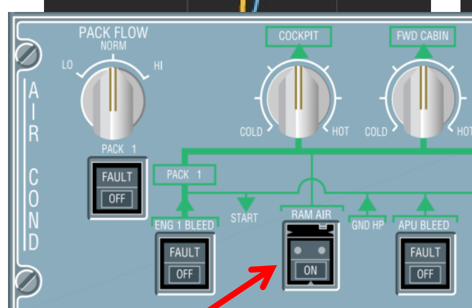
21:13: Top of Descent: Smoke starts to fill cabin i.e. when thrust setting changed.

21:16: Pilots received a fire warning from the cargo compartment and declared an in-flight emergency.

21:36: Landing. After landing there was "no visible evidence of fire, no visible flames" said Snook. "We have since determined that a seal failed in the aircraft's left engine" said Da Silva.



based on Flight Radar 24



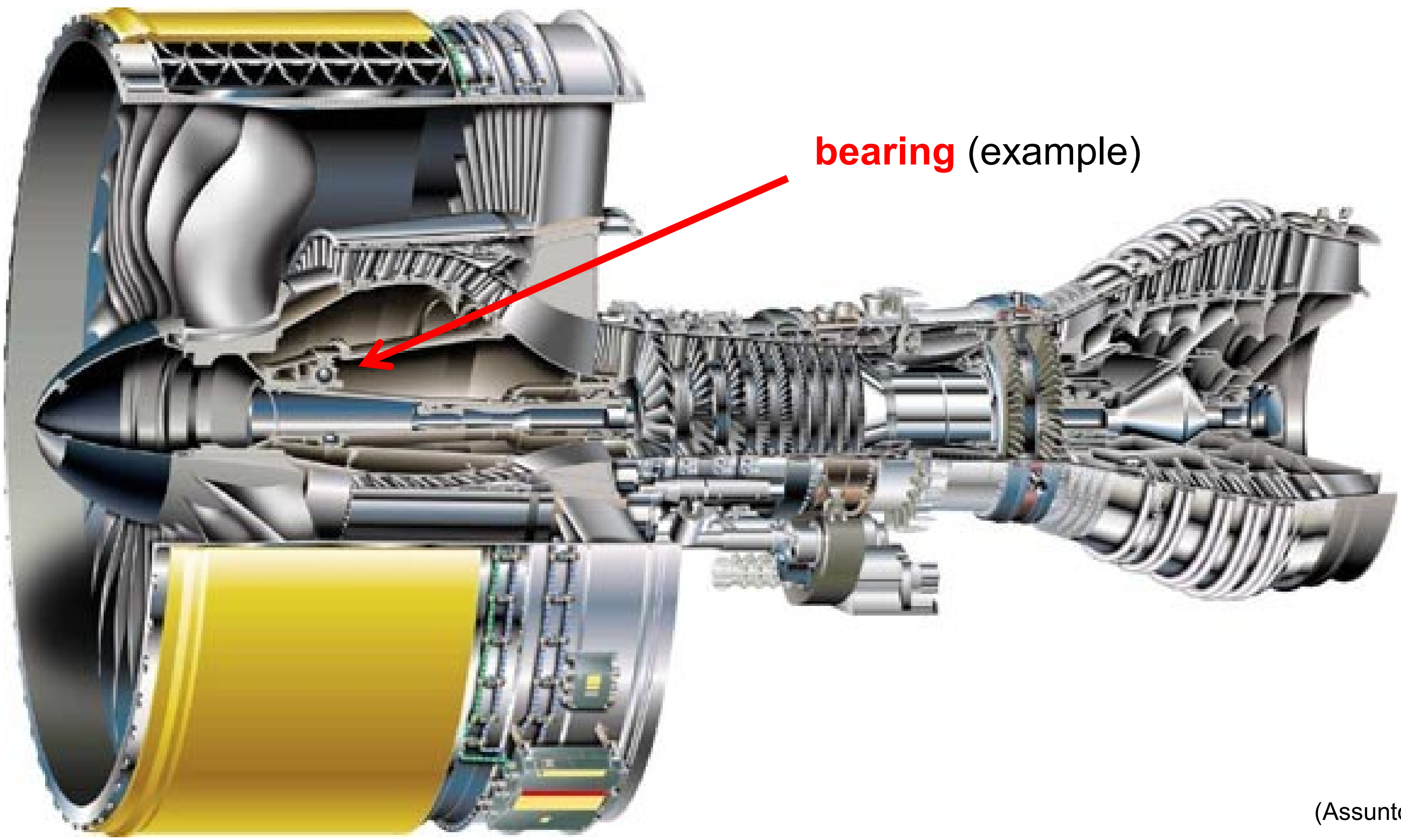
guarded pushbutton

Direct (emergency) **venting with ram air** (independently of bleed air) is possible **below 10000 ft**, but was **not used**.

Jet Engine Technology

Engine Overview

Engine Alliance GP7000

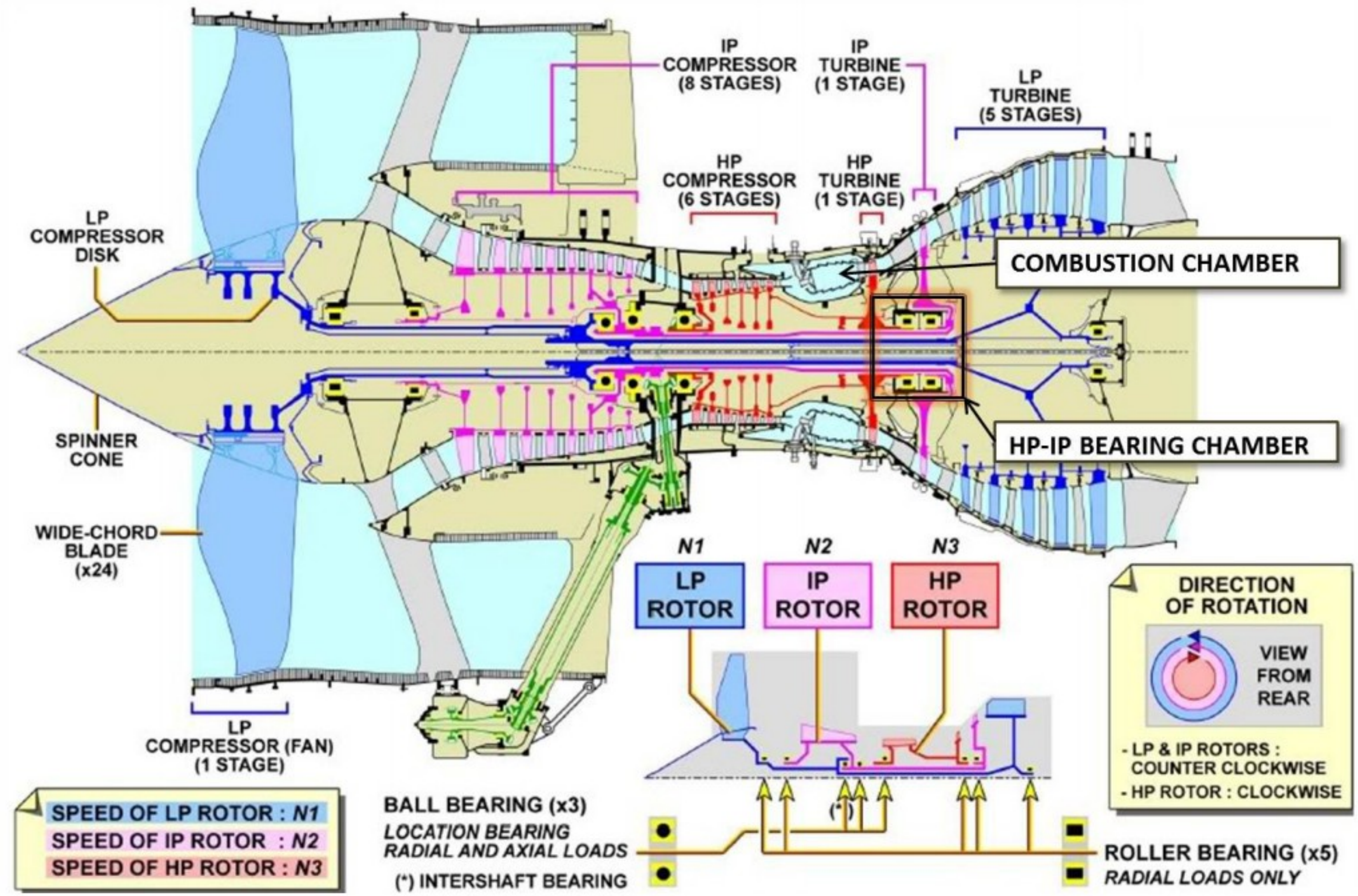


(Assuntos Militares 2013)

Jet Engine Technology

Engine Bearings

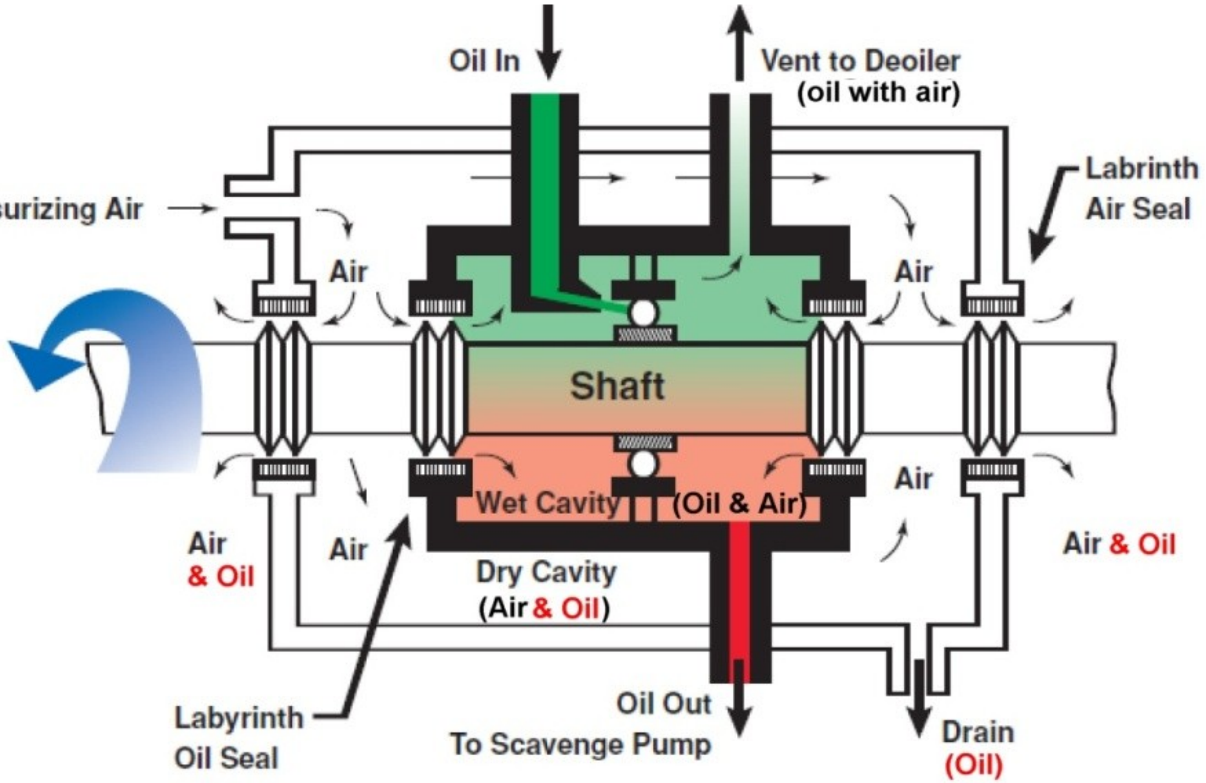
Rolls-Royce Trent 1000



(Ademiyi 2015)

Jet Engine Technology

Lubrication and Sealing of Engine Bearings



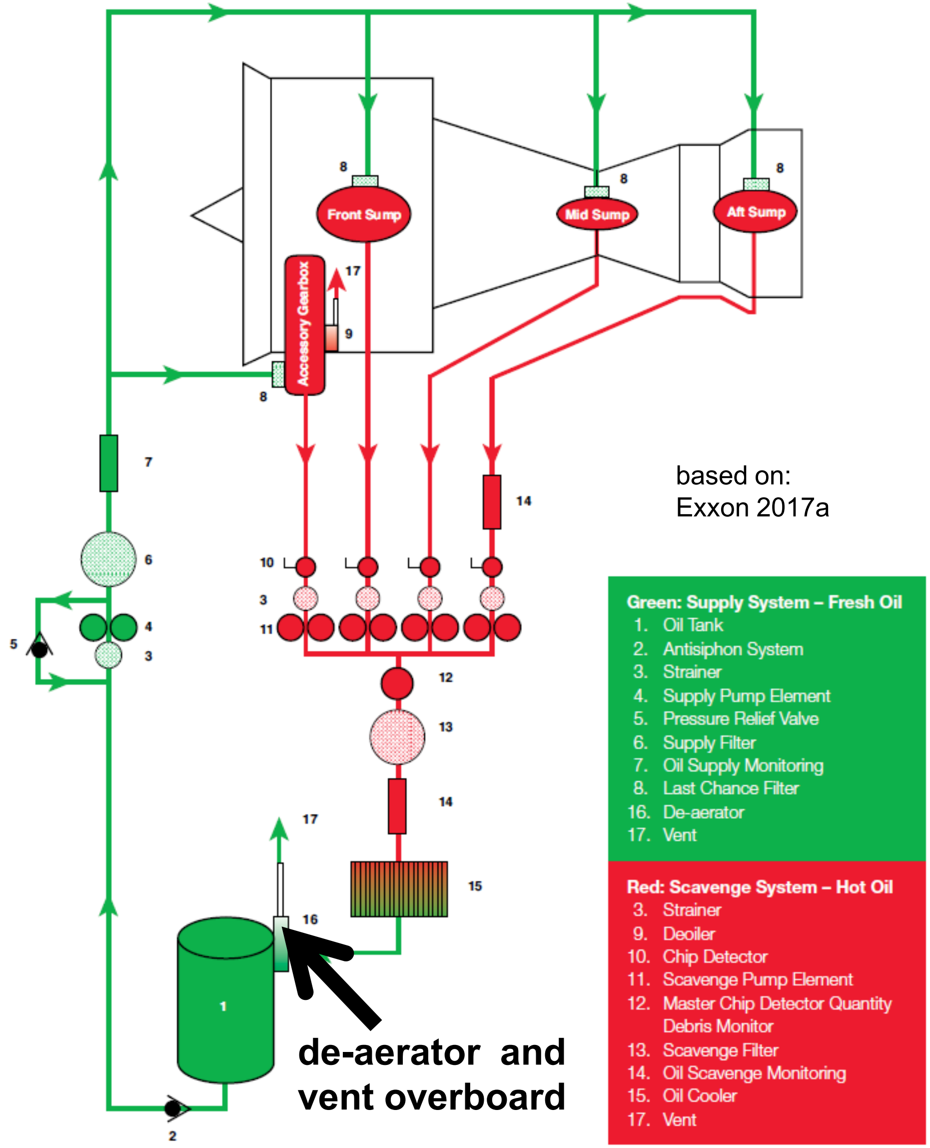
Based on (Exxon 2017b)

Normal operation of engine seals:

1. The "**drain**" discharges **oil**.
2. The "**dry cavity**" contains **oil**.
3. Air and **oil** leak from bearings **into** the **bleed air**.

=> **Engines leak small amounts of oil by design!**

Engine Air and Oil System

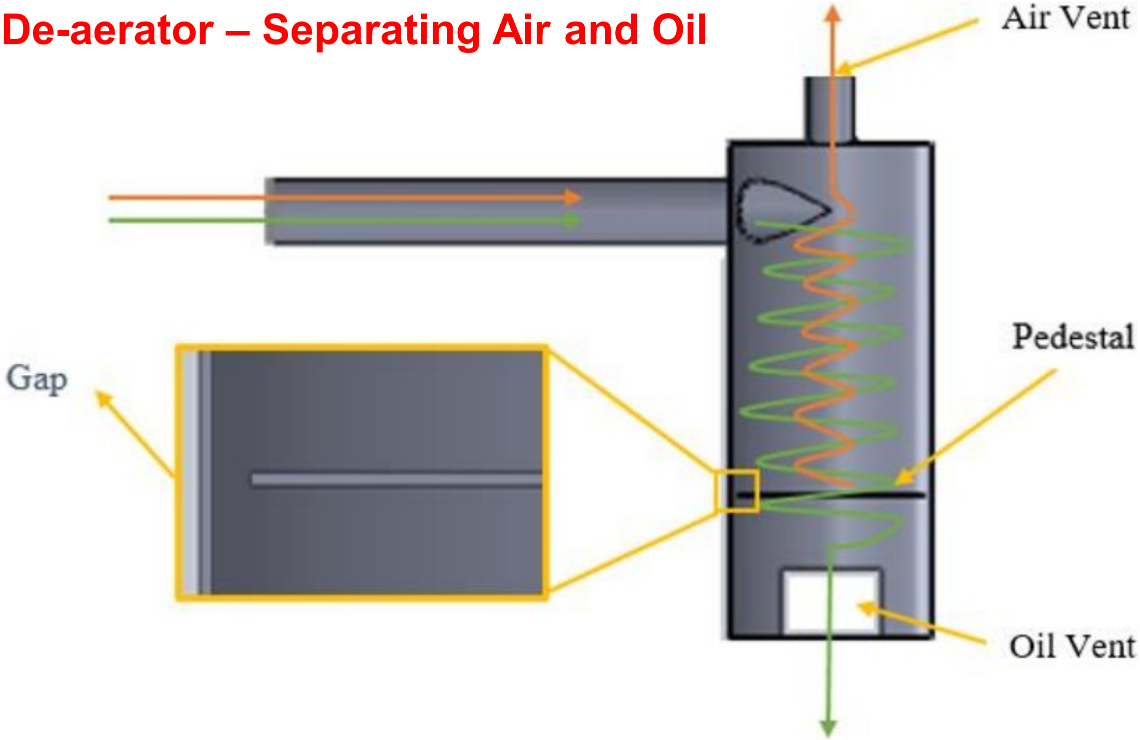


Quotes from: Exxon Mobile (2017a):
"**Jet Engine Oil System – Overview**"
with remarks:

- "The scavenged oil flow is slightly lower than the supply flow due to normal oil consumption through the deoiler, oil seals, and oil leaks." (*Remark: Oil escapes also from the seals*)
- "Therefore, a large amount of air is carried by the scavenge oil and must be removed through a de-aerator when entering the tank." (*Remark: Seals do not seal but allow large amounts of air to enter the seals. If pressure in the compressor is low compared to pressure in the oil system i.e. low* Δp*, oil can escape from the seals.*)

Jet Engine Technology

De-aerator – Separating Air and Oil



(Hehir 2016)

- Air leaving the de-aerator still contains some oil (somtimes visible on the engine as white smoke).
- Amount of oil depends on the oil separating efficiency of the de-aerator.
- Oil leaving de-aerator determines (almost exclusively) the oil consumption of the engine.
- Oil leaving through engine seals is only a very small portion *x* of the engine's oil consumption (1%?).
- Hence: Oil entering cabin depends more on this portion x then on the absolute engine oil consumption!

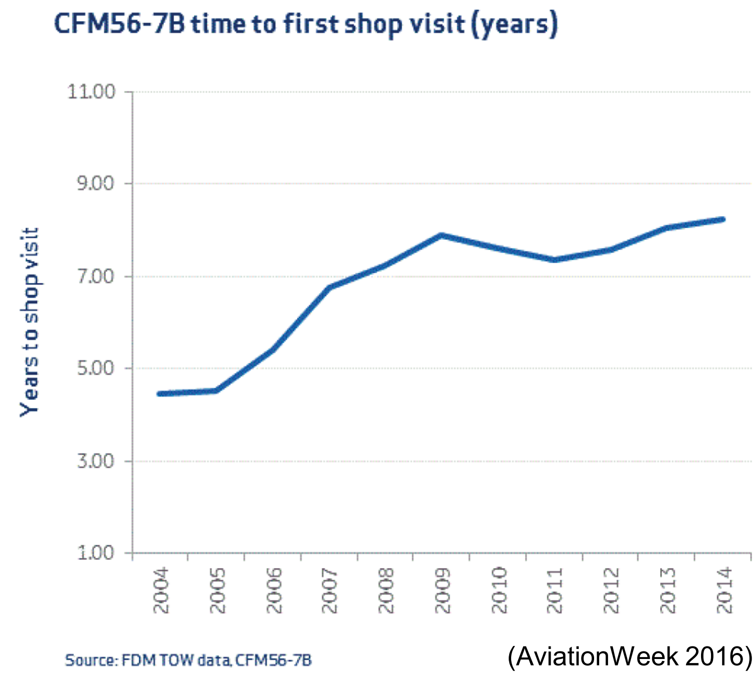
Engines Longer on Wing

Labyrinth-Seal Clearances Increase as Engines Age

"Labyrinth-seal clearances naturally increase as an engine ages. As this occurs – due to rubbing under vibration, gyroscopic torque, rough landings or any g-load factor, the engine air flow increases, resulting in even higher oil consumption" (Exxon 2016a) and hence leakage into the bleed air.

The figure shows increasing time to first shop visit of CFM56-7B engines. It follows:

During a period of 10 years (2004 to 2014) maintenance practice changed such that engines stay on the wing almost twice as long without shop visit and seal replacement.



