GCAQE
Global Cabin Air Quality Executive

Occupational Diseases in the EU. The System(s) and their role.
”Together for disease-free workers”
MCE Management Centre Europe
Brussel 3rd & 4th December 2013

New / emerging workplace risks
- Low level exposure to complex mixtures of chemicals

Dr. Susan Michaelis PhD, ATPL

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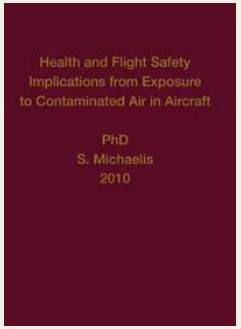
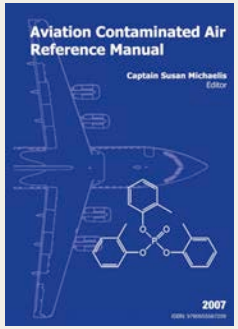
- Australian Pilot (former)
- PhD (2010) – Cabin air contamination
- Head of Research GCAQE





No financial relationships to disclose

Flight Safety Compromised

No warning systems - despite numerous calls to install

✈ December 2010 (A319) - BFU report – Germany

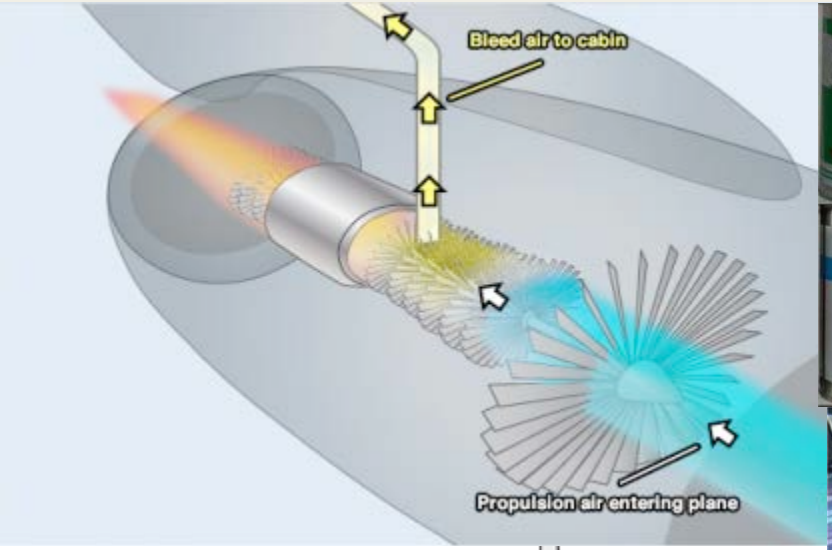
Upon landing

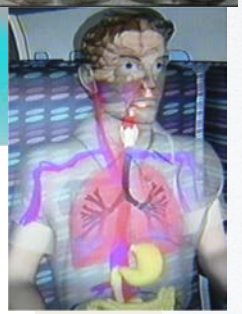
✈ Capt: strong dizziness, loosing senses, sudden tunnel vision, tingling hands & feet, stretched to the limit of capacities;

