Aircraft Air Quality incidents
Symptoms, Exposures,
and
Possible Solutions

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van Netten C, Hilliard NB. Air Quality
and Health Effects Associated with
Operation of BAE 146-200 Aircraft.
Applied Occupational and Environmental

NRC, 1986, US
“The Airliner Cabin Environment: Air
Quality and Safety.”

NRC, 2002, US
“The Airliner Cabin Environment and the
Health of Passengers and Crew”
Australian Senate Committee
House of Lords, Great Britain

November 5, 2000
Birmingham incident
Oil smell in cabin
Pilot felt “dreadful”
“seeing double when landing”

November 12, 2001
Braathens Malmo incident
Oil leak in engine #2
“Poisoned pilots almost crashed”
“Pilots close to blacking out”
Passengers seemed “passivated”

Air quality incident frequencies, based on flight incident
reports submitted to 3 North American air carriers by
flight crew members

<table>
<thead>
<tr>
<th>Aircraft type</th>
<th>Average number of incidents per aircraft per year</th>
<th>per 1000 cycles*</th>
</tr>
</thead>
<tbody>
<tr>
<td>BAE-146</td>
<td>6.4</td>
<td>3.88**</td>
</tr>
<tr>
<td>MD-80</td>
<td>1.01**</td>
<td>1.02**</td>
</tr>
<tr>
<td>A-320</td>
<td>1.67</td>
<td>1.29</td>
</tr>
<tr>
<td>B-727</td>
<td>0.34</td>
<td>1.25</td>
</tr>
<tr>
<td>DC-10</td>
<td>0.38</td>
<td>1.04</td>
</tr>
<tr>
<td>B-767</td>
<td>0.21</td>
<td>0.63</td>
</tr>
<tr>
<td>B-737</td>
<td>0.07</td>
<td>0.09</td>
</tr>
</tbody>
</table>

* A cycle is defined as: take-off, flight, and landing sequence
** based on incomplete data and estimates.
Symptoms associated with air quality incident reports

<table>
<thead>
<tr>
<th>Symptom</th>
<th>X</th>
<th>Y</th>
<th>Z</th>
</tr>
</thead>
<tbody>
<tr>
<td>Any symptom</td>
<td>58%</td>
<td>78%</td>
<td>82%</td>
</tr>
<tr>
<td>E,N,T</td>
<td>38%</td>
<td>16%</td>
<td>25%</td>
</tr>
<tr>
<td>CNS</td>
<td>45.3</td>
<td>72%</td>
<td>64%</td>
</tr>
<tr>
<td>intox.</td>
<td>45%</td>
<td>70%</td>
<td>63%</td>
</tr>
<tr>
<td>neuropsych.</td>
<td>3%</td>
<td>3%</td>
<td>2%</td>
</tr>
<tr>
<td>other</td>
<td>6%</td>
<td>19%</td>
<td>8%</td>
</tr>
<tr>
<td>Respiratory</td>
<td>9%</td>
<td>16%</td>
<td>28%</td>
</tr>
<tr>
<td>GI</td>
<td>16%</td>
<td>30%</td>
<td>21%</td>
</tr>
<tr>
<td>Skin</td>
<td>7%</td>
<td>10%</td>
<td>3%</td>
</tr>
<tr>
<td>Cardio vascular</td>
<td>2%</td>
<td>3%</td>
<td>2%</td>
</tr>
<tr>
<td>Total reports</td>
<td>128</td>
<td>598</td>
<td>299</td>
</tr>
</tbody>
</table>

Engine bleed air:
- Used to provide ventilation air to the cabin
- Prone to oil contamination when seals are worn
- Potential for pyrolysis @300 psi and @ 300-500 °C
  Choosen for: “Economical reasons”

Previous source of ventilation air: Ram air
AChE inhibition

Recent human exposures
1994 Sarin attack Matsumoto, Japan, 600 exposed, 58 admitted to hospital, 7 died
1995 Sarin attack Tokyo subway, 5000 hospitalized, 1 died

Many CNS symptoms were reported
Tests: red blood cell AChE inhibition
Pupillary constriction present with normal AChE levels

Organophosphate Ester-induced toxicity
1. AChE inhibition
2. OPIDN, Organophosphate Ester-Induced Delayed Neurotoxicity
3. OPICN, Organophosphate Ester-Induced Chronic Neurotoxicity


OPIDN, Organophosphate Ester-Induced Delayed Neurotoxicity

Wallerian-type degeneration of long and large diameter tracts of PNS and CNS, starting at distal portion
First observed in 1899, TOCP containing Creosote oil treatment for pulmonary tuberculosis
Three types, 1, 11, 111.
Test ?: Hen test,
Neurotoxicity Target Esterase, NTE inhibition
Tokyo experience: humans more sensitive to Sarin induced OPIDN than animals.
OPICN
Organophosphate Ester-Induced Chronic Neurotoxicity

Chronic neurological problems persisting for years
Distinctly different from AChE and OPIDN effects
Often referred to in the literature in many ways such as
“Chronic neurobehavioural effects”
“Chronic organophosphate induced neuropsychiatric disorders ( COPIND)” *
CNS affected: neuropathological lesions of cortex, cerebellum, hypocampal formation etc. due to:
- neuronal death and delayed apoptosis.