(AviationWeek 2016)

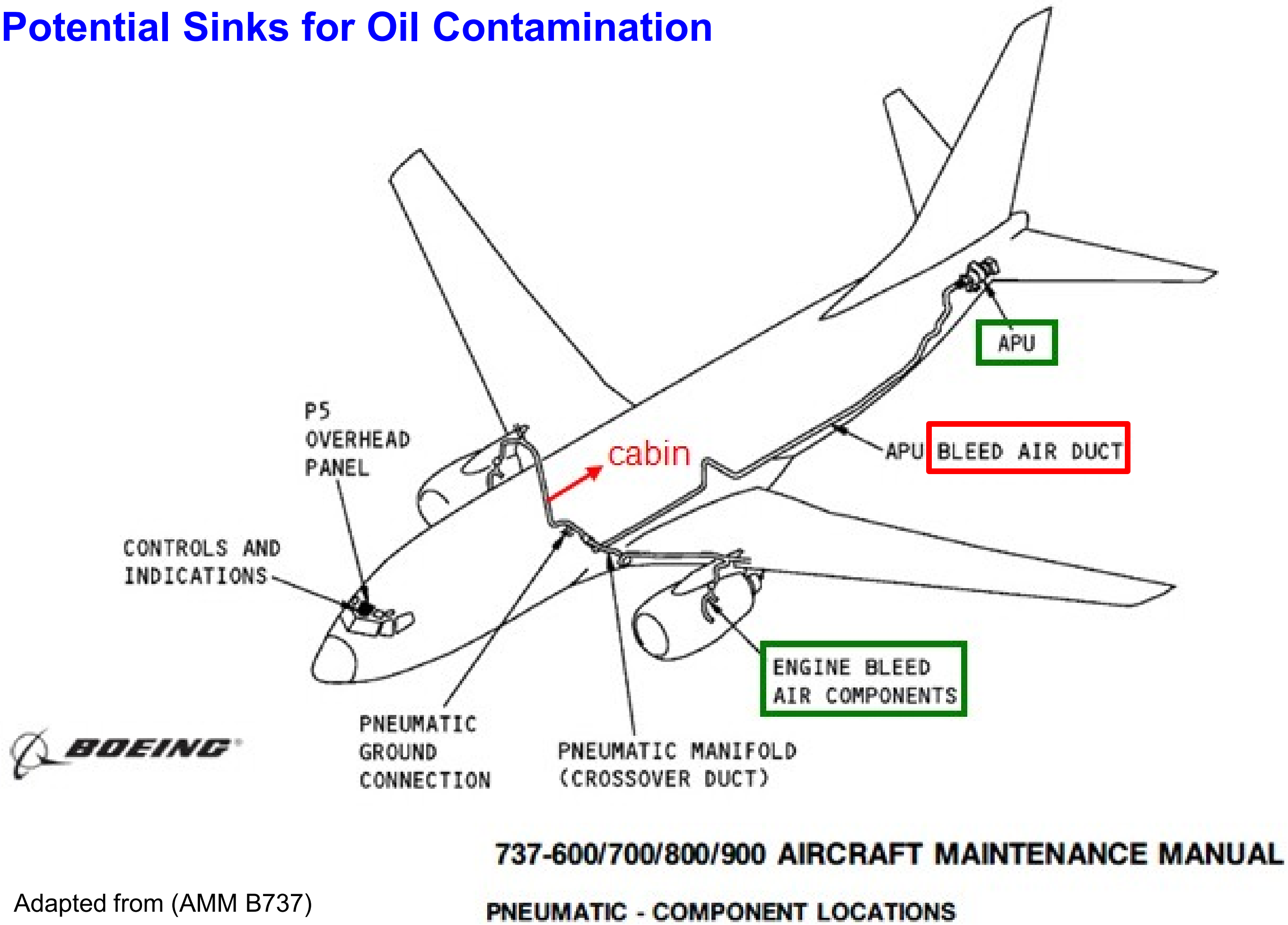
Aircraft Systems Technology

Aircraft Systems Technology

B737

Bleed Air Ducts

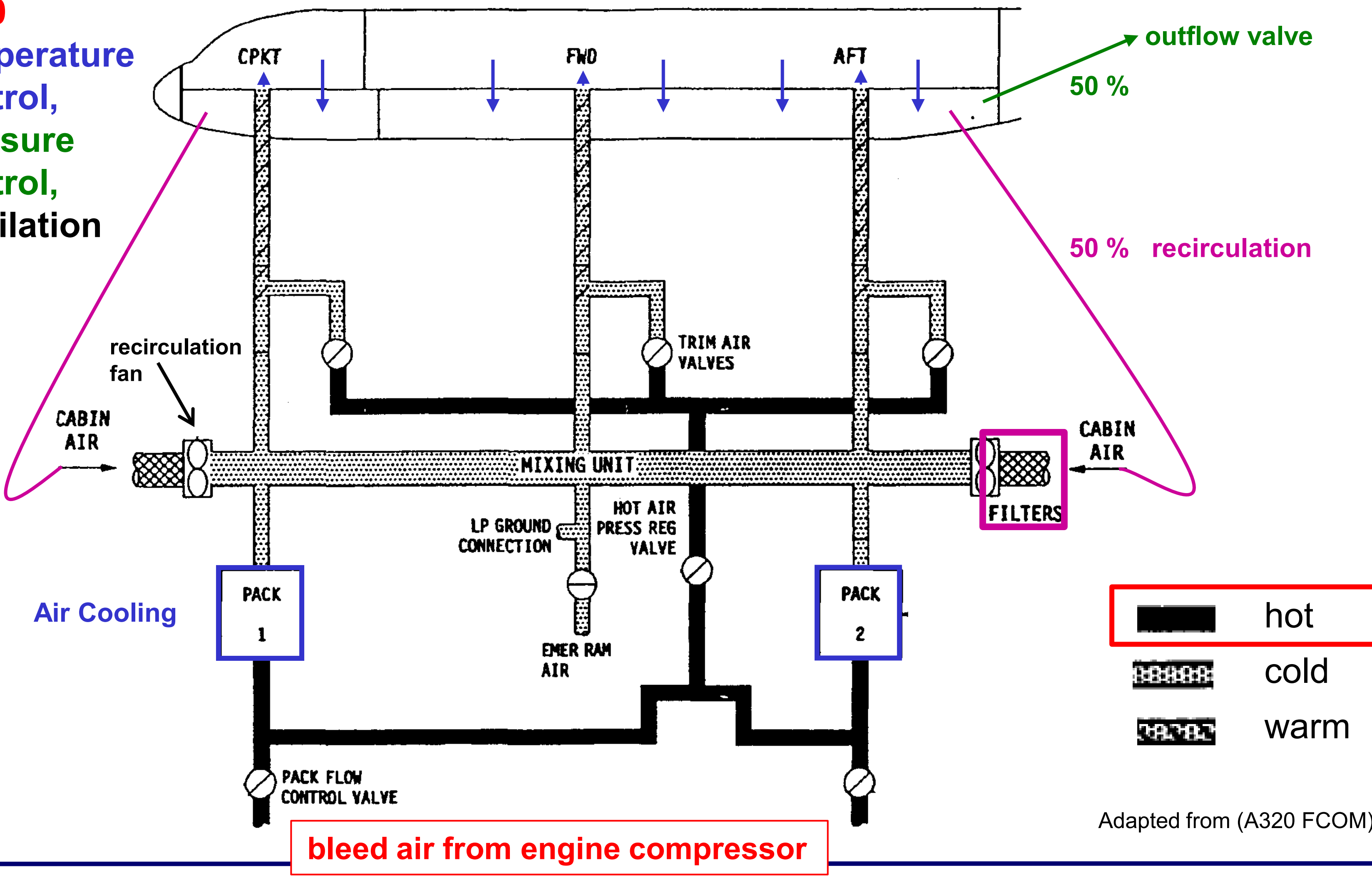
Potential Sinks for Oil Contamination



Adapted from (AMM B737)

A320

A320
Temperature Control,
Pressure Control,
Ventilation

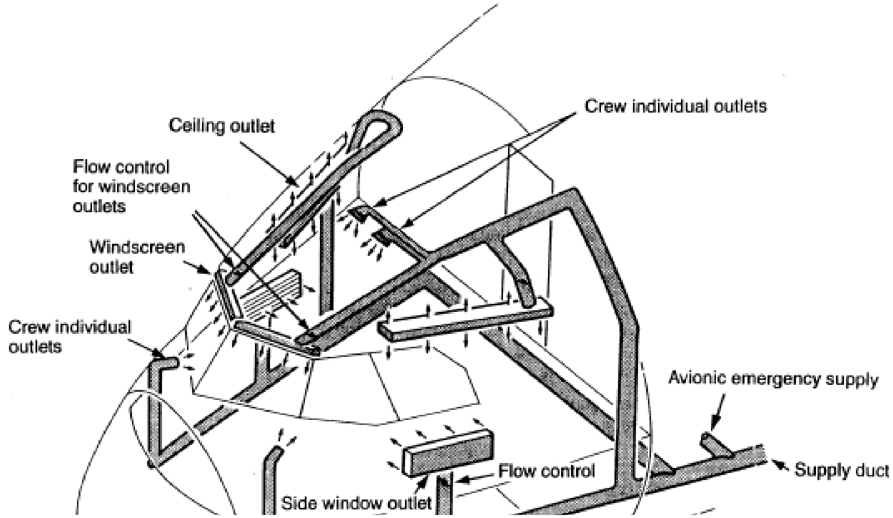


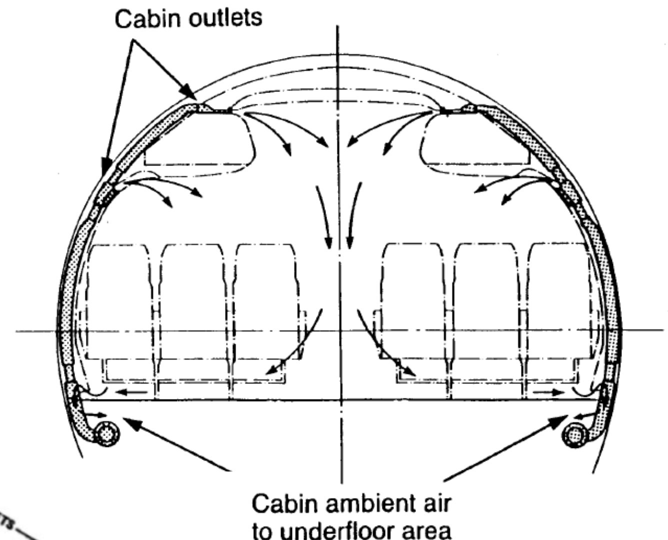
Adapted from (A320 FCOM)

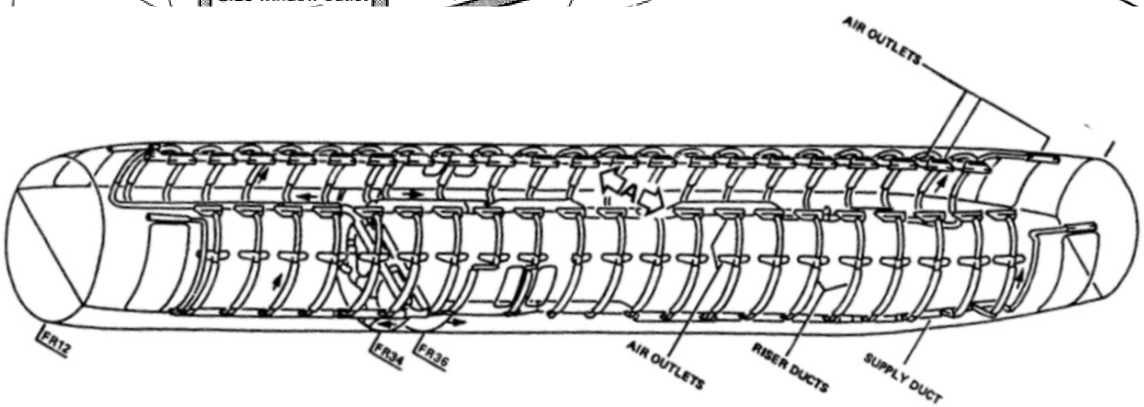
A320

Cabin Air Ducts

Potential Sinks for Oil Contamination







(GENFAM A320)

Cabin Air Ducts

Insufficient / Impossible Duct Cleaning

In the case of heavy contamination, this being assumed when there are visible traces of oil on the internal surface of the ducts, it is necessary to manually clean the affected ducts using rags and an appropriate degreasing agent.

(Airbus 2013)

Aircraft released back into service over night

after an (oil based) CACE

are not cleaned as instructed by Airbus, because

- ***ducts cannot be removed from behind the panels in this short time,***
- ***the inside of ducts is not accessible in the first place.***

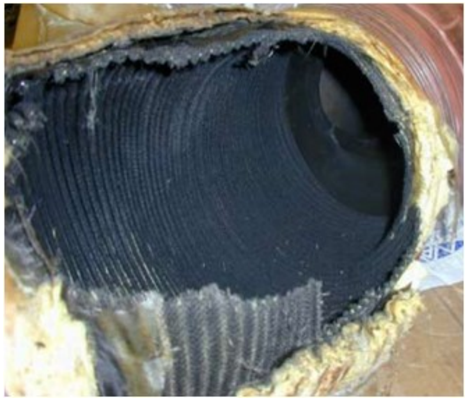
How Do We Know about Oil in the Cabin?

Oil has left traces on its way from the engine to the cabin interior:

1. Oil traces in bleed air ducts
2. Oil traces in air conditioning ducts
3. Oil traces in recirculation filters
4. Oil traces on cabin surfaces (wall panels, seats, ...)
5. Hydro carbron concentrations in the cabin can be calculated and agree with measurements

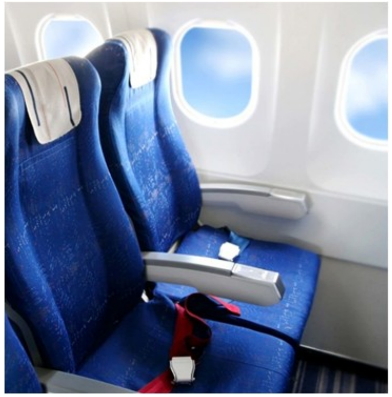
Evidence collected in Scholz 2017a and Scholz 2017b summarized here:

1. (GCAQE 2017)



2. (CAA 2004)

3. (Eckels 2014)

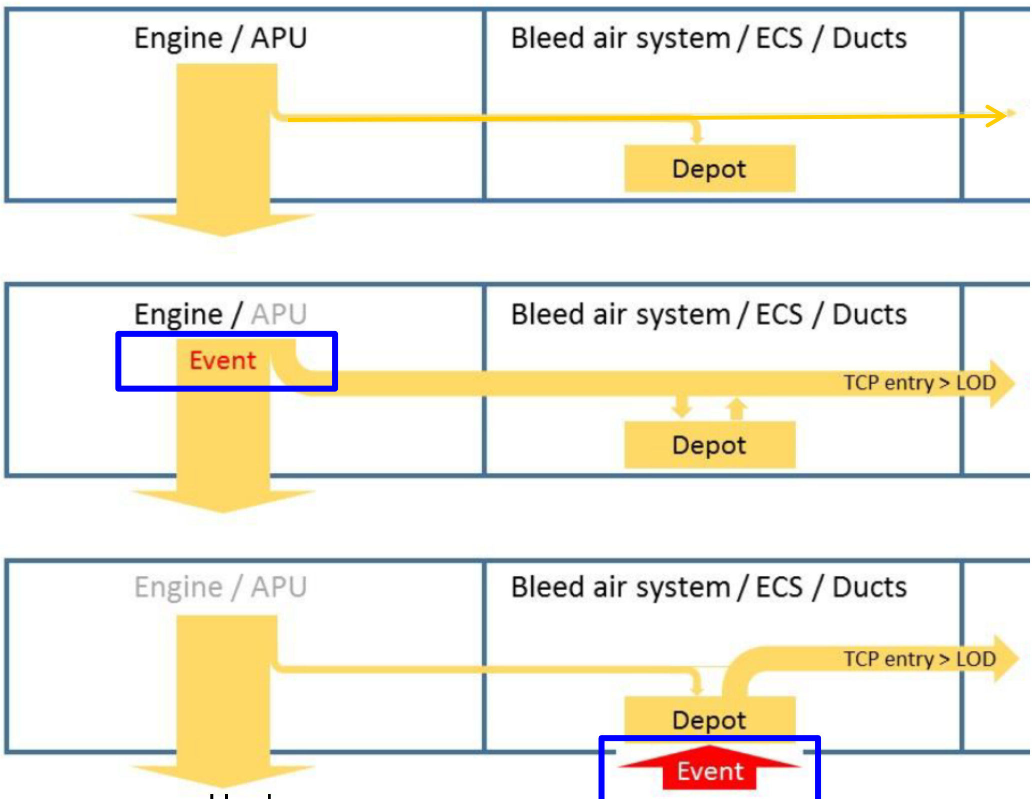


4. (Lamb 2012, Solbu 2011)

5. (Scholz 2017a)

$$\frac{m_{oil,cab}}{V_{cab}} = \frac{\dot{m}_{oil}\ x_{bear,up}\ x_{seal}}{S_{eng}\ n_{eng}\ M_{CR}\ a(h_{CR})} \cdot \frac{\rho_{cab}}{\rho_{CR}}(\mu+1)$$

Primary and Secondary Cabin Air Contamination Events (CACE)



"normal" operation

Primary CACE

Secondary CACE
(not understood today)

Event Mechanism:

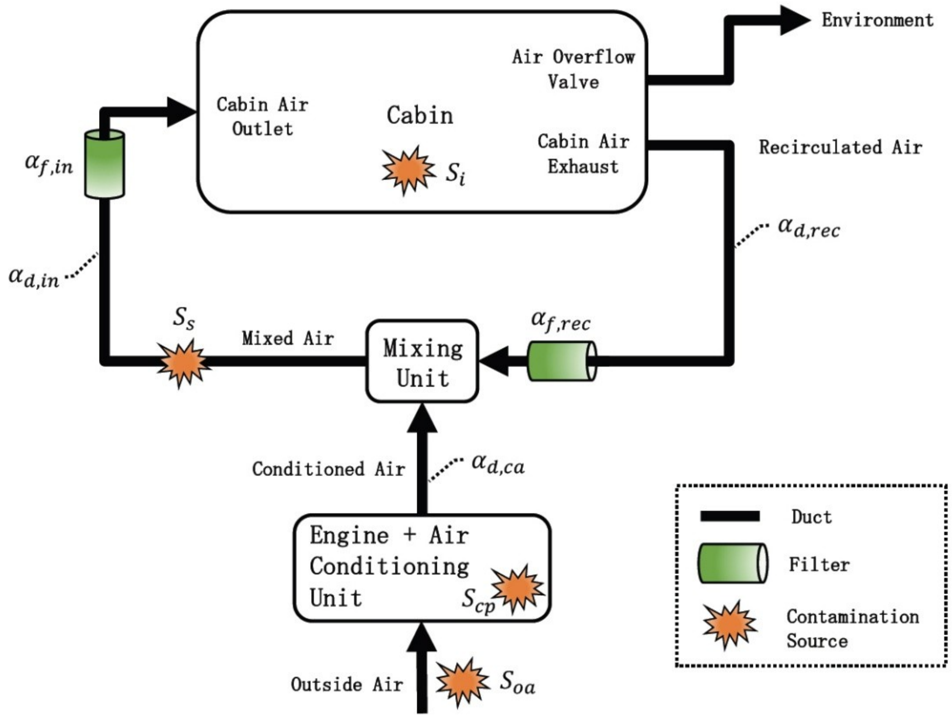
- normal leakage
- seal failure
- neg. Δp in bearing chamber
- transients

- mechanical stress?
- thermal stress?
- solvents (water, de-icing fluid, ...)?

Based on EASA 2017b

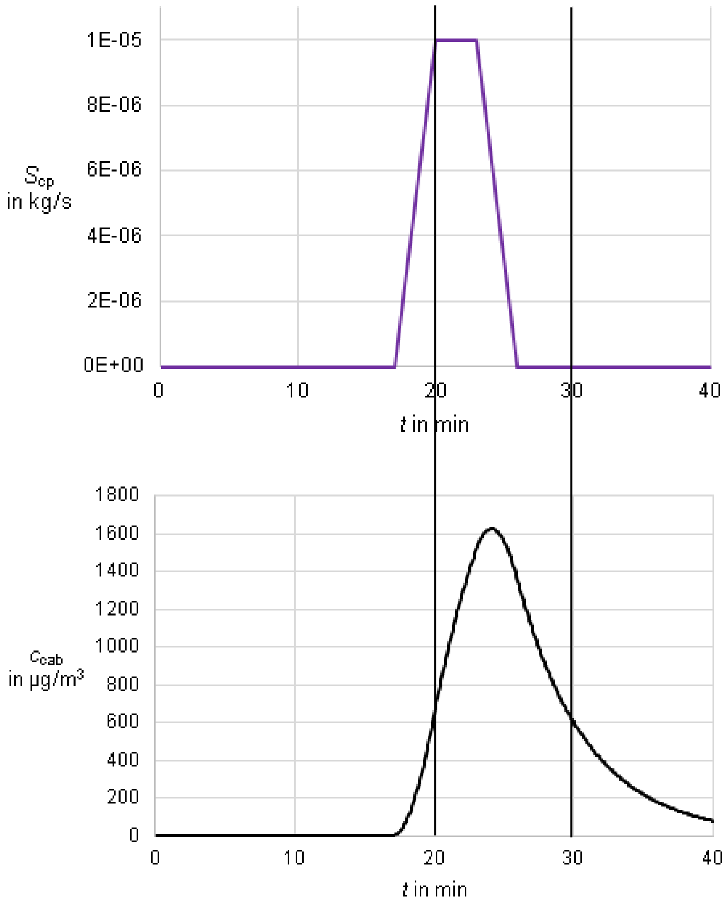
Aircraft Systems Technology

Dynamic Cabin Air Contamination Calculation Theory



$$\frac{d}{dt}c_{cab} + a \cdot c_{cab} = b_1 + b_2 \cdot t$$

It takes about **20 minutes** for a discrete cabin air contamination event (CACE) **to be washed out** by the air conditioning system ("**thinning effect**").