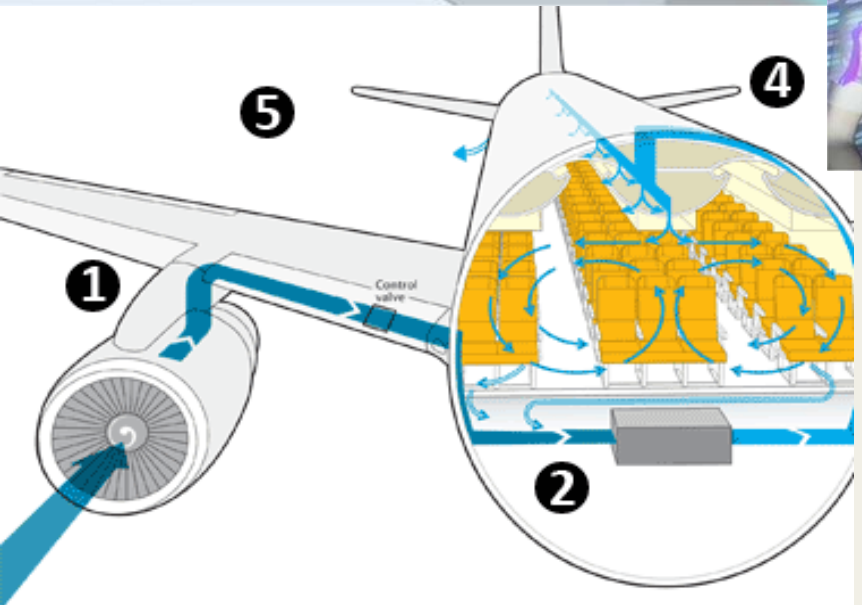
✈ Co-pilot: Feeling of throwing up, couldn't handle the flight info and general flight status

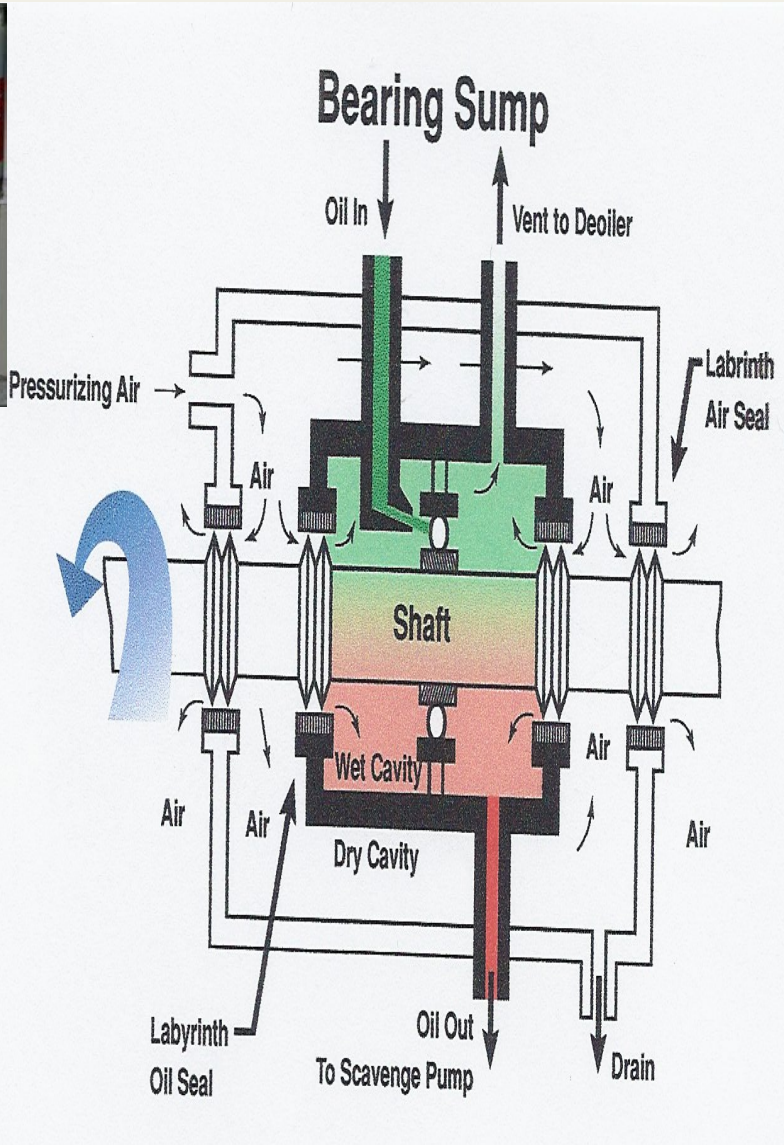
UK CAA MOR reports – 2006-2011- 250 oil fume reports/ 50 incapacitations