OPICN highly susceptible to synergist
-ie oxidative stress, NO is involved
-Other compounds that have an effect on ACh
 ie Permethrin etc.

based on studies of pesticide applicators, manufacturers, etc.
Gulf war syndrome

Exposure assessment

Direct measurement
Indirect measurement
 • Coalescer bags
 • Recirculation air filter
 • Surface wipe samples

Direct measurement preferred
(• Stealth monitoring)
Filter analysis

TCP presence
Flight deck roof vent B-757 (#1) +ve
Forward Lavatory B-757 (#1) + ve
Flight deck roof vent B-757 (#2) +ve
B-737 Lavatory filter - ve
(+ve for cocaine and amphetamines)
Prefilters form re-circair (Bae 146) +ve
HEPA filter analysis B-757 +ve
(30 micro grams TCP/filter (total area 4.5 m²)
6.6 micrograms /m²

Other agents found on filters (among many others)

- Tripropyl phosphate (Fyrol)
- Triphenyl phosphate (fire proofing agent)
- Phthalate esters (plasticizers)
- Brominated compounds (fire retardants)

Some of these are potential synergists with TCPs

Wipe sample analysis

- Prefer to use solvent such as toluene
  Vials of toluene or similar solvents not acceptable in aircraft.
- Use what is available
  "Smirnoff Vodka"
- Provide a template, gauze pad and vials for sample and solvent blank (Vodka)

Surface wipe sample results

2/8 samples from the B-757 cockpit +ve for TCPs .2 -.3 micrograms /m²

 Likely dependent on
- Cleaning regime
- Proximity to air vent, etc.
- "Wear and tear of the surface sampled"
Analysis of a pilot pants + ve for TCPs
(.17 micrograms/pair of pants)

Exposure assessment

Direct measurement

Indirect measurement
Coalescer bags
Recirculation air filter

Direct measurement preferred
(Stealth monitoring)

NRC recommendations

• Provide CO monitors to aircraft
• Use ram air rather than bleed air
• pressurize cabin to equivalent of 6000 Feet altitude

They said
“it could not be done!”

Guess what?
Propulsion Systems Feature Key Technologies

- Engine and nacelle features:
  - Higher bypass ratio
  - No-engine-bleed systems architecture
  - Low-noise nacelles with chevrons
  - Laminar flow nacelles
  - Interchangeable (at the wing)

Simply the Best: Better than the Competition

THE 787...
- Is **13% LIGHTER** than the A330
- Has **20% BETTER** fuel performance than the A330
- Emits **20% LESS** carbon dioxide than the A330

Simply the Best: Saving Fuel

The fuel savings from one round-trip in a 787 instead of an A330 is enough to offset the fuel used in your daily automobile commute to work for **31 YEARS**

A Better Experience: Lower Cabin Altitude

![Graph showing the percentage of passengers reporting overall well-being at different cabin altitudes, with 6,000 feet as the best value.]
A Better Experience: Lower Cabin Altitude

Cabin altitudes up to 8,000 are safe* for healthy individuals, however:
- 10% more available oxygen is in the air at 6,000 feet
- There is measurable comfort improvement between 6,000 and 8,000 feet
- Comfort is significantly improved by reducing cabin altitude below 8,000 feet
- Comfort is not significantly improved by reducing below 6,000 feet
- At 6,000 feet, fatigue and headaches are reduced in susceptible people

* As determined by the National Academy of Sciences

Composite Are the Smart Choice

- Fatigue and corrosion resistant
- Higher strength-to-weight ratio reduces weight
- Enables enhanced passenger comfort
- Allows larger, more integrated structure
- More future growth potential than metals

A Better Experience: Cleaner Air, Higher Humidity

- Air purification system
  - Includes HEPA particulate filtration for viruses, bacteria, fungi
  - Removes gaseous contaminants, odors, irritants
  - Boeing research shows that contaminants cause many of the same symptoms as low humidity – dryness and eye irritation, headaches, dizziness
- Advanced airflow management
  - Controls airflow balance resulting in higher moisture levels to maximize comfort

Patent pending
Thanks for your attention