Lakies 2019 at HAW Hamburg
Download of project report: https://doi.org/10.15488/4543

Aircraft System Design Principles

Interpretation of CS-25.1309 with respect to Bleed Air from Jet Engines

CS-25 (AMC 1309, 6. Background, b. Fail-Safe Design Concept)

The CS-25 airworthiness standards are based on ... the fail-safe design concept ...
(2) The fail-safe design concept uses the following design principles:

(i) Designed Integrity and Quality including Life Limits, to ensure intended function and prevent failures.
(v) Failure Warning or Indication to provide detection.
(xi) Error-Tolerance that considers adverse effects of foreseeable errors during the aeroplane's design, test, manufacture, operation, and maintenance.

- *The probability of CACEs must not be compared with the effect-probability relationship of CS-25.1309 which is for statistical errors.*
- *Errors of the bleed air-based air conditioning system are well known, permanent and non-statistical.*
- *The system's error-tolerance (e.g.: two pilots, autopilot, cockpit crew oxygen masks) is compromized, if it has to cope with already known design errors that are not rectified out of negligence.*
- *In case of bleed air used for cabin ventilation: Known problems need to be rectified!*

CS-25.1309
Effect-Probability Relationship

Effect	Probability
Minor	< 10^{-3} 1/ FH
Major	< 10^{-5} 1/ FH
Hazardous	< 10^{-7} 1/ FH
Catastrophic	< 10^{-9} 1/ FH

Engineering Design Principles for Air Conditioning from SAE

SAE AIR 1168-7: Aerospace Pressurization System Design
(first edition: 1991, A in 2011)

"Compressor bleed from turbine engines is attractive because of the mechanical simplicity of the system." However, "**oil contamination ... can occur in using compressor bleed air from the main engines**." "Popular opinion regarding the risk of obtaining contaminated air from the engine **may preclude its use for transport aircraft, regardless of other reasons**."

Engine Metals from the Oil into the Body

Engine Metals from the Oil into the Body

Used Oil Analysis for Metal Particles

- Spectrometric Oil Analysis Program (SOAP) is an analysis of metal particles in the oil.
- SOAP can be combined with oil filter inspection and magnetic chip detector inspection which identifies larger metal particles.
- A monitor program helps to identify the condition of the engine:
- Catastropic failure of mechanical parts usually generate larger metal particles that can be analysed in magnetic chip detectors.
- Slow progressing damage to gears, bearings and spinning bearing races in the engine case is identified with SOAP. Wear particle size is between 1 µm and 5 µm.
- Normal wear can produce even smaller particles (nano particles).
- The most important wear metal in the evaluation is iron followed by chromium – both are present in bearings. If the engine case is titanium, increased titanium levels indicate a spinning bearing outer race.
- Larger metal particles will stay in the engine.

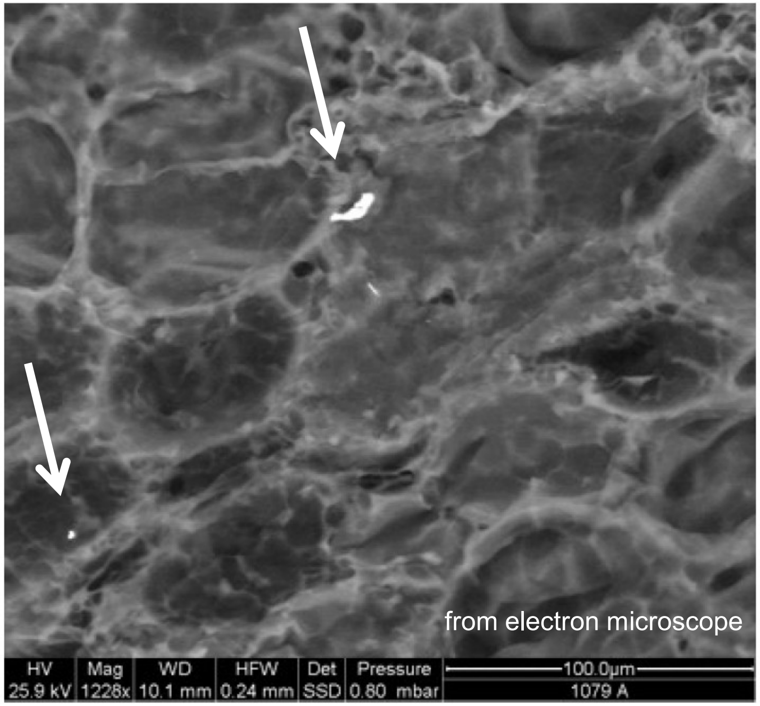
- **Metal micro and nano particles can leave the engine together with the oil into the cabin!**

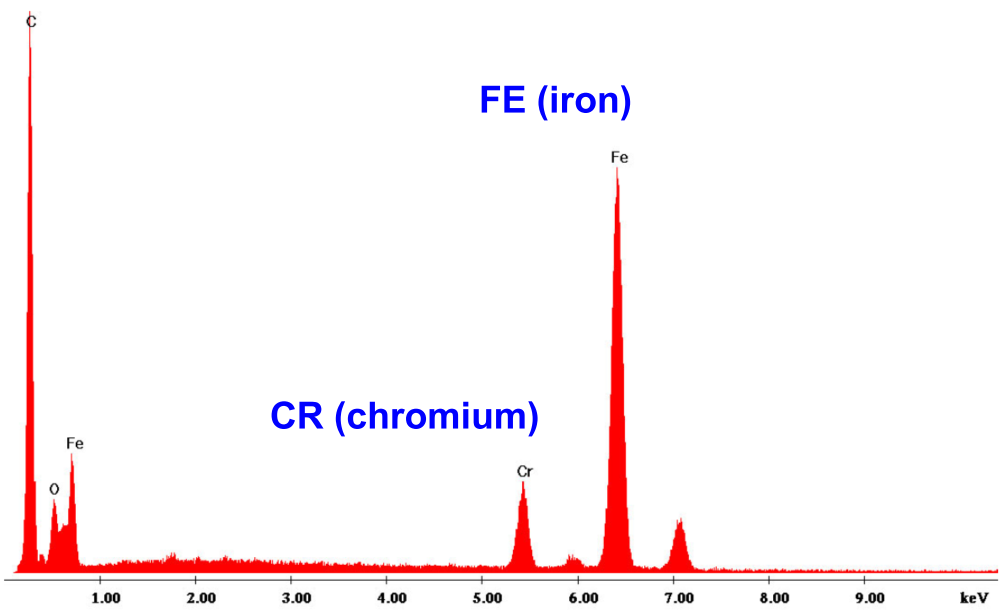
Partially based on Exxon 2016b

Engine Metals from the Oil into the Body

Metal Particles in Human Fatty Tissue

(Gatti 2019, report written for client)





Analysis 8 of Table I. High-magnification image (1228x) and EDS spectrum of 10-micron and 1-micron brighter-looking particles composed of Carbon, Iron, Chromium and Oxygen: a stainless-steel composition. EDS: Energy-Dispersive X-ray Spectroscopy.

Summary (1)

There is a problem with aircraft air conditioning systems based on bleed air. The evidence:

- Engine bearing seals leak small amounts of oil by design and more so in failure cases.
- Engines are longer under the wing. Therefore seals are worn out more and leak more.

- Oil residue found in bleed ducts, air conditioning ducts, recirculation filters and on cabin surfaces.

- Hydro carbron concentrations in the cabin can be calculated and agree with measurements.
- Hydro carbons are about two-fold in standard pax A/C cabins compared to B787.
- "dirty socks smell" comes from the base stock of the oil. This smell is an indication for oil products in the cabin.

- Chemicals and certain metals that are common in the workplace are found in employee's.

Summary (2)

- There is a "thinning effect" that reduces the contamination concentration, but concentration depends also on the source strength and duration. Accordingly, examples show the cabin constantly full of oil smoke.

- ECS uses bleed air. This design should not be used (SAE).
- Certification rules are violated.

- An aircraft once contaminated with oil cannot be cleaned. Ducts and components would need to be replaced.

- Instead of applying a cautionary proactive attitude, those responsible use too much effort to play things down. We need a change of attitude to the cabin air problem! We need to get back to aviations proven principle of caution and safety first.

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Cabin Air Contamination – A Summary of Engineering Arguments

Quote this document:
Scholz, Dieter: *Contaminated Aircraft Cabin Air –A Summary of Engineering Arguments*. International Aircraft Cabin Air Conference 2019, Imperial College London, 17/18.09.2019. – Download from: http://CabinAir.ProfScholz.de

See also:

Scholz, Dieter: *Technical Solutions to the Problem of Contaminated Cabin Air*. German Aerospace Congress, Friedrichshafen, Germany, 04.-06.09.2018. – Presentation No. 0270, download from: http://CabinAir.ProfScholz.de

A GP's Perspective of Fume Incidents Over 20 Years

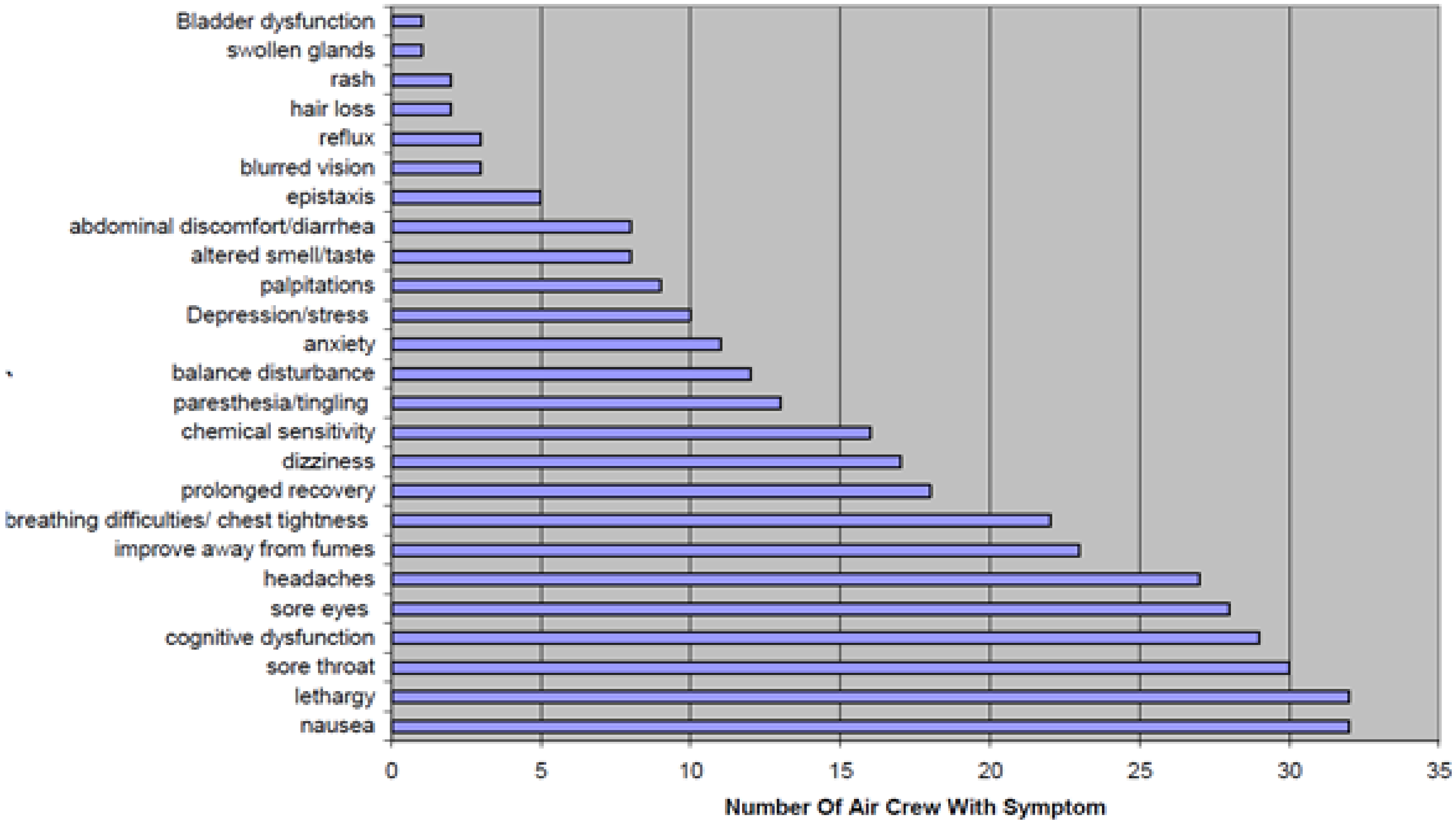
Dr Moira Somers

Aircraft Cabin Air Conference 2019

I will reflect briefly on 4 areas

- My experience with over 38 flight crew
- Dr John Snow and Cholera
- The Asbestos Story and
- My experience with workers from the Alcoa Wagerup Refinery

Figure 1: Frequency of Symptoms recorded for 36 Air Crew



- Consistent history across aircrew

- Consistent history across aircrew

- Fume incidents often consistent with technical logs

- Consistent history across aircrew
- Fume incidents often consistent with technical logs
- Same aircraft frequently reported as having fume incidents

- Consistent history across aircrew
- Fume incidents often consistent with technical logs
- Same aircraft frequently reported as having fume incidents
- Continuum of exposure

Alternate Diagnoses

- Infection
- Primary anxiety disorder
- Hyperventilation
- PTSD
- Depression
- Dehydration
- Gastro-Oesophageal Reflux Disease
- Mass Psychogenic Illness
- "All in the Head"
- "Just flying"
- Stress
- Bronchitis
- Viral illness
- No diagnosis - fit to fly
- Somatoform disorder

Dr John Snow and Cholera

Dr John Snow and Cholera

- **Detailed history is most important**
- **Just because we don’t understand the exact mechanism or have the appropriate tests doesn’t mean the condition isn’t real or cause serious harm.**
- **Simple measures can be instituted to prevent harm.**
- **In time Medicine will gain understanding. All disease is subject to advancing knowledge.**

Asbestos

Asbestos

- **First diagnosis Asbestosis early 1920’s**
- **Dr Eric Saint – warning to Government WA re Wittenoom in 1948**
- **First legal cases 1970’s not successful**
- **Corporate Veil pierced – CSR held accountable**

Alcoa Wagerup Refinery

Alcoa Wagerup Refinery

- **Demonstration Corporate Responsibility**

- **Zeigarnik effect**

Reflection Points

Barriers to GPs:

- **Time**
- **Knowledge**
- **Reluctance to be involved in medicolegal issues**

Reflection Points

Barriers to Aircrew:

- **Lack of information**
- **No exposure plan**
- **Lack of support**
- **No disease status for Aero Toxic Syndrome**
- **Multiple Emergency Departments**
- **Fear of job loss/worker's compensation**
- **Multiple inconsistent diagnoses**
- **No dedicated protocol for assessment**

Possible change

- **Symptoms surveys prior to and post flight – epidemiological studies**
- **Information at induction**
- **Exposure plan**
- **Assessment/diagnosis/treatment protocols**
- **Specimens collections for biomarkers/genetic studies**
- **Corporate/workforce/research/medical collaboration**

Fresh Air Filtration

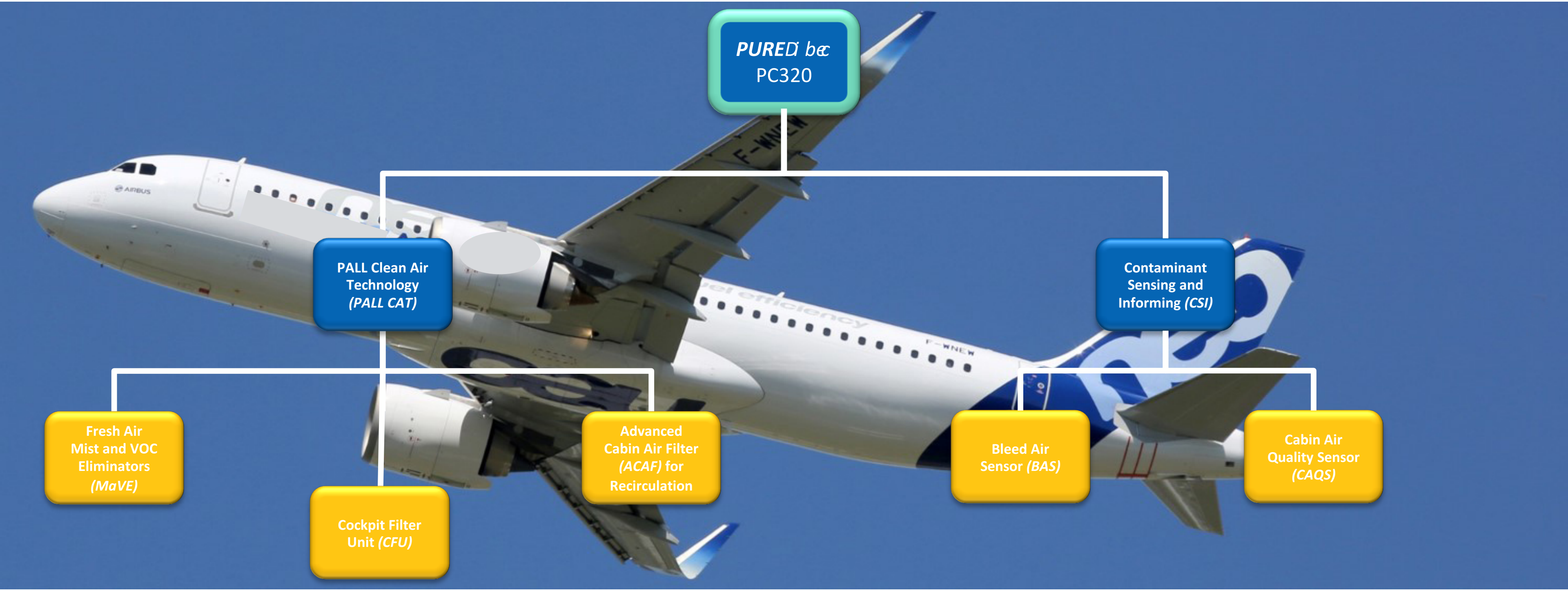
Reaching the Finish Line

David Stein
GCAQE

Aircraft Cabin Air Conference

September, 2019

*PURE*cabin Concept



Cabin air quality control through advanced filtration and sensing.

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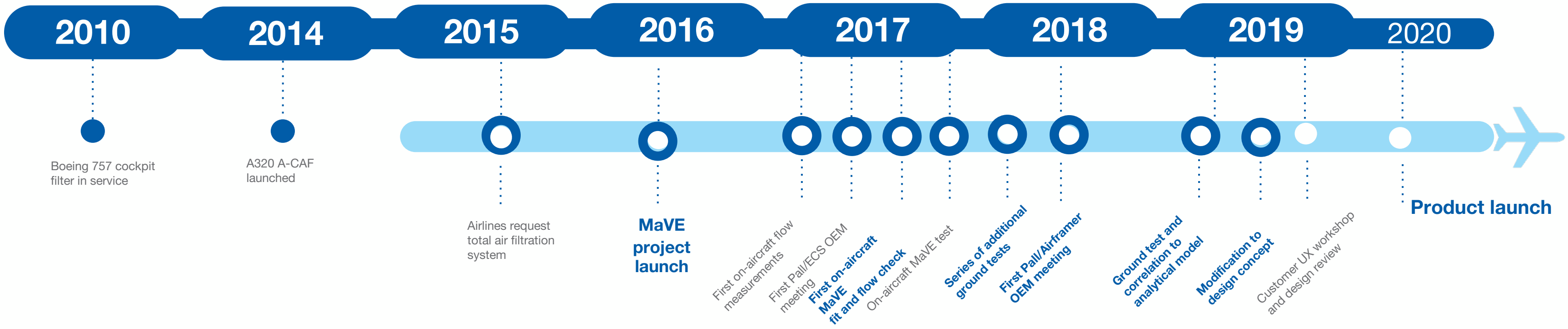
How we Finished the 2017 Conference

Project Timeline



Solutions take partners: Airlines, OEMs, and Pall.