Cabin Air = Bleed Air

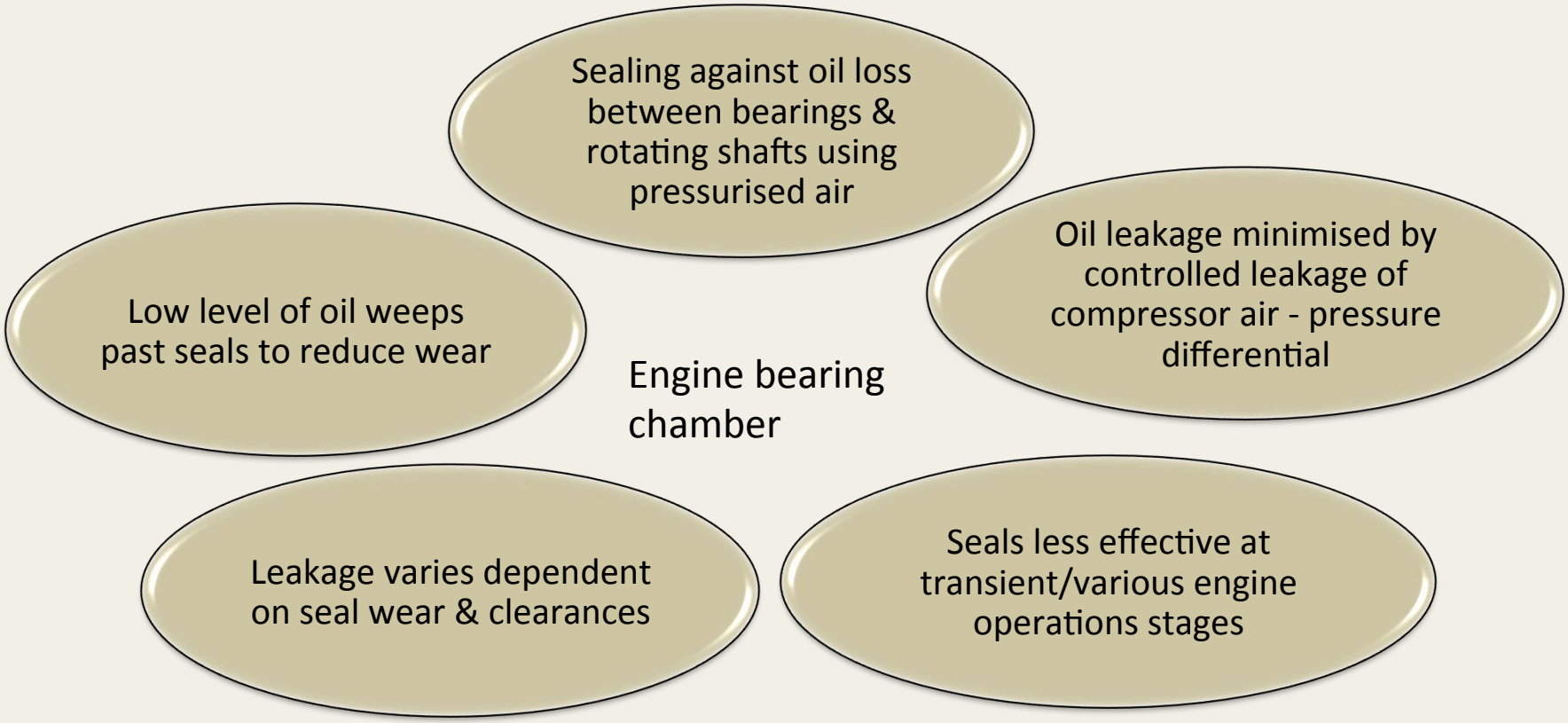








Oil leaks as function of design & operation of bleed air system

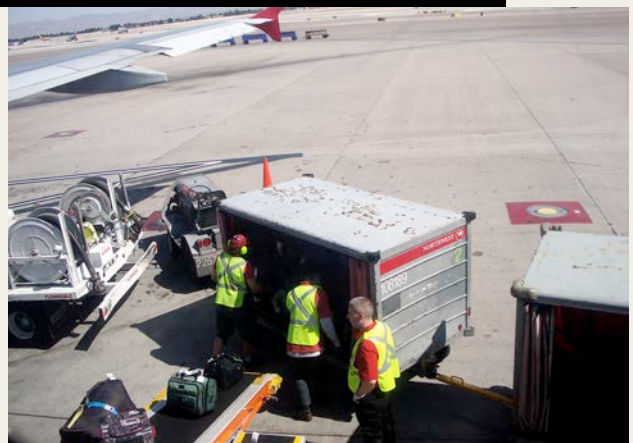


Low level oil leakage occurs as a function of normal flight, yet focus has incorrectly been on rarer failures

Not just crew and passengers
Aviation & Aero derivative engine

Offshore workers

Aircraft engineers & ramp workers



Oil leakage

Permissible leakage past seals

Escape of mist/aerosol via engine breathers

Loss during servicing

"Major portion of oil loss…"
Rolls Royce 1969

Engine manufacturer: Toxic cabin air - "5th biggest engine problem"

Working Environment

Complex mixture

Lower level chronic exposure / acute

Poorly defined

No monitoring/ filtration

Inadequate protection

14+ hour shifts at altitude

bio-accumulation

" All levels found are below safe levels"

??

Chemical mixtures

- Risk assessments based on single substance evaluations may underestimate the toxicity of a mixture:
  - Additive approach

"It is possible that interactions between chemicals may change the dose-response relationships observed for chemicals tested in isolation, leading to adverse effects at lower than expected doses or additional toxic effects that would not be predicted based on the toxicity of individual components."

The Interdepartmental Group on Health Risks from Chemicals
Chemical Mixtures: A framework for assessing risks to human health, 1999, UK