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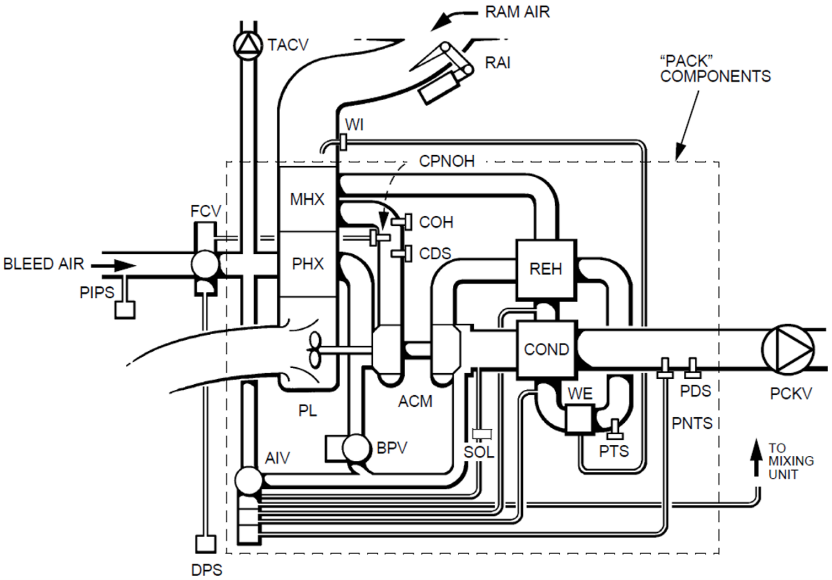
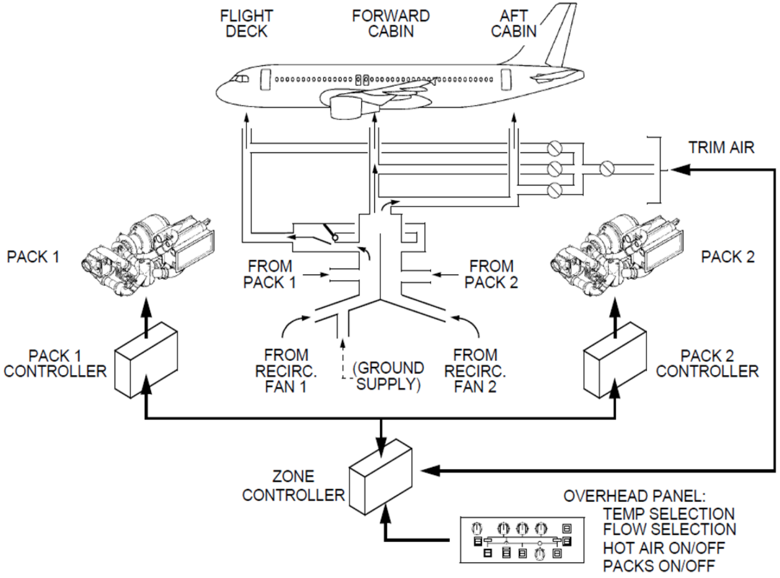
Aircraft Integration

System Interactions

Detailed ECS knowledge essential to incorporating additional pressure drop filtration system

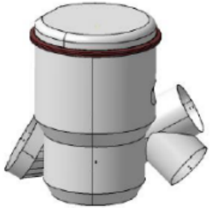
OE support on system performance and interactions critical

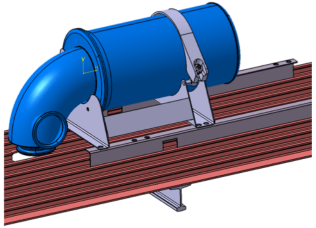




Design Evolution

Pall Clean Air Technology (CAT) filters fresh air provided by the engines or APU before it enters the cabin. To date, work has focused on a solution that requires a filter to be installed directly upstream of the mixing chamber, with an additional high temperature filter to remove particulate and VOC from the trim air.

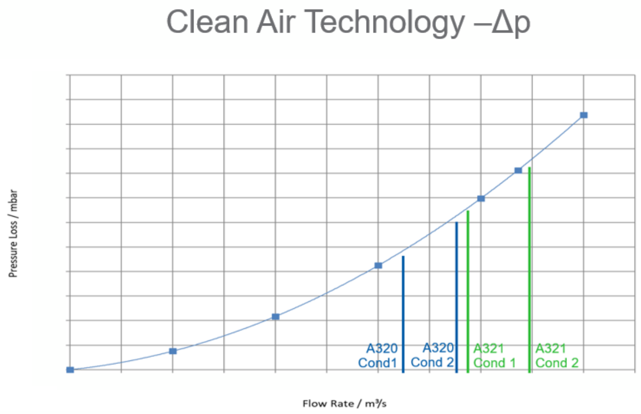




Constraints

Based on a typical PAX loading and considering atmospheric conditions at a number of airports worldwide, the air temperature in this location will typically be at or below 32°F with large quantities of free water being produced.

	Heathrow			Frankfurt			New York			Atlanta			Reykjavik			Tampa		
	Max	Min	Ave	Max	Min	Ave	Max	Min	Ave	Max	Min	Ave	Max	Min	Ave	Max	Min	Ave
Jan	8	2	5	5	-1	2	4	-3	0.5	12	0	6	3	-3	0	21	10	15.5
Feb	8	2	5	6	-1	2.5	5	-2	1.5	14	2	8	3	-2	0.5	22	11	16.5
Mar	11	3	7	11	1	6	10	2	6	19	6	12.5	4	-2	1	25	14	19.5
Apr	14	5	9.5	17	5	11	17	7	12	23	9	16	6	1	3.5	28	17	22.5
May	18	8	13	20	9	14.5	22	12	17	27	14	20.5	10	4	7	31	20	25.5
Jun	21	11	16	24	12	18	27	18	22.5	30	18	24	12	7	9.5	32	23	27.5
Jul	23	13	18	26	14	20	29	21	25	32	21	26.5	14	9	11.5	33	24	28.5
Aug	23	13	18	25	13	19	29	20	24.5	31	20	25.5	14	8	11	33	24	28.5
Sept	20	10	15	21	10	15.5	25	16	20.5	28	17	22.5	11	6	8.5	32	23	27.5
Oct	16	7	11.5	15	6	10.5	18	10	14	23	10	16.5	7	2	4.5	29	19	24
Nov	11	4	7.5	9	3	6	12	5	8.5	18	5	11.5	4	-1	1.5	26	15	20.5
Dec	9	3	6	6	0	3	7	0	3.5	13	2	7.5	3	-2	0.5	23	12	17.5



The system has to:

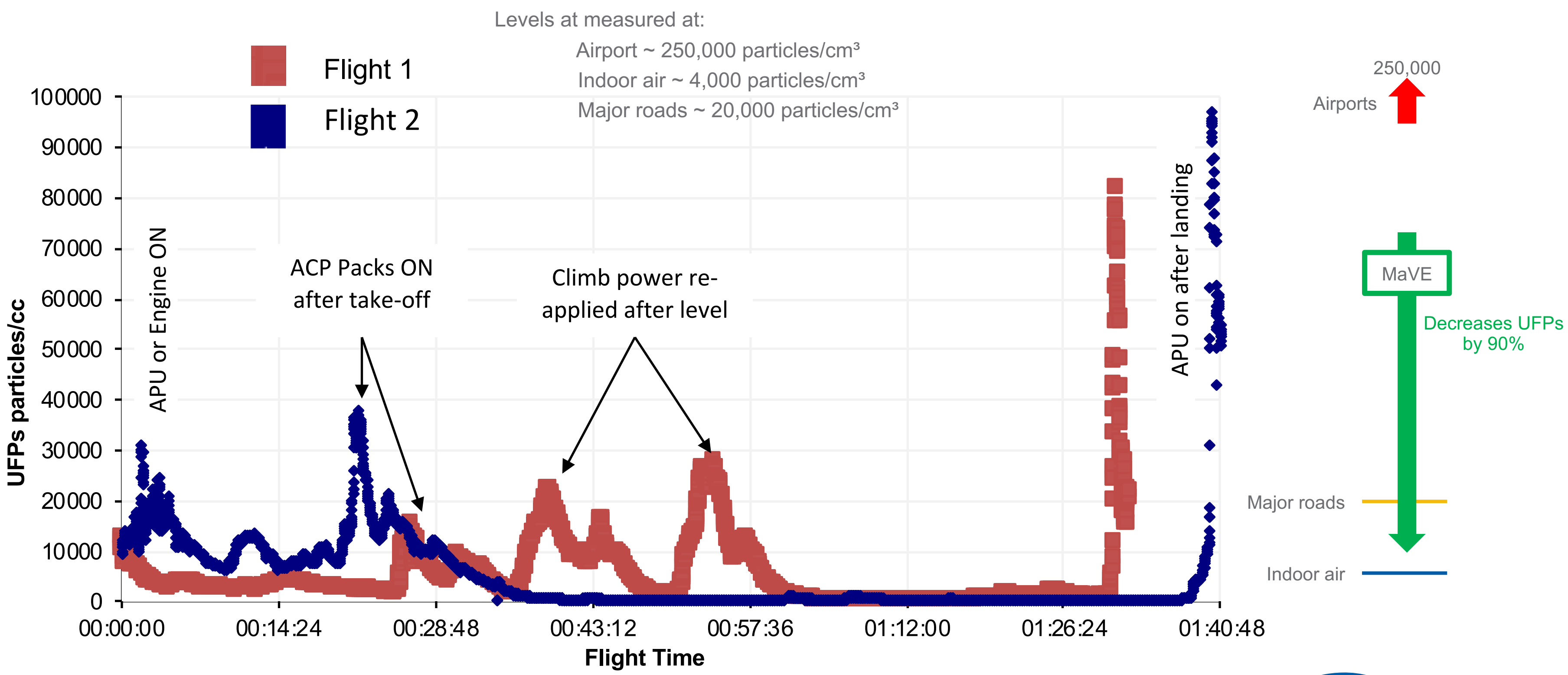
- *Be able to manage high levels of free water and icing*
- *Must not negatively impact the performance of other system components*
- *Must not negatively affect the cabin heating and cooling performance*
- *Must meet all the CS-25 certification requirements*

Key Design Consideration

Performance Requirements

- Integration in the aircraft (critical to field a solution)
- Meet the ultimate goal of reducing fume events and odors

Odor Events Come with Ultra-fine Particles



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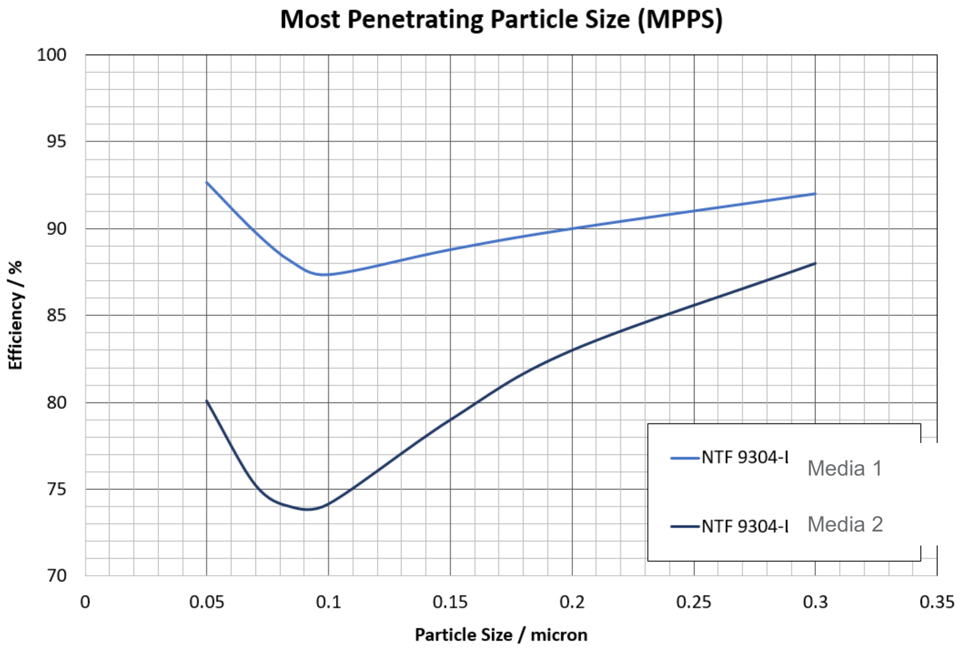
Particulate Filtration

Ultrafine particulate (UFPs) – PM0.1

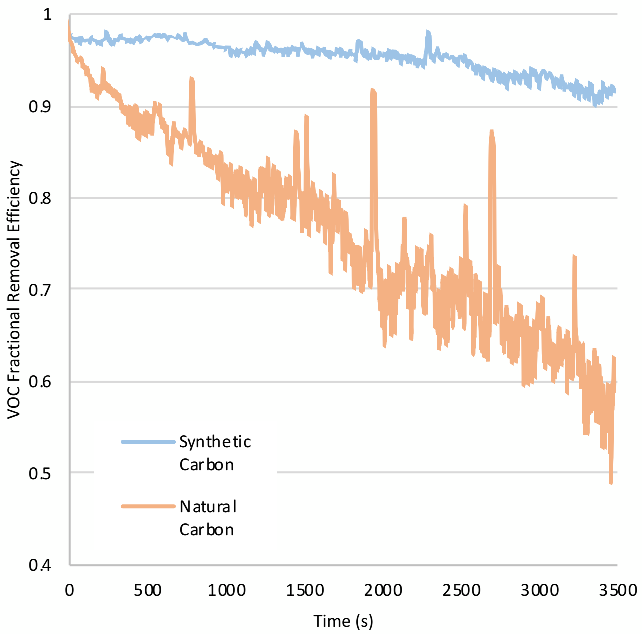
- Often condensates of hydrocarbons
- Elevated UFP levels during fume events

Latest Technology
Filter Membrane

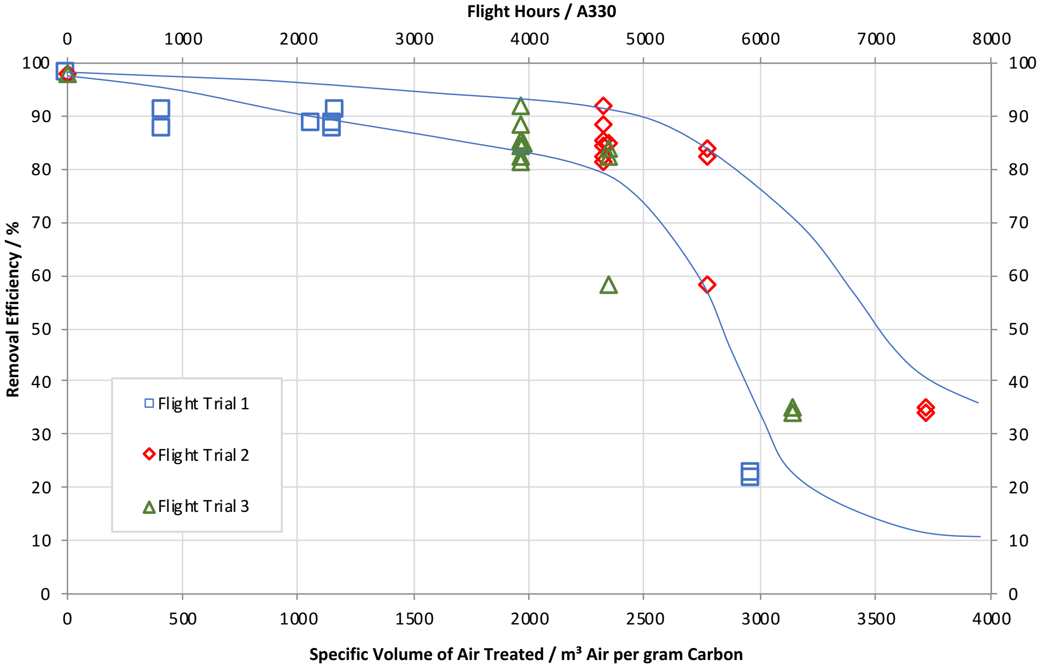


Proven Experience in VOC Removal

VOC Removal Efficiency:
Synthetic vs. Natural Carbon 100 PPM limonene



In-Cabin Performance Dodecane Challenge at 10 ppm Face Velocity 1.1 m/s



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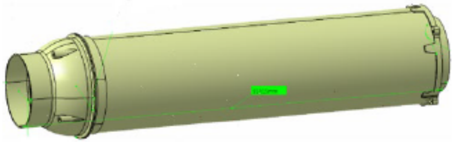
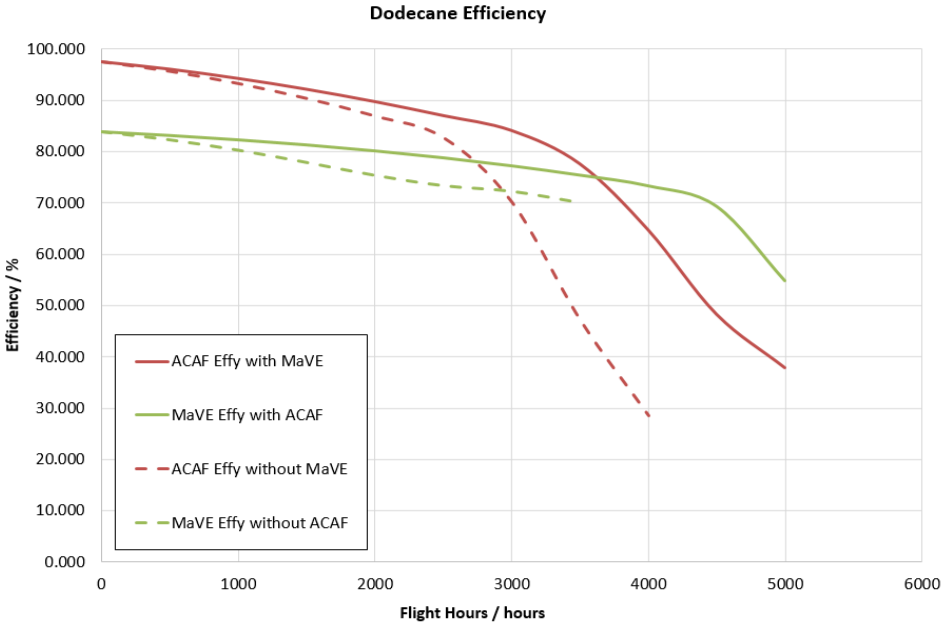
A-CAF and MaVE in Combination

A-CAF (Advanced Cabin Air Filters)

Representative MaVE



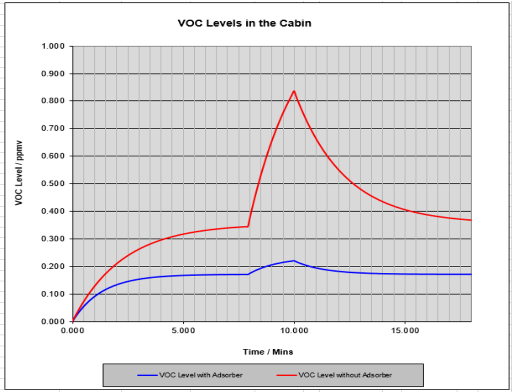


Validated Simulation Models

Cabin Air Quality Simulation

Through numerous ground tests and simulating fume events we validated our simulation analysis tool to enable optimization of the VOC adsorbent.

System Parameters							
System Flows							
Total Cabin Flow	Q Tot	1.7	m³/s	3599	CFM	102000	l/min
Percentage Outside Air		60	%				
Percentage Recirc Air		40	%				
Bleed Air Flow	Q In	1.02	m³/s	2160	CFM	61200	l/min
Recirculation Flow	Q Recirc	0.68	m³/s	1440	CFM	40800	l/min
Out Flow	Q Out	1.02	m³/s	2160	CFM	61200	l/min
System Conditions							
Cabin Volume	V Cab	139	m³	139000	litre		
Number of Passengers	N	168	People				
Ambient O2 Level	Camb	16	%	0.16	frac%		
O2 Consumed per Person	O2p	23	l/hr/pers	0.38	l/min/pers		
Ambient CO2 Level	Camb	350	ppmv	0.00035	frac%		
CO2 Output per Person	CO2p	20	l/hr/pers	0.33	l/min/pers		
VOC Conditions							
Residual VOC Level	C Res	0	mg/m³	0.00	ppmv		
Bleed Air VOC Level	C Bleed	0.2	mg/m³	0.29	ppmv		
General VOC Density	Rho VOC	2.5	kg/m³				
VOCs Generated in Cabin	Mvoc Gen	0.7	mg/s				
Fume Event							
Start Time	t FES	480	secs	8	mins		
Finish Time	t FEF	600	secs	10	mins		
VOC Concentration	C FE	2	mg/m³	0.8	ppmv		
Carbon Dioxide Adsorber Performance							
Flow through CO2 Adsorber	Qcl	1971	m3/hr	1159	CFM	32850	l/min
CO2 Adsorber Efficiency	AH Effy	0	%	0	frac%		
VOC Adsorber Performance							
Recirc Adsorber Efficiency	E RAHs	97	%	0.97	Frac %		
MaVE Adsorber Efficiency	E BIAHs	87	%	0.87	Frac %		



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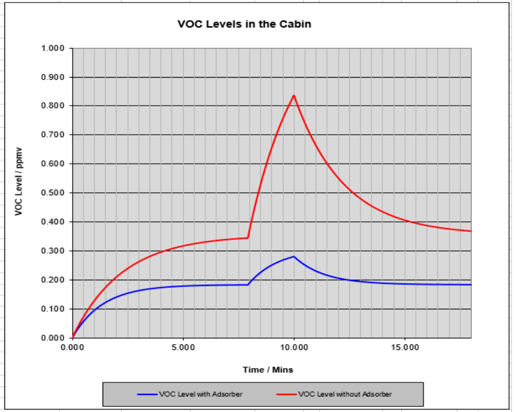
Flow through CO2 Adsorber	Qcl	1971	m3/hr	1159	CFM	32850	l/min
CO2 Adsorber Efficiency	AH Effy	0	%	0	frac%		
VOC Adsorber Performance							
Recirc Adsorber Efficiency	E RAHs	65	%	0.65	Frac %		
MaVE Adsorber Efficiency	E BIAHs	75	%	0.75	Frac %		



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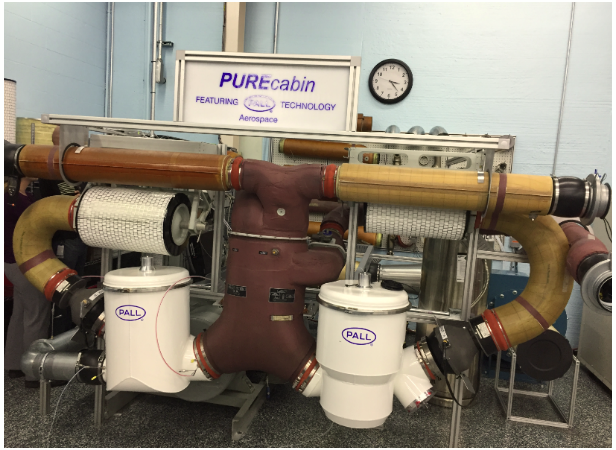
Product Performance

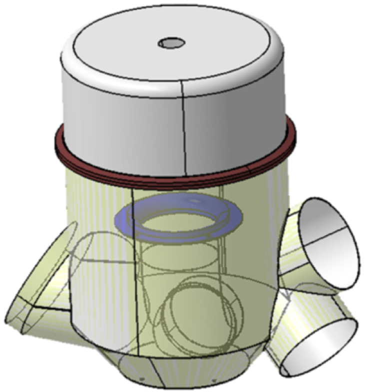
Test Capability

Replica of ECS system enables:

- Pressure Testing
- VOC tests
- Water Tests
- Icing Tests



Key Performance Parameters



- Integration in existing aircraft with minimum and acceptable impact on performance of ECS and associated equipment
- Removal of contaminants that could be present in the fresh air supply before they reach the cabin or cockpit
  - Validation in the laboratory
  - In aircraft (film)
- Service life aimed to match existing A-CAF
  - Will be confirmed through service evaluation

Aircraft Ground Test

THANK YOU

Pall Corporation

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Filtration. Separation. Solution.SM

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Imperial College London

Aircraft Cabin Air Conference 2019

Health effects of air pollution

Terry Tetley

National Heart and Lung Institute
Imperial College London

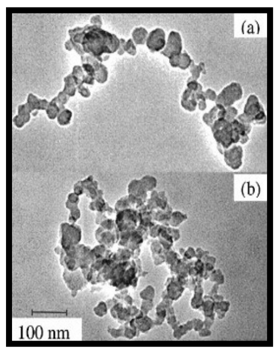
Ambient air pollution

London smog 1952:

Increased hospital admissions with

>4,000 of premature deaths.

Clean air act 1956 “solved” the problem



TODAY - PM10, PM2.5, gases etc, due to urban traffic, industry, combustion…

DEP: <100nm diameter; high particle number concentration/m^3 and /unit mass

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- **PM2.5 caused 4.2 million deaths/year globally in 2015, compared to 3.5 million in 1990;**

- **5th highest ranking mortality risk factor**

Deaths associated with fine ambient particulate matter ($PM_{2.5}$):

- Cardiovascular (~48%; ischaemic heart disease and stroke),
- Respiratory conditions (~35%; asthma, chronic obstructive pulmonary disease, cystic fibrosis).
- Lung cancer (~9%)

Particulate air pollution was classified as a carcinogenic agent by the International Agency for Research on Cancer (IARC) in 2013

WHO; Global Burden of Disease; European Environment Agency.
AJ Cohen et al. Lancet 2017; 389:1907-1918

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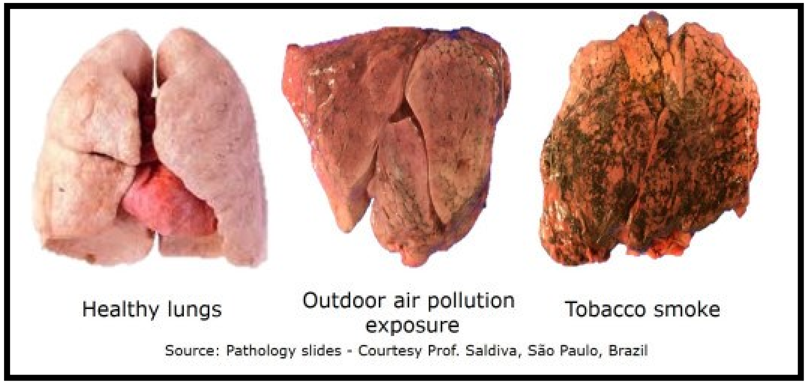
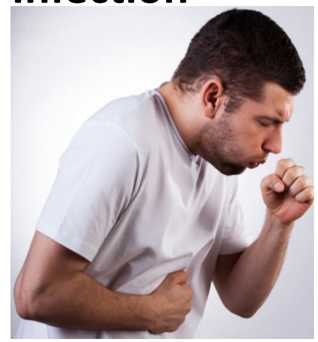
Respiratory effects of air pollution

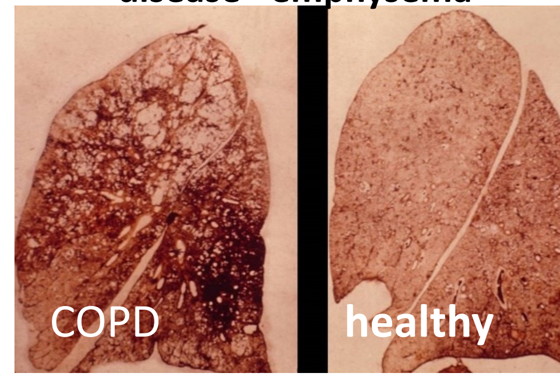


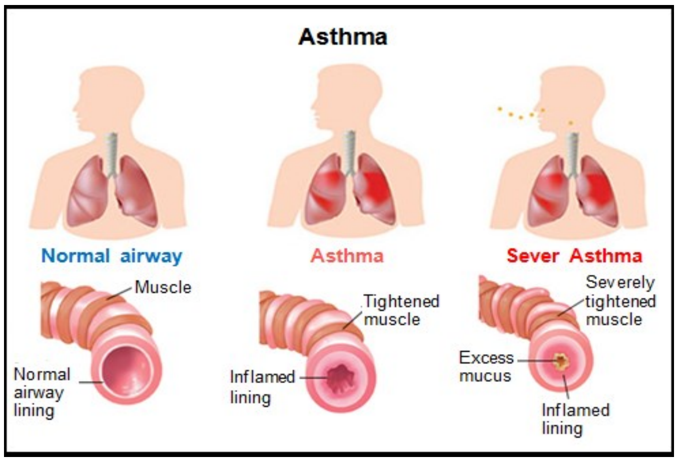
Cough

Infection



Chronic obstructive pulmonary disease - emphysema

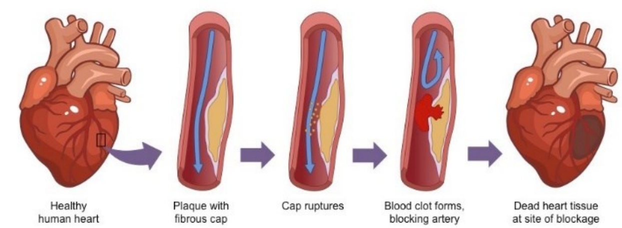




Cancer

Heart rate variability

Atherosclerosis



SYSTEMIC EFFECTS

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Respiratory effect:

- Increased respiratory mortality
- Increased incidence and exacerbation of chronic pulmonary diseases:
  asthma, chronic obstructive pulmonary disease, cystic fibrosis
- Increased pulmonary infections – compromised, young and elderly
- Increased symptoms: cough, phlegm, wheezing, breathlessness
- Increased lung cancer
- Reduced lung function/growth in childhood which affects adult health

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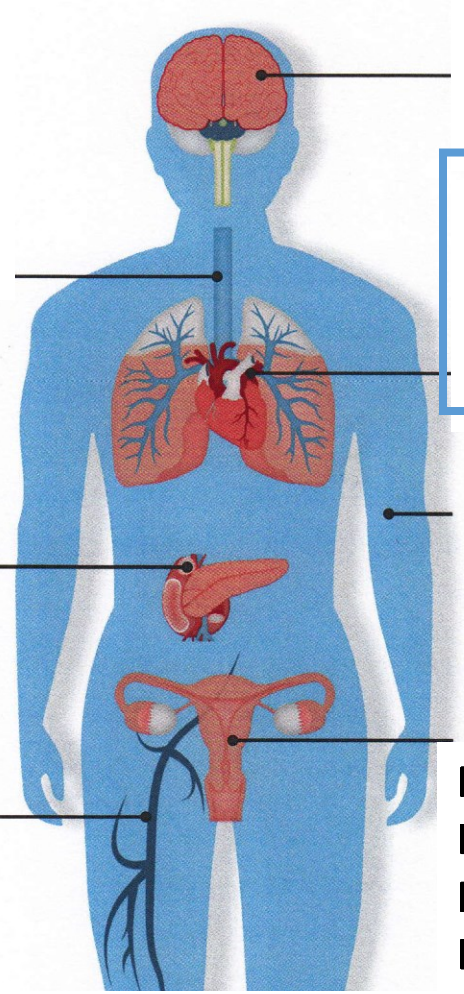
Health effects of air pollution

Respiratory disease – COPD, asthma, infection, lung cancer

Reduced lung growth
Reduced lung function

Strokes
Neurological development
Mental health
Neurodegenerative disorders



Cardiovascular disease – myocardial infarction, cardiac arythmia, cardiac failure

Type 2 diabetes
Type 1 diabetes
Liver toxicity
Renal disease
Altered bone metabolism

Accelerated aging
Autoimmune rheumatic disease

High blood pressure
Endothelial dysfunction
Increased blood clotting
Systemic inflammation
Thrombosis
Atherosclerosis

Premature birth
Low birth weight
Reduced/delayed foetal growth
Lower sperm quality, infertility
Preeclampsia

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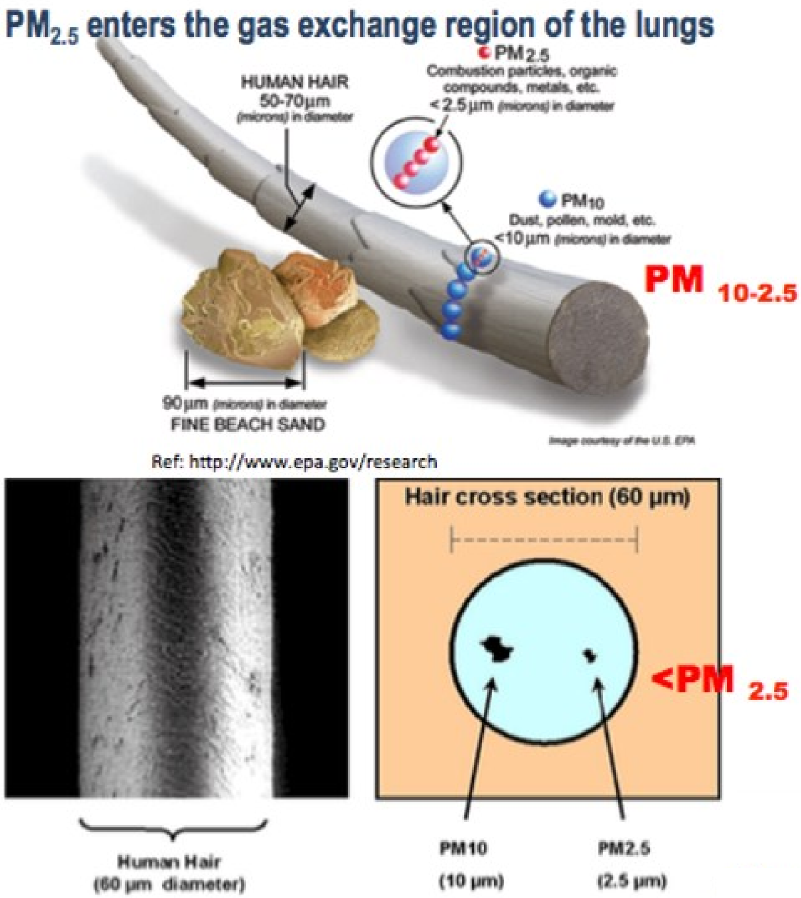
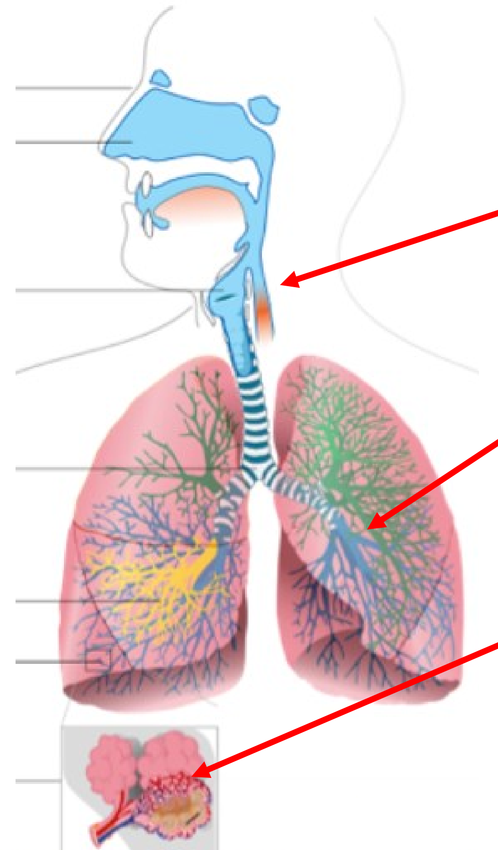
Respirable PM_{10} and $PM_{2.5}$





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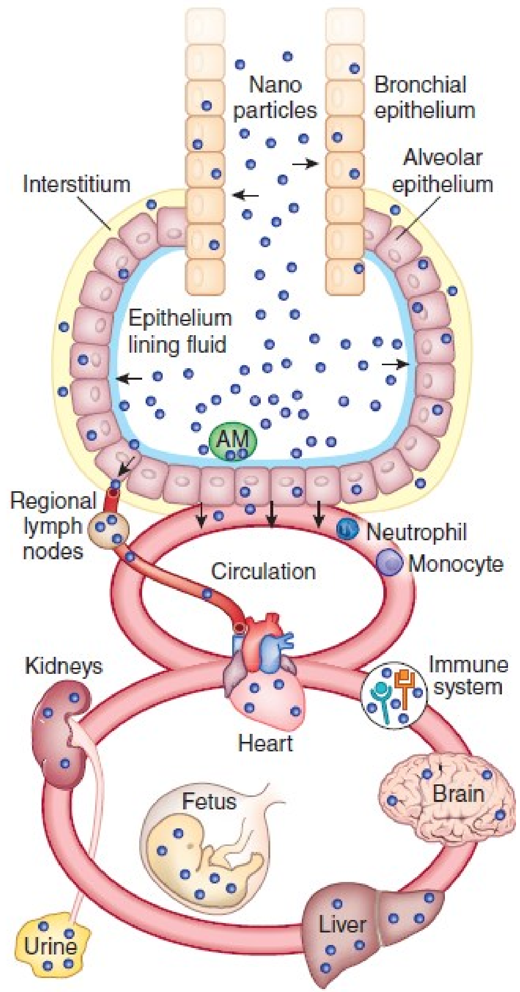
Deposition and impact of inhaled $PM_{2.5}$ and $PM_{0.1}$



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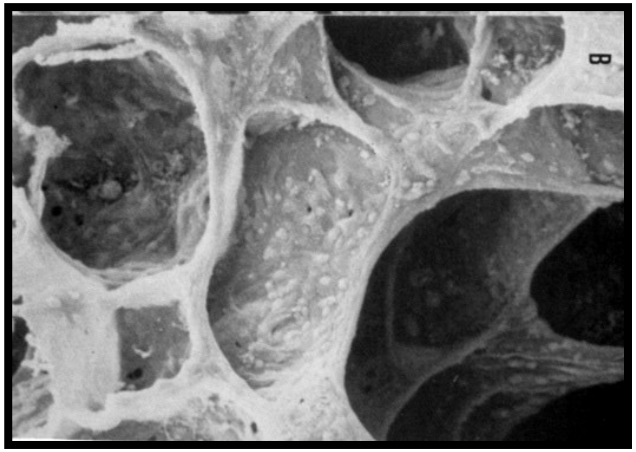
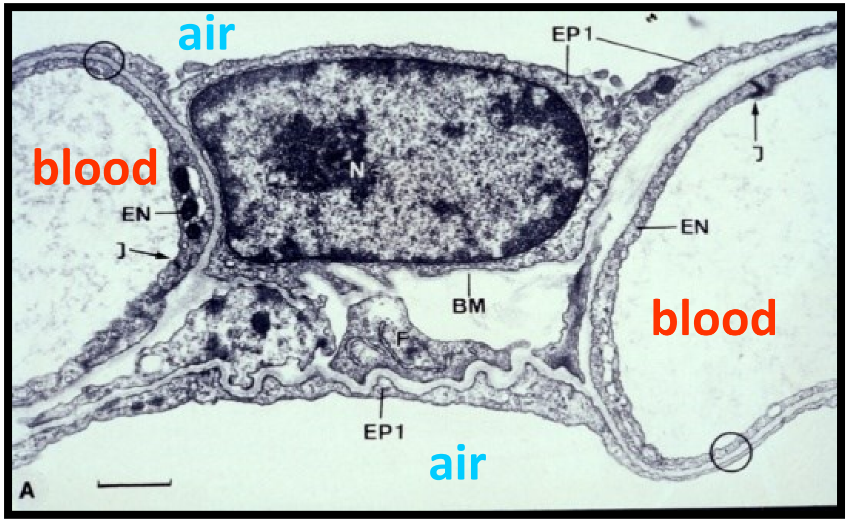
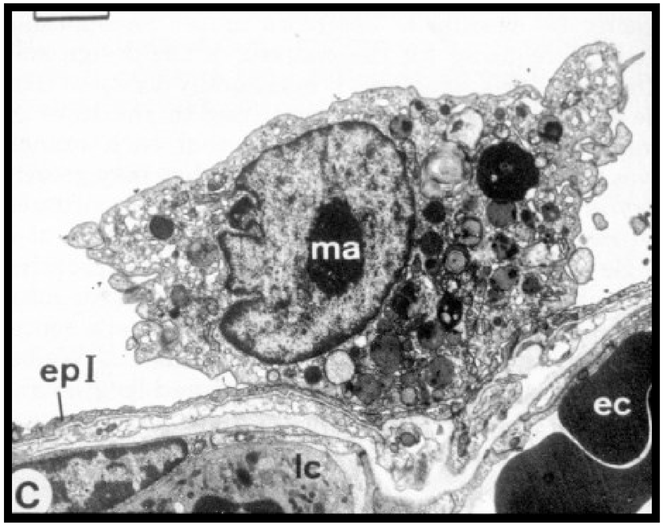
Structure of the lung







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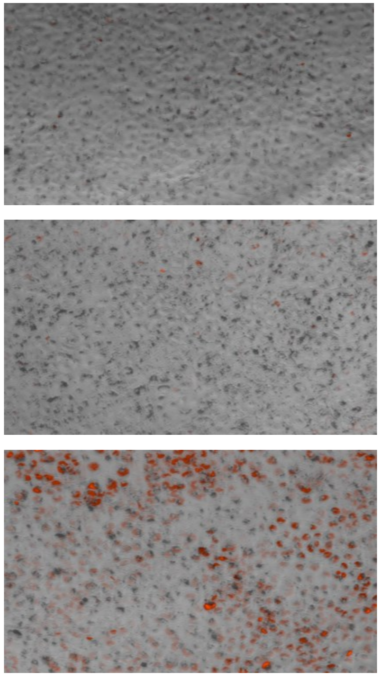
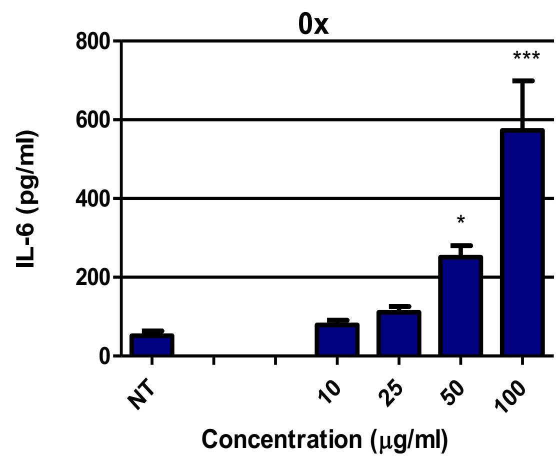
Oxidative stress and IL-6 mediator release from human lung respiratory epithelial cells following 24 hour exposure to DEP/Envirox

25µg/ml

50µg/ml

100µg/ml





Prenatal and early life diesel exhaust exposure disrupts (brain) cortical lamina organization: Evidence for a reelin-regulated pathogenic pathway induced by interleukin-6

Related to AUTISM SPECTRUM DISORDERS (ASD)

Chang YC et al. Brain Behav Immun. 2019 May;78:105-115

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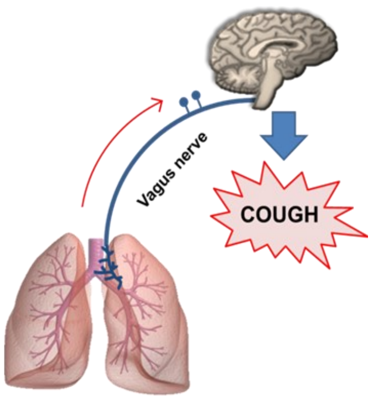
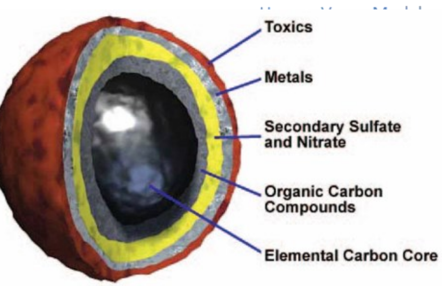
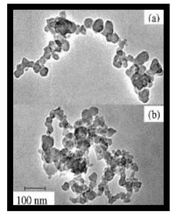
Diesel exhaust particles (DEP) activate guinea pig and human airway sensory nerves- involvement in cough?