Cabin air quality studies

- 53 Air Quality Studies (Michaelis PhD 2010)
  - 62% – Bleed Air Contamination studies.
  - 38% – General conditions/ no techniques to identify bleed air contaminants.
  - NONE measured during an event.
  - Only 27% of specific studies suggested “acceptable“ air quality.
  - Organophosphate (TCP) was found in 48 % of contaminated Air Studies, Oil was found in 60 % of them.
- Norwegian Study: TCP in 4% air samples,39% swab, all HEPA Filters. (Solbu, 2011)
- UK study: TCP found in 23% of flights – No fume event. (Cranfield, 2011)

Lubricating Oils

Triaryl phosphates

Antiwear additives

TCP, TXP

Wide range of pyrolysis substances

(some unknown)

Amine antioxidants

PAN

& contaminants, BNA…

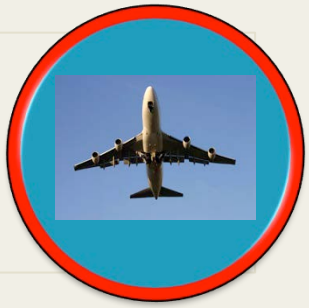
Temps > 700°F (315°C)

Ester base stock

Deicing fluids

Hydraulic oils

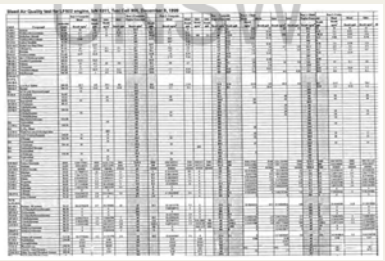
Relevant factors



- Lower level chronic exposures (design) or acute (failure)
- Oils exposed to extreme temperatures in compressor
- Complex mixture & wide range of pyrolysis substances
- Constituents partially unknown/proprietary
- Reduced pressure environment/no escape
- Most substances do not have exposure standards
- Variability: P450s modified genetically/environmentally
- Studies not undertaken on heated oils/inhalation

Similar problems in other industries, particularly where there is combustion/ thermal degradation