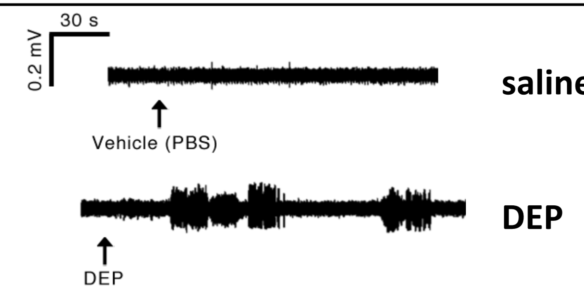


SPECIALIST PRE-CLINICAL MODELS

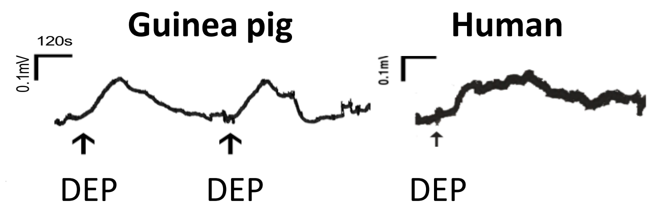




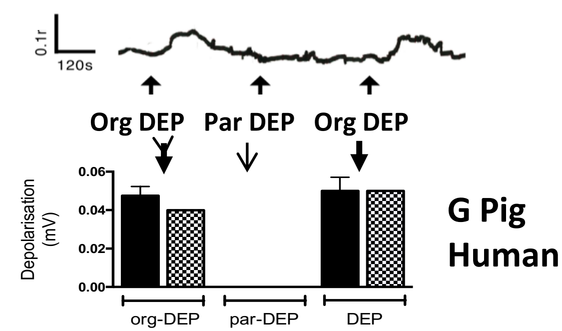
Introduction of DEP into the airways caused airway nerve activation in a guinea pig model



DEP caused activation of isolated guinea pig and human vagus nerve



The organic soluble component, not the carbon core, caused guinea pig and human afferent vagal nerve activation



Mechanistic link between diesel exhaust particles and respiratory reflexes. Robinson et al. J Allergy Clin Immunol. 2018; 141(3): 1074–1084

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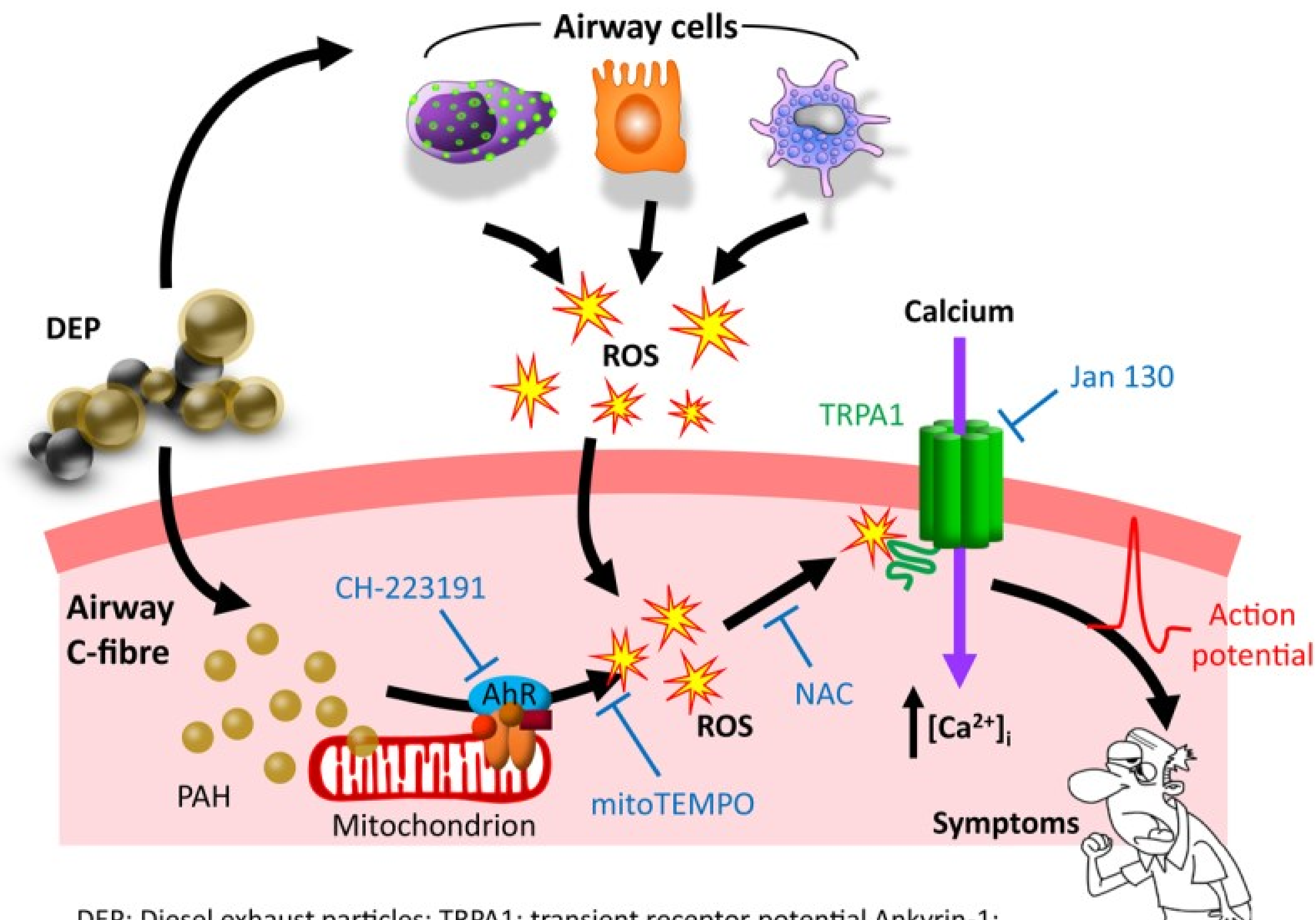
Mechanistic link between diesel exhaust particles and respiratory reflexes.

Robinson et al. J Allergy Clin Immunol. 2018; 141(3): 1074–1084



DEP: Diesel exhaust particles; TRPA1: transient receptor potential Ankyrin-1;
PAH's: Polycyclic aromatic hydrocarbons; ROS: Reactive oxygen species.

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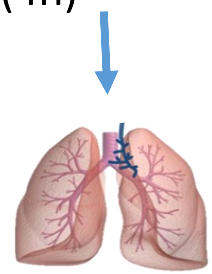
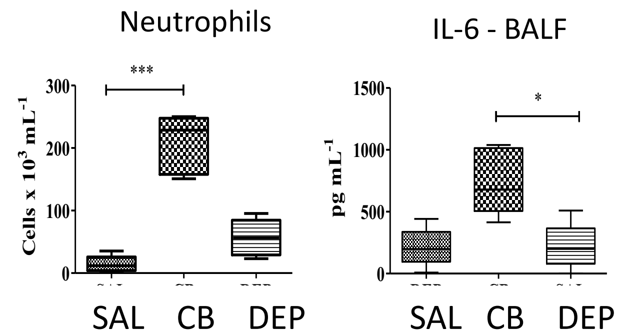
Effect of intratracheal instillation of DEP and carbon black (CB) on lung inflammation and pulmonary vascular platelet activation (thrombosis) in mice (4h).

Introduce 25 µg DEP or carbon black into lung (4h)

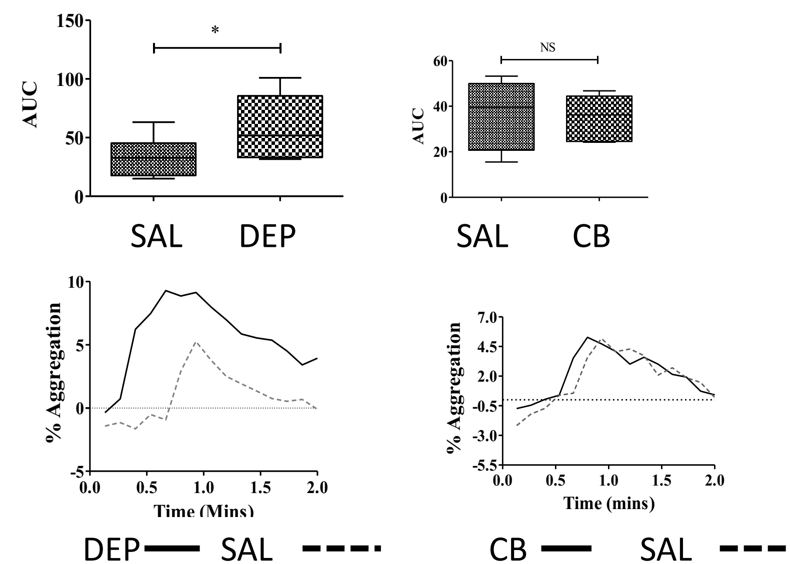


Track and localise labelled platelets

Intratracheal instillation of **CB**, but not DEP, causes marked **pulmonary inflammation in mice**



Intratracheal instillation of **DEP,** not CB, causes significantly **greater vascular pulmonary platelet aggregation in mice** in vivo that is slow to resolve



Influence of inflammation and nitric oxide upon platelet aggregation following deposition of diesel exhaust particles in the airways.
Smyth et al. Br J Pharmacol. 2017 Jul;174(13):2130-2139

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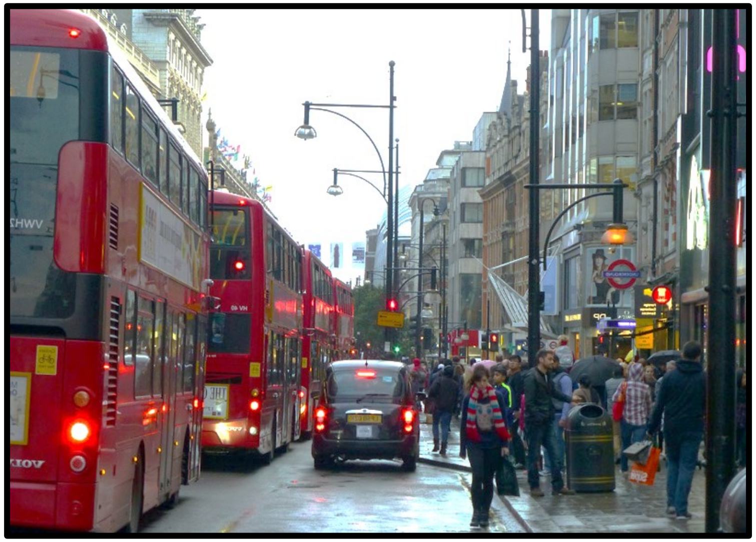
OXFORD STREET II

Respiratory and cardiovascular responses to walking down a traffic-polluted road compared with walking in a traffic-free area in participants aged 60 years and older with chronic lung (COPD) or heart disease (IHD) and age-matched healthy controls: a randomised, crossover study.

Sinharay et al. Lancet 2018;391(10118):339-349



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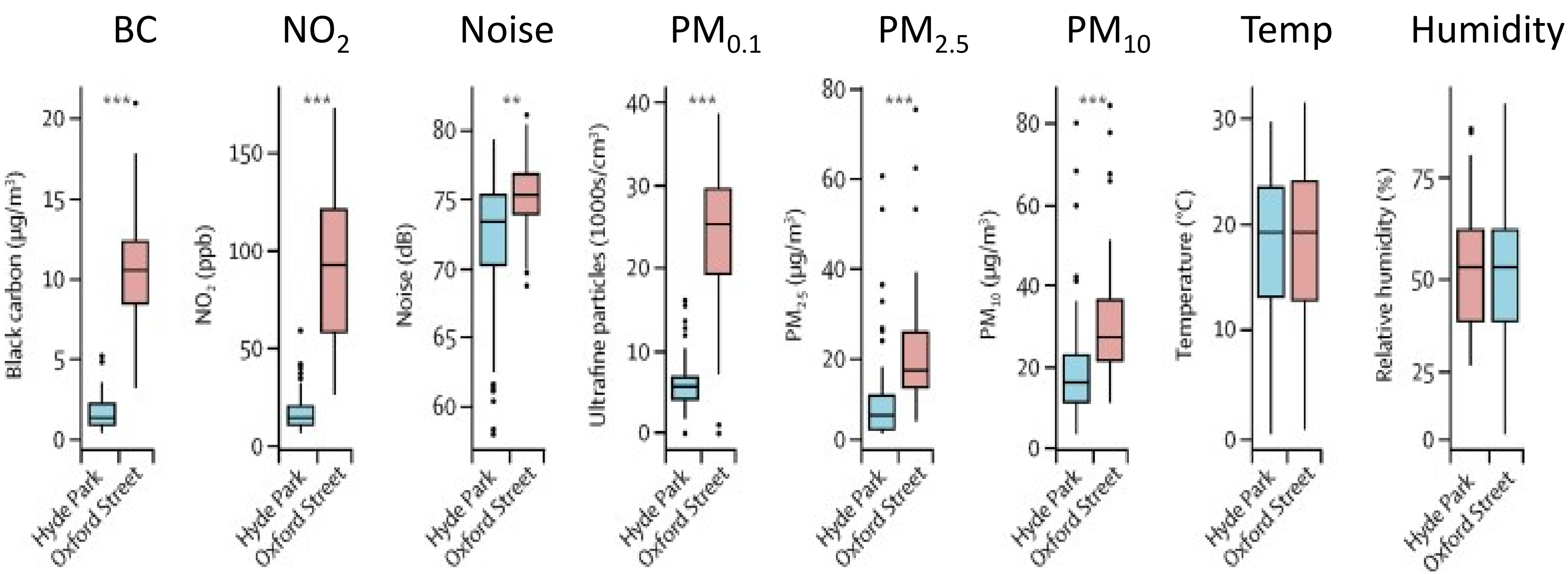
OXFORD STREET II STUDY

Distribution of black carbon, nitrogen dioxide (NO_2), noise, ultrafine particles, $PM_{2.5}$ and PM_{10}concentrations, temperature, and relative humidity on the visit days to Oxford Street or to Hyde Park – *Sinharay et al. Lancet 2018, **391**:339*



Box plots with 95% CIs. PM=particulate matter.
***p<0·01. ***p<0·001.*

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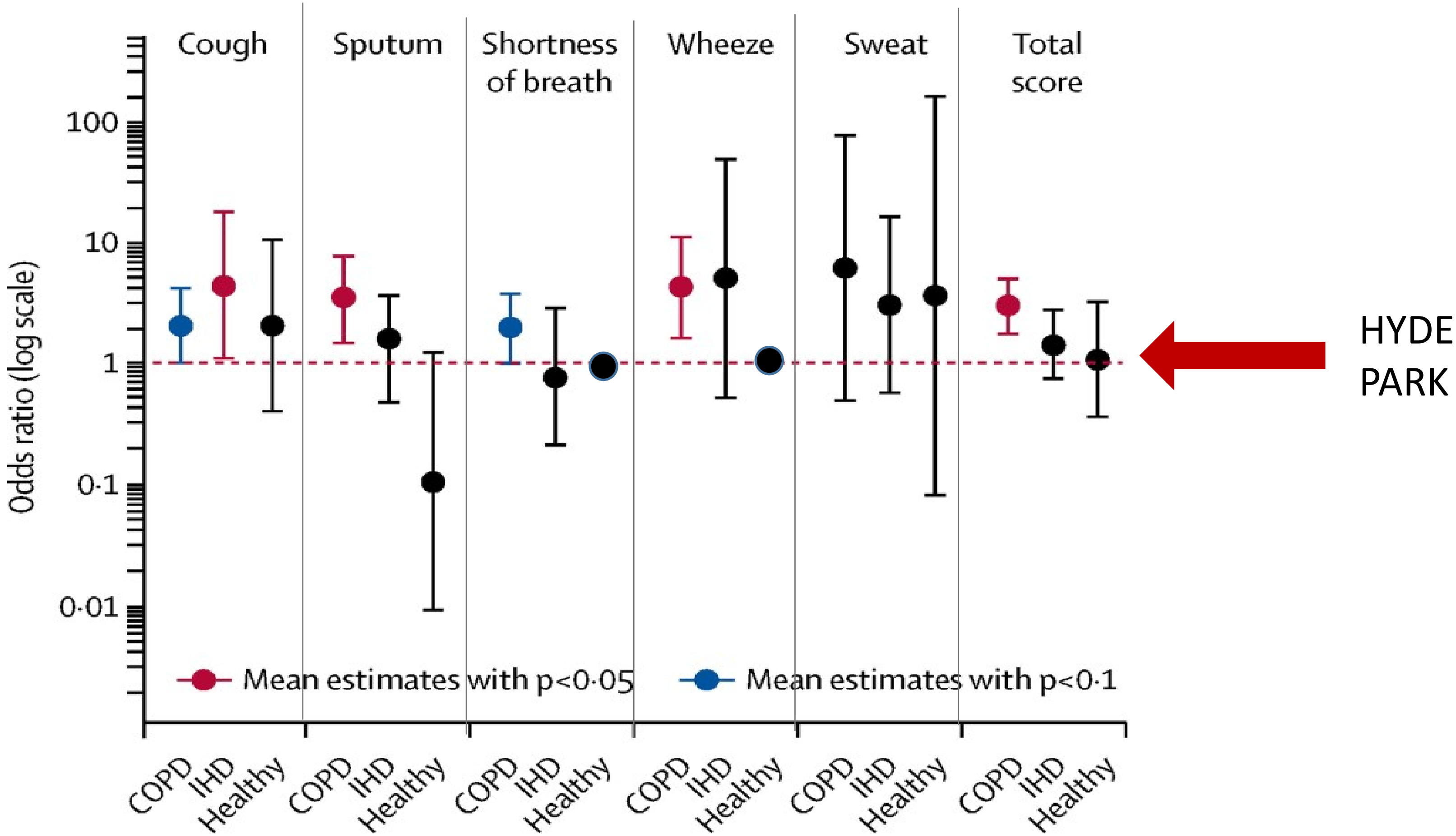
OXFORD STREET II STUDY

Odds ratio of getting worse symptoms of cough, sputum, shortness of breath, wheeze, sweat, and total scores for all these symptoms at Oxford Street versus Hyde Park for healthy volunteers and participants with COPD or IHD – *Sinharay et al. Lancet 2018, **391:** 339*



COPD=chronic obstructive pulmonary disease.
IHD=ischaemic heart disease.

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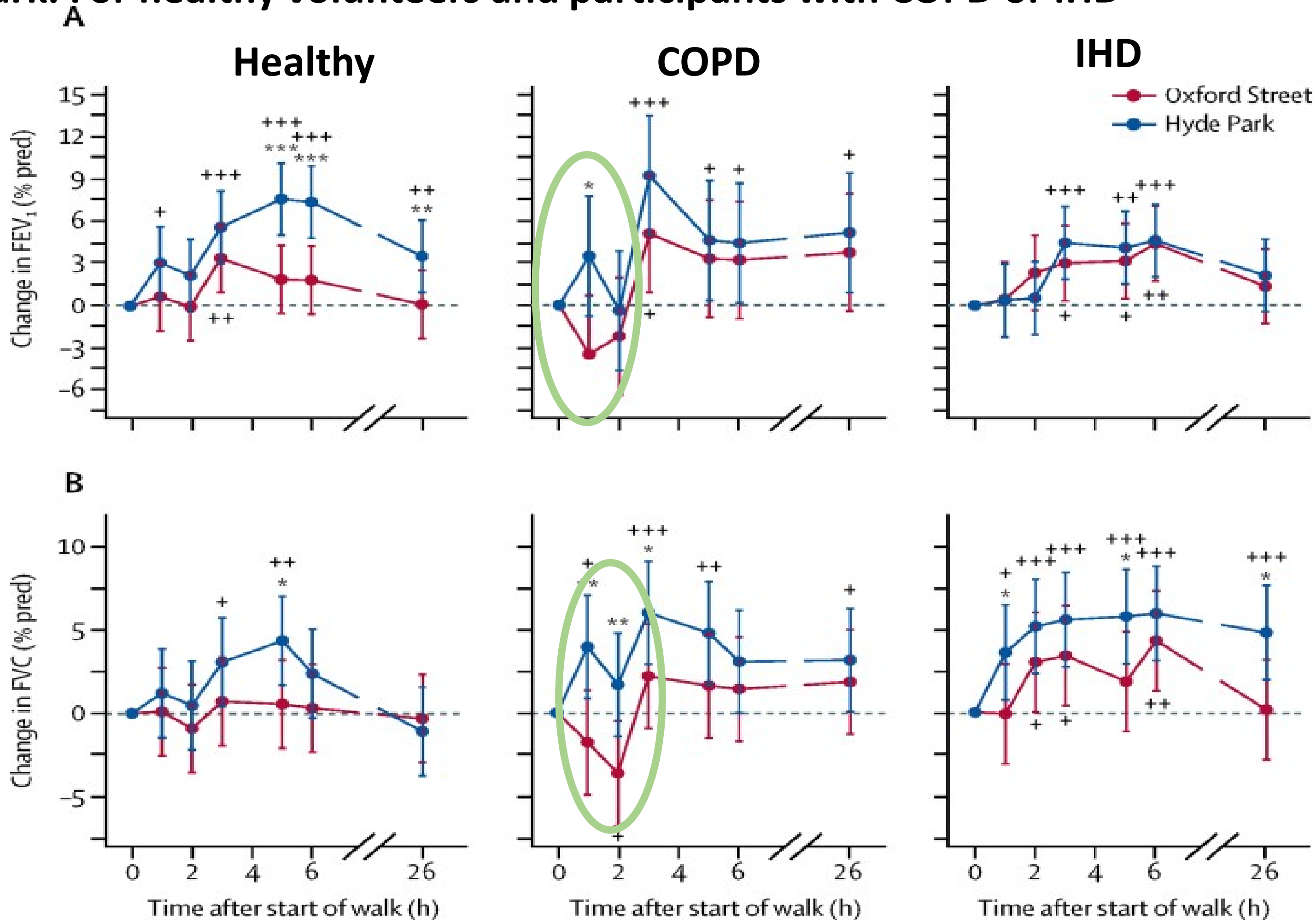
OXFORD STREET II

Change in FEV_1 % of predicted value (A), and FVC % of predicted value (B) from the time 0 and at intervals after the start of the 2 hour walk in Oxford Street or Hyde Park. For healthy volunteers and participants with COPD or IHD



FEV_1=forced expiratory volume in the first second. FVC=forced vital capacity.
**p<0·05, **p<0·01, ***p<0·001, comparing Oxford Street with Hyde Park.*
+p<0·05, ++p<0·01, +++p<0·001, compared with time point 0.

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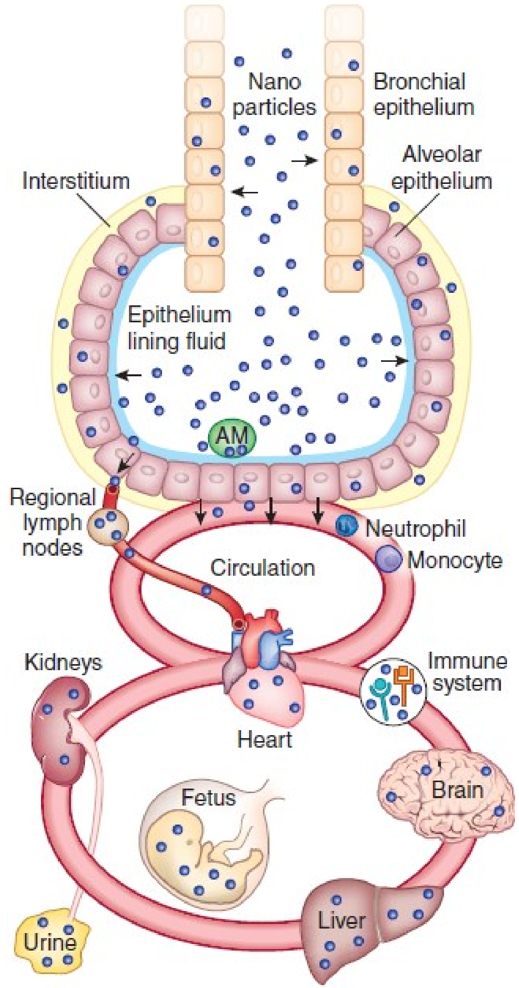
- Symptoms, including cough and wheeze increased in Oxford Street

- Reduced lung function in COPD subjects was related to levels of NO_2, ultrafine $PM_{0.1}$ and fine $PM_{2.5}$ particles.

- Cardiovascular changes, including increased arterial stiffness in Oxford Street, were seen in healthy and COPD subjects and related to NO_2 and ultrafine particles.

- Cardiovascular medication prevented the effects of air pollution on (increased) arterial stiffness in subjects with heart disease

Deposition and impact of inhaled $PM_{2.5}$ and $PM_{0.01}$



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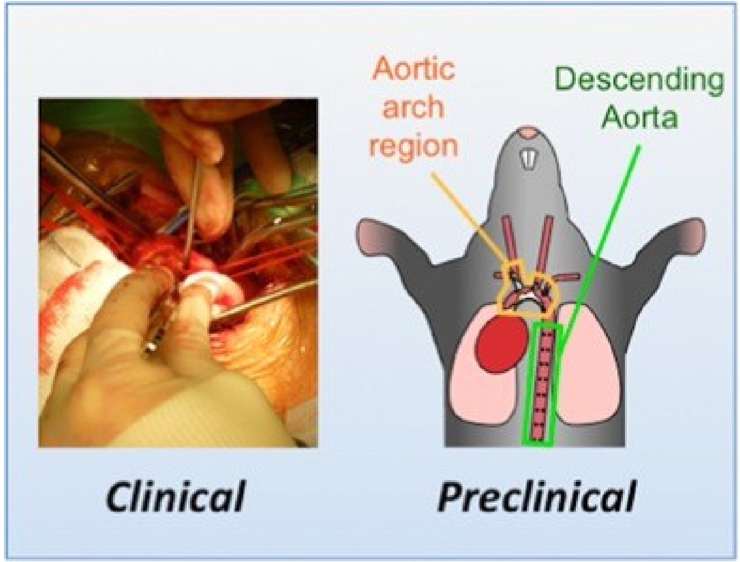
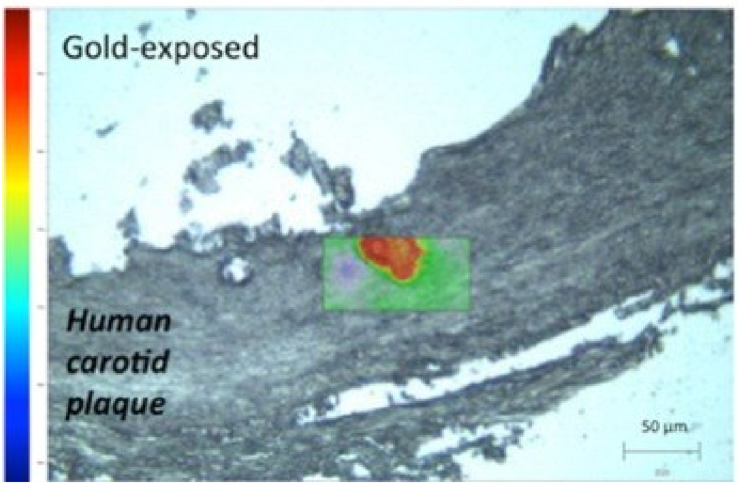
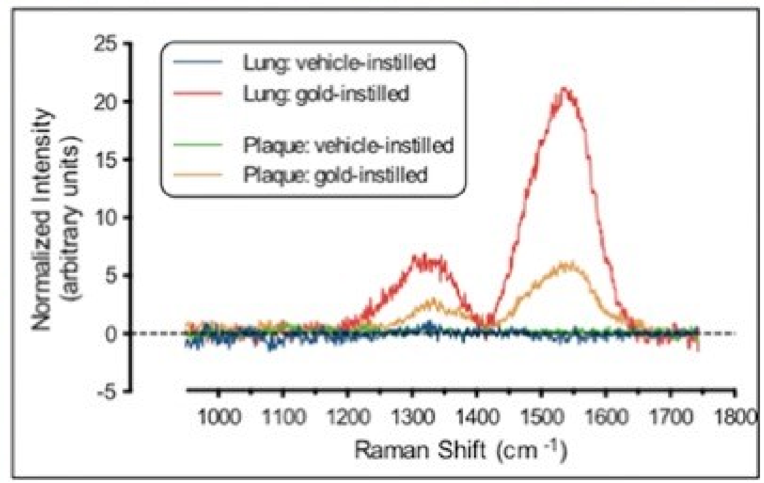


Inhaled Nanoparticles Accumulate at Sites of Vascular Disease.

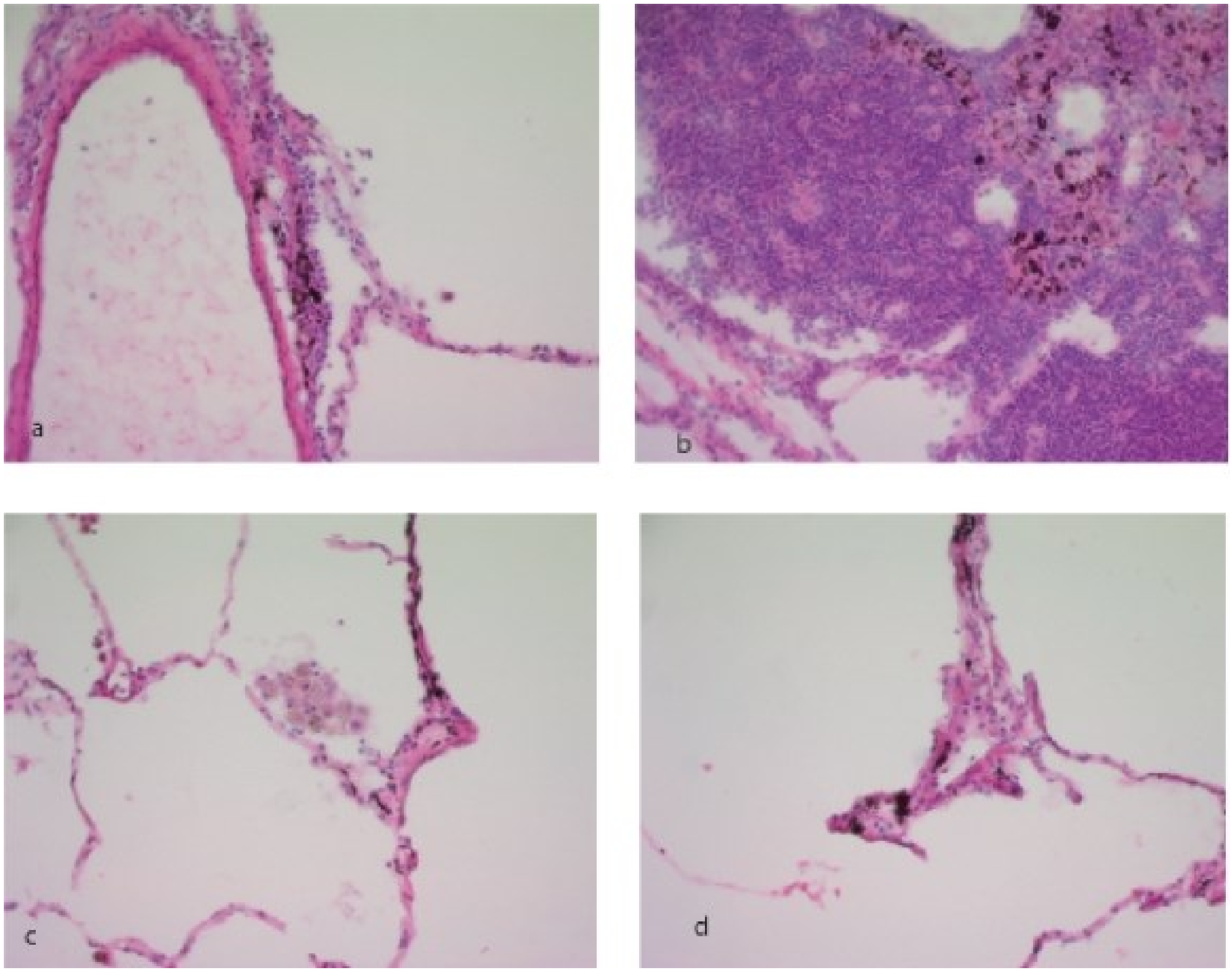
Miller et al. ACS Nano. 2017 May 23; 11(5): 4542–4552





- 0.02% of inhaled nanogold (~20nm diameter) excreted in urine by healthy individuals after 2h exposure during exercise.
- Nanogold in human and mouse atherosclerotic plaques after 4h exposure.

Particles reach the interstitial tissues of the lung and can remain there



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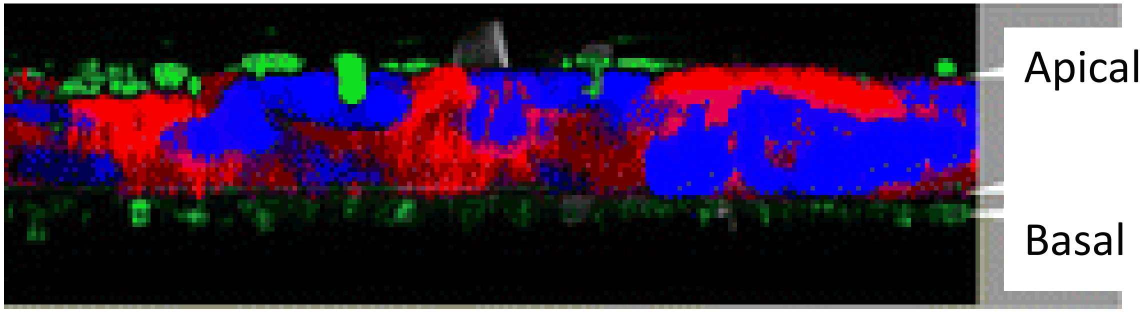
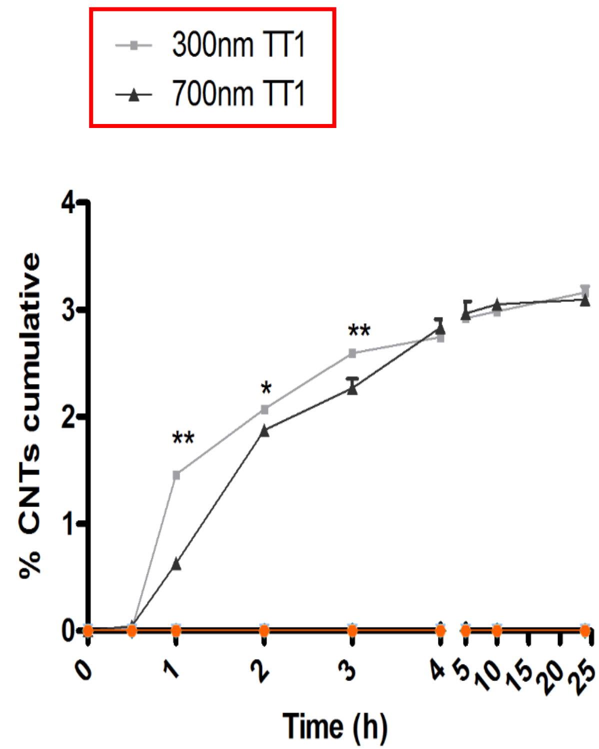
Uptake and translocation of MWCNTs by human alveolar epithelium

Alveolar epithelial type 1 cells exposed to MWCNTs



70-80% of 300nm CNTs (green) intracellular

2-3% translocate to the basolateral compartment



Rueuraroengsak, Porter, Tetley
unpublished

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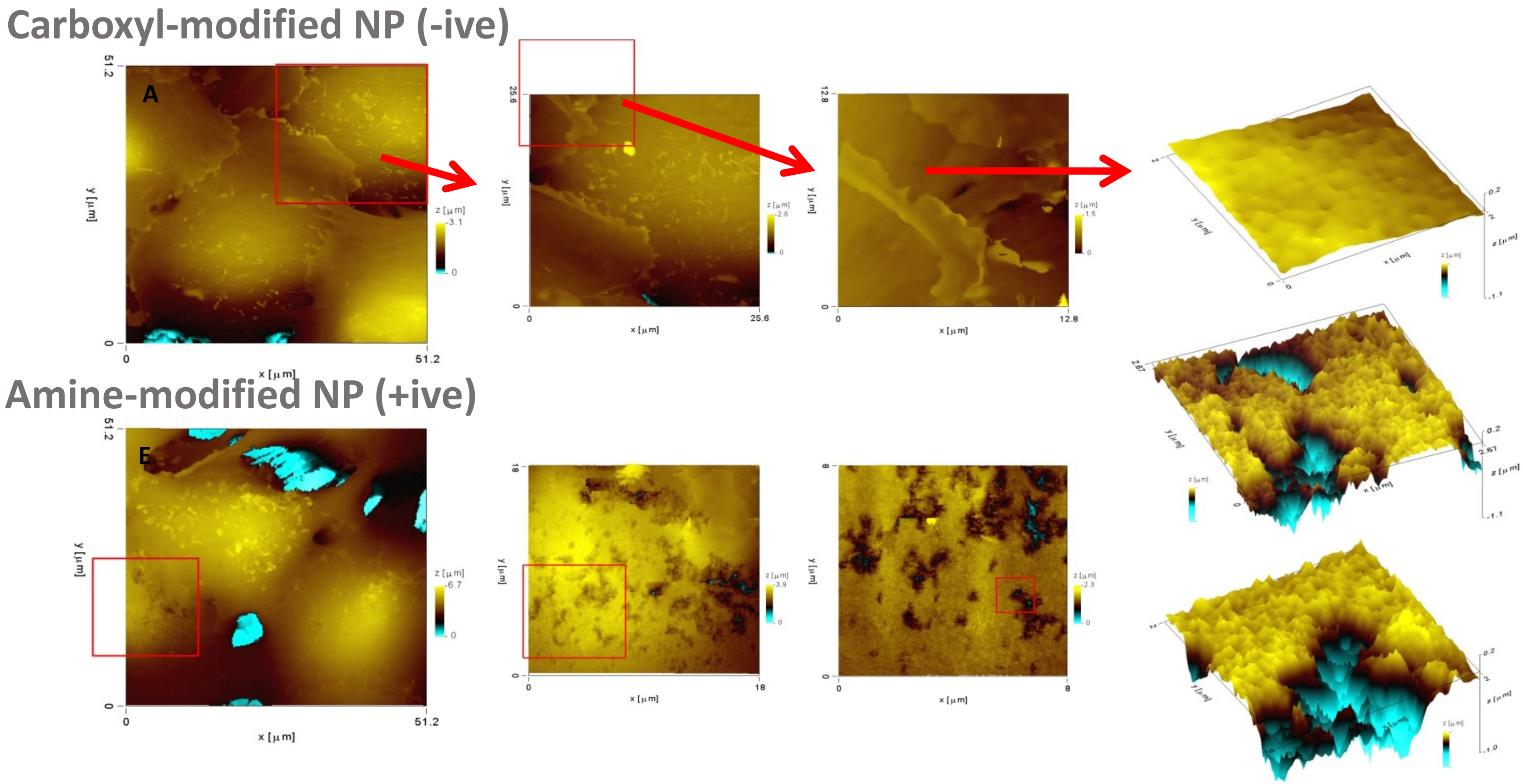
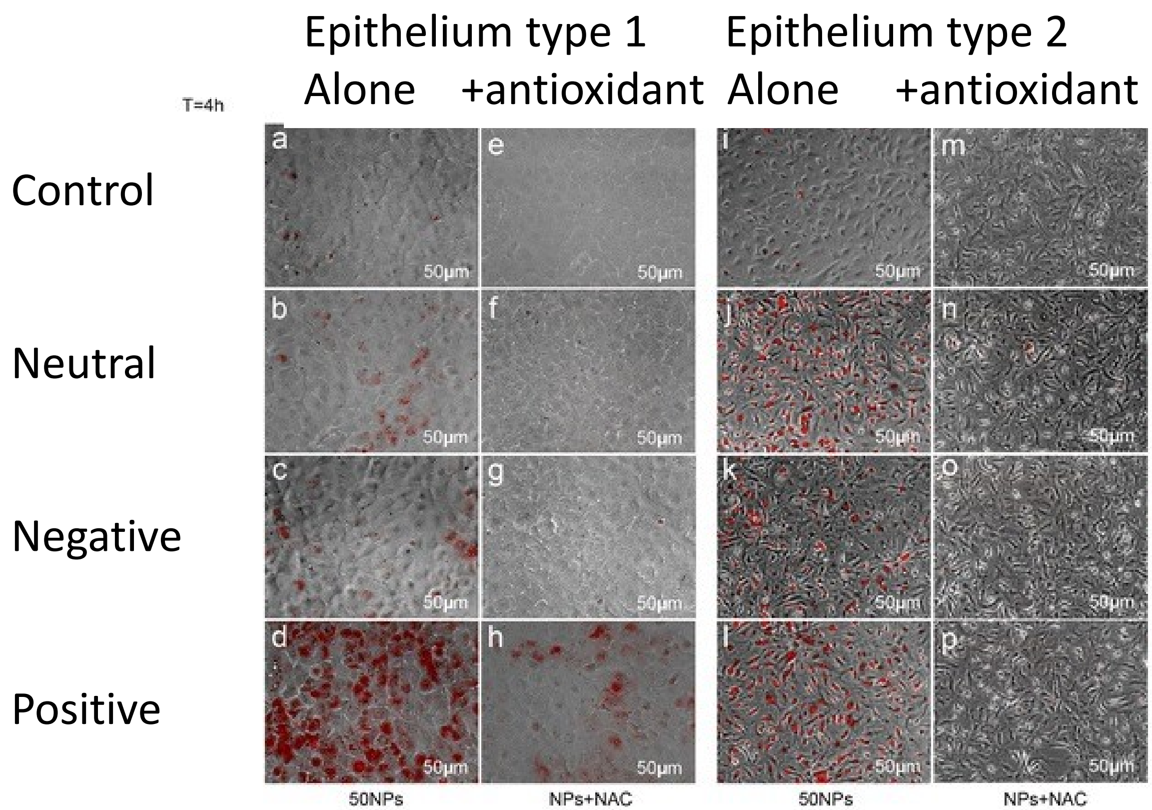
Hopping probe ion conductance microscopy of human respiratory alveolar epithelial cells exposed to carboxyl-modified and amine-modified particles for 4 hours.