People being exposed

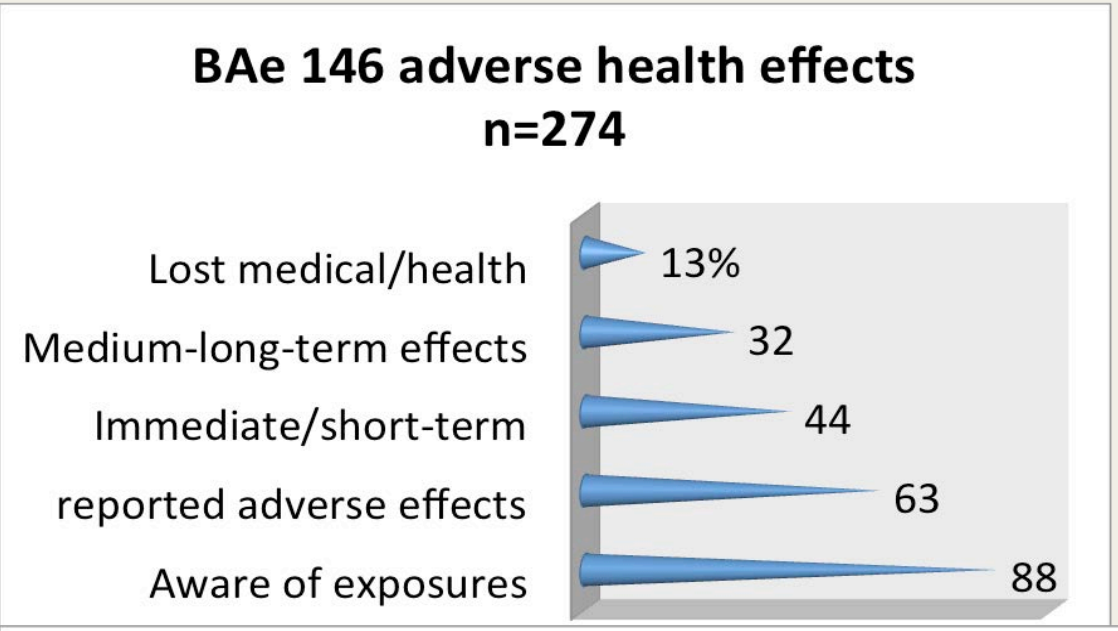


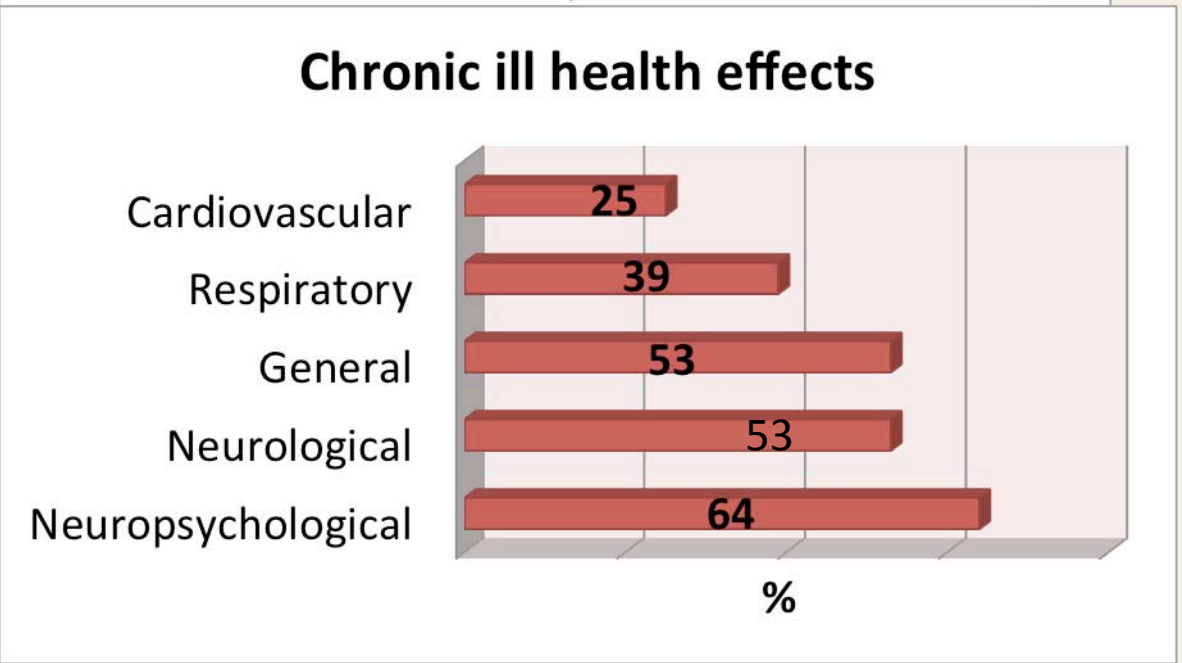
1. Swedish Malmo 1999 – worst case scenario - pilots incapacitated - SHK BAe 146 investigation - Oil leak identified
2. UK Cranfield study 2011: - No fume events (normal flight)
   - 23% of flights show TCP; 78% - TBP
   - 38% of flights – fumes/oily smells reported
3. German: Social Accident Insurance (2012)
   - Metabolites of TBP, TPP (flame retardants/hydraulic oils) significantly elevated - 332 urine samples
   - Aircrew occupational exposure to OPs