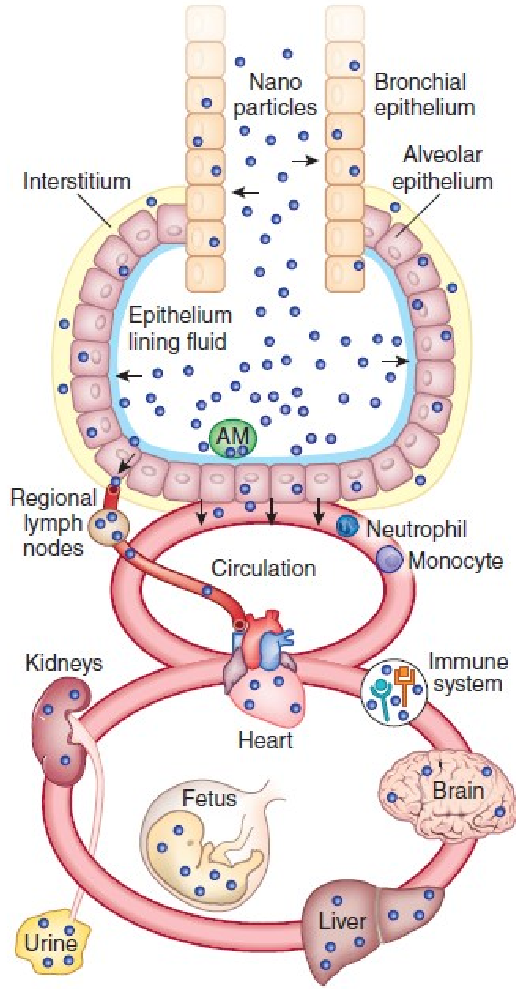
Ruenraroengsak et al. Respiratory epithelial cell cytotoxicity and membrane damage (holes) caused by amine-modified nanoparticles, Nanotoxicology 2012, 6:94-108

Nanoparticle-induced reactive oxygen species (ROS), importance of surface charge and protection by antioxidant treatment.



Rueuraroengsak & Tetley
PFT 2015

Systemic impact of inhaled $PM_{2.5}$ and $PM_{0.1}$



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Association between $PM_{2.5}$ and constituents of $PM_{2.5}$ and preterm delivery in California 2000-2006.

Basu et al. Paed. Perinatal Epidemiology, 2017; 31:424-434

231,637 births; 23,265 preterm births

50% PTB were 25-34 years old

PM2.5 data from 7 monitor sites, collected every 3rd or 6th day

Related to:
Traffic and biomass combustion

Long term exposure

Hispanic and Asian background

Constituent	**overall % change**
Total PM2.5	**+16.4 (13.5-19.5**
NH_4^+	**+21.2 (17.1-25.4)**
NO_3^-	**$^+$18.1 (14.9-21.4)**
Br	**+16.7 (13.2-20.3)**
Elem. Carbon	**+10.9 (6.3-15.6)**
Zn	**+14.4 (10.3-18.6)**
Cl	**-8.2 (-10.3 - -6.0)**
Na	**-13.2 (-15.2 - -11.3)**
Na^+	**-11.9 (-14.1 - -9.6)**
V	**-19.2 (-25.3 - -12.6)**

SUMMARY

- There are significant systemic health effects of ambient air pollution particles
- Size, chemistry and shape matters
- Susceptibility eg age, defence mechanisms, genetics, existing disease all play a part
- Mechanisms involved remain unclear

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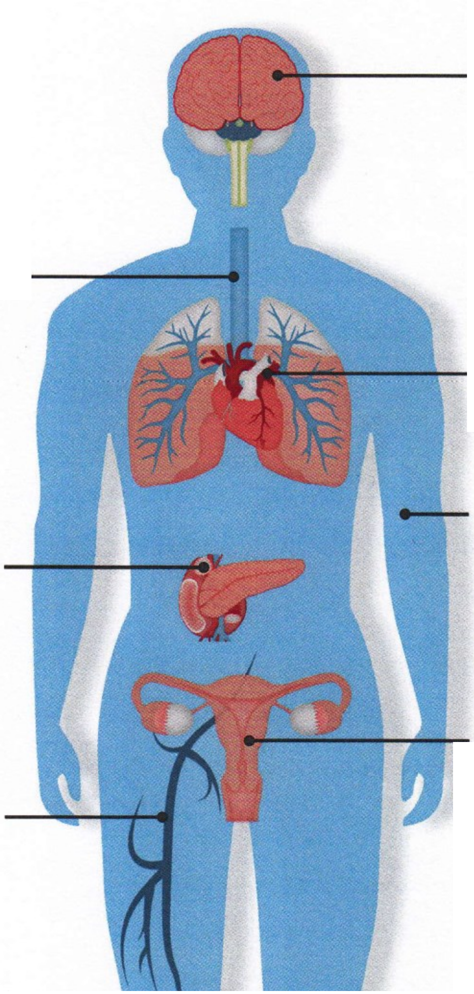
Health effects of air pollution

Respiratory disease –
COPD, asthma,
infection, lung cancer

Reduced lung growth
Reduced lung function

Type 2 diabetes
Type 1 diabetes
Liver toxicity
Renal disease
Altered bone metabolism

High blood pressure
Endothelial dysfunction
Increased blood clotting
Systemic inflammation
Thrombosis
Atherosclerosis



Strokes
Neurological development
Mental health
Neurodegenerative disorders

Cardiovascular disease –
myocardial infarction, cardiac
arythmia, cardiac failure

Accelerated aging
Autoimmune
rheumatic disease

Premature birth
Low birth weight
Reduced/delayed foetal growth
Lower sperm quality, infertility
Preeclampsia

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London

THANK YOU

A review of the possible associations between ambient PM2.5 exposures and the development of **Alzheimer**'s **disease**.
Shou Y, Huang Y, Zhu X, Liu C, Hu Y, Wang H.
Ecotoxicol Environ Saf. 2019 Jun 15;174:344-352

Maternal exposure to fine particulate **air pollution** induces epithelial-to-mesenchymal transition resulting in postnatal pulmonary dysfunction mediated by transforming **growth** factor-β/Smad3 signaling.
Tang W et al. Toxicol Lett. 2017;267:11-20

Triggering Mechanisms and Inflammatory Effects of Combustion Exhaust **Particles** with Implication for Carcinogenesis.
Øvrevik J, Refsnes M, Låg M, Brinchmann BC, Schwarze PE, Holme JA.
Basic Clin Pharmacol Toxicol. 2017 Sep;121 Suppl 3:55-62

Short-term effects of airport-associated ultrafine particle exposure on **lung function** and inflammation in adults with asthma.
Habre R, Zhou H, Eckel SP, Enebish T, Fruin S, Bastain T, Rappaport E, Gilliland F.
Environ Int. 2018 Sep;118:48-59

Association between PM$_{2.5}$ and PM$_{2.5}$ Constituents and Preterm Delivery in California, 2000-2006.
Basu R, Pearson D, Ebisu K, Malig B.
Paediatr Perinat Epidemiol. 2017 Sep;31(5):424-434

Association between **fertility** rate reduction and pre-gestational exposure to ambient fine **particles**in the United States, 2003-2011.
Xue T, Zhu T. Environ Int. 2018 Dec;121(Pt 1):955-962

Association between **fertility** rate reduction and pre-gestational exposure to ambient fine **particles**in the United States, 2003-2011.
Xue T, Zhu T. Environ Int. 2018 Dec;121(Pt 1):955-962

Ambient fine particulate **pollution** associated with **diabetes mellitus** among the elderly aged 50 years and older in China.
Yang Y, Guo Y, Qian ZM, Ruan Z, Zheng Y, Woodward A, Ai S, Howard SW, Vaughn MG, Ma W, Wu F, Lin H. Environ Pollut. 2018;243(Pt B):815-823

Exposure to Environmental and Occupational Particulate **Air Pollution** as a Potential Contributor to Neurodegeneration and **Diabetes**: A Systematic Review of Epidemiological Research.
Dimakakou E, Johnston HJ, Streftaris G, Cherrie JW.
Int J Environ Res Public Health. 2018 Aug 9;15(8)

Alzheimer's **disease** and alpha-synuclein pathology in the olfactory bulbs of infants, children, teens and adults ≤ 40 years in Metropolitan Mexico City. APOE4 carriers at higher risk of suicide accelerate their olfactory bulb pathology.
Calderón-Garcidueñas L, González-Maciel A, Reynoso-Robles R, Kulesza RJ, Mukherjee PS, Torres-Jardón R, Rönkkö T, Doty RL.
Environ Res. 2018 Oct;166:348-362

Exposure to ambient fine **particles** and neuropsychiatric symptoms in cognitive disorder: A repeated measure analysis from the CREDOS (Clinical Research Center for Dementia of South Korea) study.
Lee H, Kang JM, Myung W, Choi J, Lee C, Na DL, Kim SY, Lee JH, Han SH, Choi SH, Kim SY, Cho SJ, Yeon BK, Kim DK, Lewis M, Lee EM, Kim CT, Kim H.
Sci Total Environ. 2019 Jun 10;668:411-418

IFALPA Position on Cabin Fume Events

Capt. Antti Tuori, M.D., Ph.D.

Aircraft Cabin Air Conference 2019


IFALPA represents the international community of air line pilots;
A Federation of nearly 100 National Associations
And over 100,000 Pilot Members
Driven by dedicated volunteers who seek to improve Aviation Safety

The Mission of IFALPA is to promote the highest level of aviation safety worldwide and to be the global advocate of the piloting profession; providing representation, services and support to both our members and the aviation industry.

IFALPA Position & Briefing Leaflet On Cabin Fumes

https://www.ifalpa.org/publications/library/cabin-fumes--2777

https://www.ifalpa.org/publications/library/cabin-fumes--2781

IFALPA
The Global Voice of Pilots

Position

18POS24 | 5 December 2018

Cabin Fumes

BACKGROUND

For most modern commercial jet aircraft, cabin air is taken directly from compressors in the engine compartments without filtering. Occasionally, oil fumes from the hot section of the engine and /or APU leak into this air, resulting in what is known as a fume event. This fact has been recognized by regulatory authorities, safety agencies, scientists, airlines, occupational doctors, oil manufacturers, and crew unions. A fume event may result in incapacitation of crew members and jeopardize flight safety, but some of the consequences of such leaks are still subject to debate. Immediate safety concerns resulting from an abnormal situation (fume events) should be differentiated from any potential short and long-term health effects.

IFALPA advocates bleed air free design as an ultimate solution. Meanwhile, filters and detection systems should be improved and installed. More information on Cabin Fume events can be found in the **Briefing Leaflet 18HUP-BL03, Cabin Fumes**.

POSITION

- **IFALPA is calling for better regulatory enforcement in relation to bleed air contamination.**
- **Effective and comprehensive reporting of fume events is paramount.**
- **A comprehensive and uniform medical assessment protocol after a fume event should be developed and implemented.**
- **Crews should be given basic and recurrent training on fume events.**
- **More medical/scientific research and results are needed on the long-term health effects of fume events along with clinical and epidemiological correlation.**
- **IFALPA advocates bleed air free design as an ultimate solution. Meanwhile, filters and detection systems should be improved and installed.**

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Human Performance Briefing Leaflet

18HUPBL03 | 5 December 2018

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OBJECTIVES

This briefing leaflet focuses on the safety case resulting from a fume event; how to train for, mitigate against, and report fume events.

When a fume event occurs, cabin air contamination can cause short-term physical effects which may compromise flight safety. Sufficient scientific concern exists requiring more studies in order to determine any short and long-term effects of fume exposures.

DEFINITIONS USED IN THIS PAPER

Contaminant: The presence of an unwanted constituent or impurity in the air.

Odour(s): A particular and distinctive smell. In the context of this position paper, odours can be an indicator of bleed air contamination.

Fume(s): Gaseous, often odorous compounds which are not necessarily visible but may be irritating, offensive, or noxious. Fumes may occur in an aircraft when bleed air is contaminated by fluids such as engine oil, hydraulic fluid, anti-icing fluid, or other potentially hazardous chemicals.

Fume event: A period of time, transient or sustained, in which the aircraft occupants are exposed to fumes.

Note: Crew members should not assume that signs of contaminants (e.g. smoke or haze) must be visible in order to recognize, assess, and report them.

Smoke: The product of burning materials made visible by the presence of small particles.

- PAGE 1 OF 6 -

Fume Event – A Safety Issue

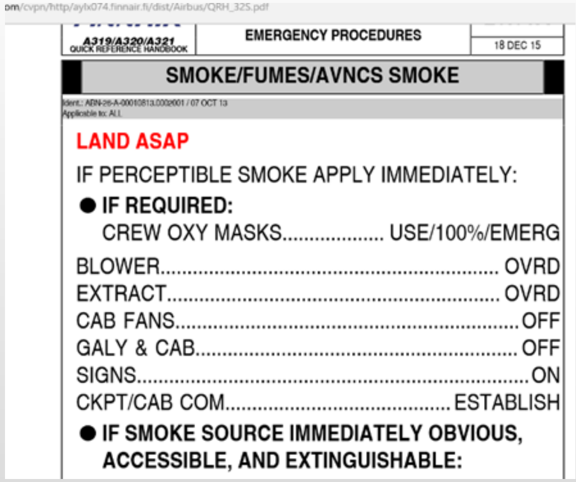
- A fume event may result in the incapacitation of crew members and jeopardize flight safety
- Immediate safety concerns resulting from an abnormal situation (fume events) should be differentiated from any potential short and long-term health effects
- some of the consequences of such leaks are still subject to debate
- Various types of fumes may contaminate the air supply system

Bleed Air Certification Specifications

- The airworthiness design standards FAR 25.831 (U.S.) and CS 25.831 (Europe) contain ventilation specifications.
  - “Crew and passenger compartment air must be free from harmful or hazardous concentrations of gases or vapors.”
  - However, clean air has not been adequately defined. This condition must be met at initial design certification as well as on an ongoing basis known as ‘continuing airworthiness’.
- There are currently no required methods for air sampling after fume events. There is a lack of certification specifications for continued airworthiness once engines have been installed on the aircraft.
- Detection systems are also required by FAA & EASA 25.1309(c),
  - these requirements have never been enforced regarding bleed air

Crew Action

- Always follow the manufacturer's and/or operator's procedures.
- Don oxygen masks
- Establish communication
- Follow the associated emergency procedures


A319/A320/A321 QUICK REFERENCE HANDBOOK | EMERGENCY PROCEDURES | 18 DEC 15

SMOKE/FUMES/AVNCS SMOKE

LAND ASAP

IF PERCEPTIBLE SMOKE APPLY IMMEDIATELY:

- IF REQUIRED:
  CREW OXY MASKS USE/100%/EMERG

BLOWER .... OVRD
EXTRACT .... OVRD
CAB FANS .... OFF
GALY & CAB .... OFF
SIGNS .... ON
CKPT/CAB COM .... ESTABLISH

- IF SMOKE SOURCE IMMEDIATELY OBVIOUS, ACCESSIBLE, AND EXTINGUISHABLE:

Reporting

- Effective and comprehensive reporting system is required
- a standardized reporting form (ICAO circular 344) is encouraged to be used
- Required reports:
  - mandatory reports, as required by the State of the Operator
  - aircraft technical log
  - smoke and fumes reporting form

STANDARDIZED SMOKE AND FUMES REPORTING FORM

SECTION 1: FLIGHT AND REPORTER DETAILS

Note: For each question, check all that apply. If one answer is dominant for a given question, write a ☆ next to that item.

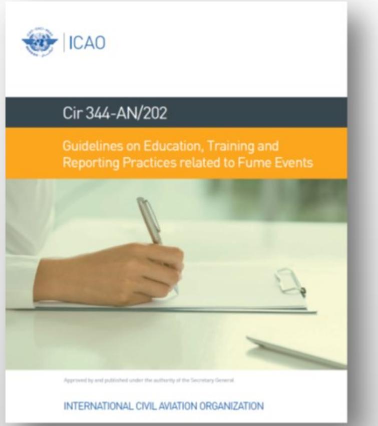
AC number: ______	Flight date (DD/MM/YYYY): ______	Form completed by: ☐ Flight crew ☐ Cabin crew ☐ Maintenance ☐ Other
AC type: ______	Reporter name: ______	
Tech log # (if known): ______	Employee no.: ______	
Departure stn.: ______	Email: ______	PIC signature: ______ (operator discretion)
Arrival stn.: ______	Phone: ______	

Phase(s) of flight: ☐ Parked (pre-flight) ☐ Pushback ☐ Engine start ☐ Taxi-out ☐ Take-off	☐ Climb ☐ Cruise ☐ Descent ☐ Approach ☐ Landing ☐ Taxi-in ☐ Parked (post-flight)	**Estimated duration of incident:** ____ (hrs.) ____ (min.) **Engine power level changes:** ☐ Yes ☐ No ☐ Unknown **Known history of similar conditions on same aircraft?** ☐ Yes ☐ No ☐ Unknown	**Recent aircraft service history:** ☐ None ☐ De-icing or anti-icing ☐ Engine/APU oil serviced ☐ Hydraulic fluid serviced ☐ Pesticide application ☐ Other: ______ ☐ Unknown

SECTION 2: SMOKE OR FIRE INFORMATION

Note: For each question, check all that apply. If one answer is dominant for a given question, write a ☆ next to that item.

Evidence of smoke or fire? ☐ Smoke ☐ Fire ☐ Neither smoke nor fire **Type of smoke or fire?** ☐ Localized smoke ☐ Generalized smoke ☐ Open flame	**Location of smoke or fire:** ☐ Cabin; if cabin ☐ Flight deck ☐ Flight crew rest area ☐ Cabin crew rest area ☐ Lavatory ______ ☐ Galley ______ ☐ Cargo	☐ Forward cabin ☐ Mid cabin ☐ Aft cabin ☐ Upper deck cabin **Skip to SECTION 4.**

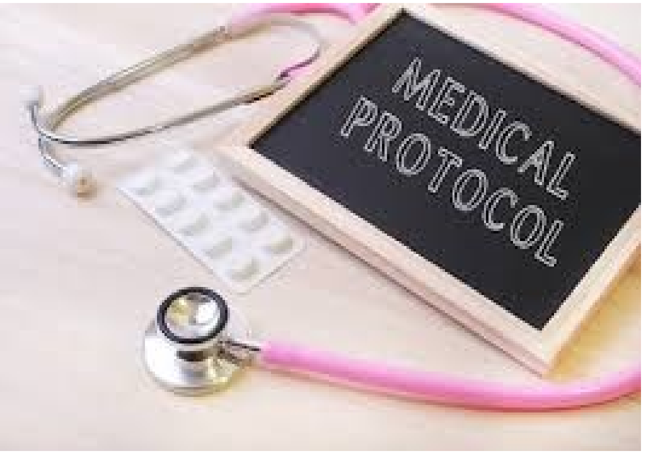


Post Event Procedures

- review the in-flight incident including consultation with the flight and cabin crew as soon as practicable
- Determine whether any crewmember felt unwell, and/or whether their performance was adversely affected;
- Require any crewmember who felt unwell, or felt their performance was affected, not to operate as a member of the crew until they have been assessed as fit by a medical practitioner.
  - The medical check should be done as soon as practicable after the fume event.
- Fill in required reports
- Follow the recommendations of your doctor, operator, and pilot association.

Medical Examination After A Fume Event

- So far no uniform protocol on medical checks after fume event have been established. Therefore, only general guidelines on what medical tests should be performed can be given.
- Follow your own operator's procedure if operator has one.
- Additional tests may be performed as part of ongoing research.
- Some more specific volatile organic compounds tests are under development for fume events, but they are not yet in routine use.



Medical Examination

- Clinical history, physical examination, including neurological evaluation
- Laboratory tests, depending on the clinical situation, that may include, but are not limited to,
  - O2-Saturation and arterial blood gas analysis (PaO_2, $PaCO_2$, Ph, HCO_3^-)
  - Hemoglobin, methemoglobin, carboxyhemoglobin
  - Blood-glucose, lactate, electrolytes
  - In case of respiratory problems, spirometry, and lung diffusion capacity test
  - Any additional tests deemed necessary by the treating doctor.

Training

► Basic and recurrent training on fume events

► Training according to ICAO Circular 344

A - Sources and types of on-board fumes

B - Odour descriptors to recognize the presence of oil and hydraulic fluid fumes

C – Potential for impairment

D – Procedures to apply during and after fume events

E – Reporting of fume Events

Long Term Health Effects

- Still unclear whether fume events cause long-term health effects
- Minimal seal leakage may occur even in normal operations
  - This may explain why only some of the crew experience symptoms whilst others remain asymptomatic after a fume event. Those whose “cumulative dose” exceeds a certain threshold may experience symptoms.
  - Genetic differences in metabolism may play a role in the cumulative effects
- IFALPA awaits further scientific evidence

Maintenance

- Post event maintenance should be carried out in accordance with the Trouble Shooting Manuals and Aircraft Maintenance Manuals (TSM/AMM).
  - These contain appropriate actions regarding how to proceed after a fume event, including the cleaning of the air conditioning ducts when an oil leak has been identified.
- All maintenance actions shall be clearly documented and visible for the next operating crew.
- Avoid overfilling of engine and APU oil

New Technologies/ Solutions?

- Alternatives to bleed air systems
- Bleed air filtration
- Fume event detection/monitoring
- Reduced toxicity oils
- Separate checklists for fume events

Conclusions & IFALPA Position

- IFALPA is calling for better regulatory enforcement in relation to bleed air contamination.
- Effective and comprehensive reporting of fume events is paramount.
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- IFALPA advocates bleed air free design as an ultimate solution. Meanwhile, filters and detection systems should be improved and installed.

Thank you

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