Frequency: Oil fumes reported in 1% of flights but design using bleed air system explains lower level exposure as a normal part of flight.

Health

Chronic ill health
37- 433%
above controls





Aircrew/passengers are reporting: Chronic neurological, respiratory disease consistent with exposure to jet engine oils including OPs

Cancers: Higher than population averages

Aerotoxic Syndrome is a valid term - causative relationship exists

Michaelis S (2010) PhD - Health and Flight Safety Implications from Exposure to Contaminated Air in Aircraft'.

Aviation - EU/UN HAZARD CLASSIFICATIONS (CLP) Harmonized & notified

Substances reaching a hazardous classification: TCP, TXP (*SVHC*), PAN, TCP ortho isomers

Hazard classifications - YES

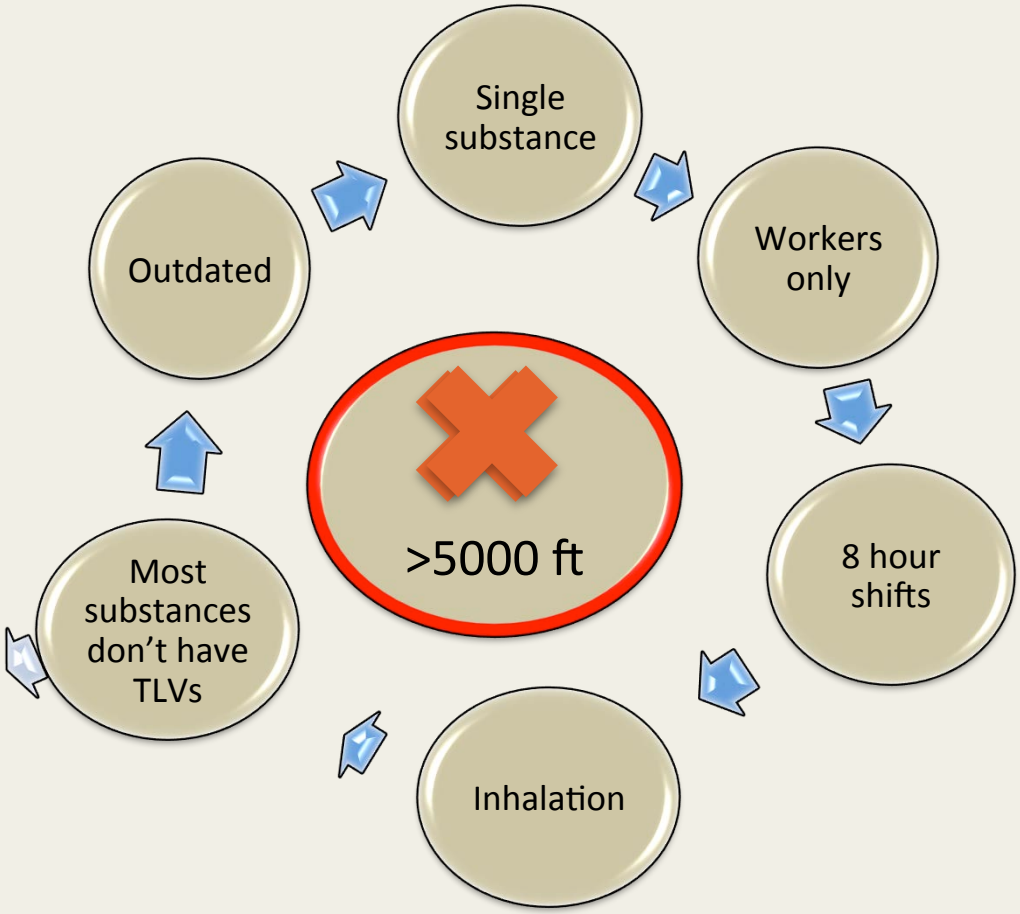
- Harmful if swallowed/dermal:
- May damage fertility or the unborn child
- Eye/skin irritant & ? respiratory irritant
- Skin sensitizer
- Single exposure target organ toxicity - nervous system
- Very toxic by inhalation
- Germ cell mutagenicity

Substances possibly warranting a hazard classification: TCP ortho isomers, BNA, PBN

Hazard classification ?

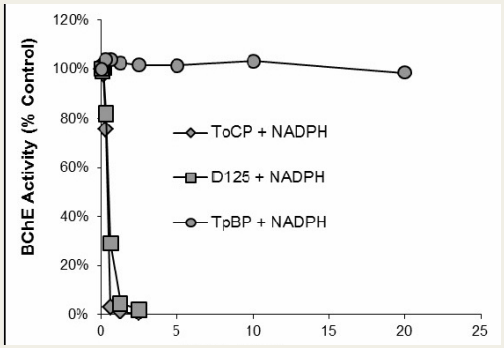
- Single exposure target organ toxicity - nervous system
- May cause cancer
- suspected of causing cancer
- Skin/eye irritant

Exposure standards/TLVs



Subtle health impacts don't work for all classes- endocrine disruptors/flame retardants in cabin

Science



1. **Treon 1954 (USAF)**

-Toxicity arises from thermal decomposition of oil base stock (95% of oil)

-Mists at 600^{o}F very much more toxic than at lower temps

-Pneumonitis, degenerative changes to liver, brain & kidneys

American Industrial Hygiene Association Quarterly. 16: 3, 187-195, 1955 (USAF)

2. **Furlong – University Washington**

-TCP formulation (DURAD 125) bioactivates in liver into enzyme inhibitors almost like TOCP that paralysed 50,000 in prohibition

-Other triaryl phosphate isomers (including TPCP) adversely affect normal physiological processes

Chemico-Biological Interactions. Volume 203, Issue 1, 25 March 2013, Pages 257–264

3. **Abou-Donia – Duke University**

-Chronic exposure results in neurodegeneration below threshold where neurologic deficits occur.

-Temporal association between exposure and biologic damage

Journal of Toxicology and Environmental Health, Part A, 76:363–380, 2013

What to do?

- Bleed free aircraft (Boeing 787)
- Training
- Chemical monitoring/filtration
- Risk assessments/studies on whole mixtures/ mixed exposures in specific environment
- Assess the people
- ??????

Thank you

GCAQE
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http://www.itfglobal.org/campaigns/cabin-air-quality.cfm

http://www.ifalpa.org/downloads/Level1/Safety%20Bulletins/Medical/13SAB006%20-%20Cabin%20air%20quality.pdf

www.aerotoxic.org