Proving and preventing exposure to oil smoke/fumes on commercial flights

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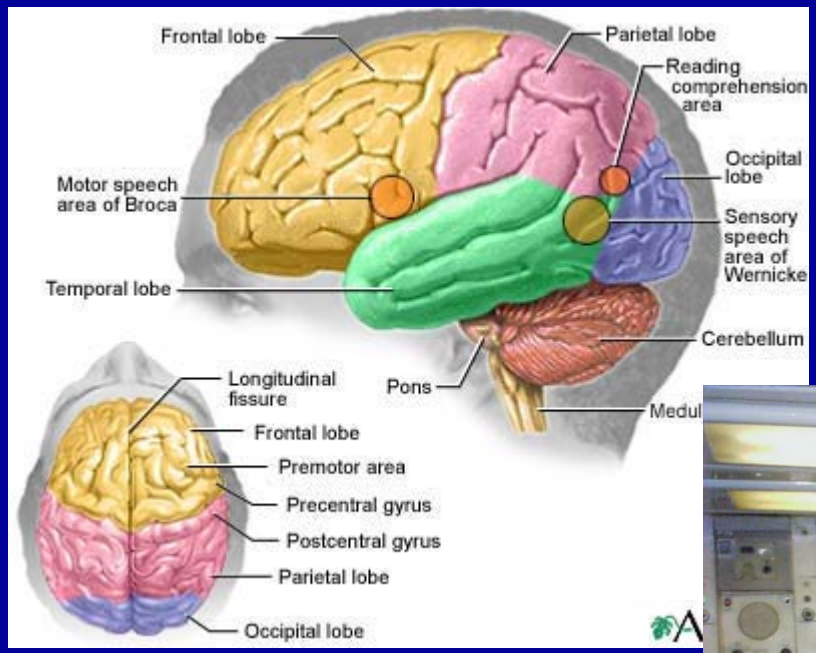
Why is she talking about oil smoke/fumes at fire safety conference?

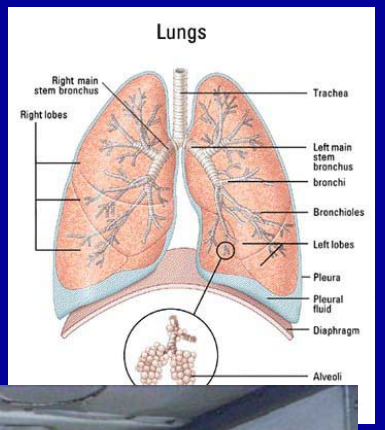
- US Flight Safety Foundation estimates average of 5-10 diversions due to smoke/fumes on aircraft/day (globally).
- Crew, pax exposed to smoke/fumes but source may not be obvious (could be SMOKE from electrical, cigarette, cargo, bomb, etc. or could be engine oil fumes in the supply air)
- Airlines don't monitor the air supply. Instead we rely on...

Recent model: chemical sensor for air supply system, commercial aircraft

Other sensor types...

Current outside air filtration system



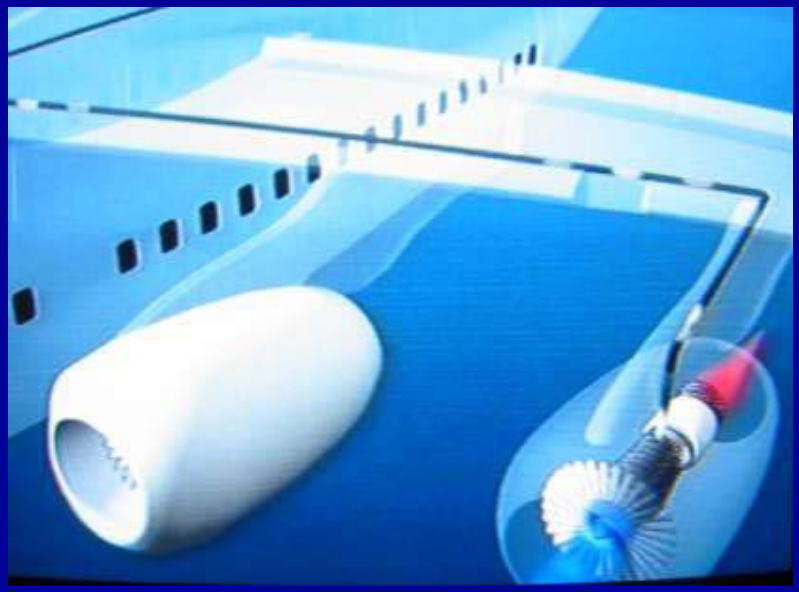


Overview of presentation

- Background… (How do oil smoke/fumes enter air supply? What's in the oils? How often?)
- Proving… (Challenges and developments…)
- Preventing… (Filter, monitor, less toxic oil, crew training, proactive maintenance)
- Time for questions and discussion…

How does oil contaminate supply air?

- Outside air is compressed in the engines.
  - Most used for engine thrust.
  - Some “bled” off the engines and routed to cabin/flight deck.
- Engines/APU sometimes leak oil (maintenance, design, or both); crew/passengers notice smell and maybe smoke/haze/mist/fume in cabin/flight deck



Graphic compliments of Welcome Aboard Toxic Airlines www.welcomeaboardtoxicairlines.com, Produced and Directed by Captain Tristan Loraine

Oil warnings

CHEMICAL NAMES AND SYNONYMS: SYN. HYDROCARBONS AND ADDITIVES
INGREDIENTS CONSIDERED HAZARDOUS TO HEALTH:

Substance Name	Wt%
TRICRESYL PHOSPHATE (1330-78-5)	1-5

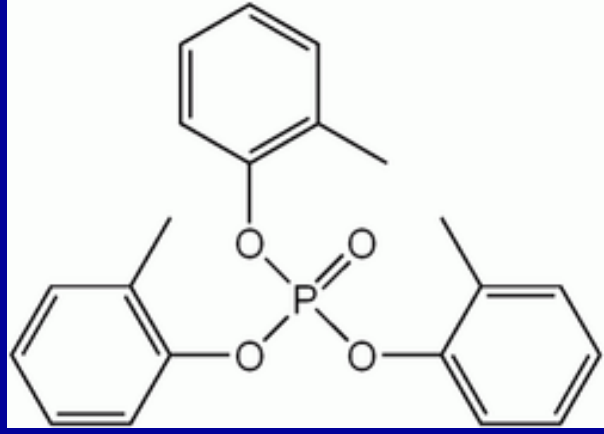
See Section 15 for European Label Information.
See Section 8 for exposure limits (if applicable).

US OSHA HAZARD COMMUNICATION STANDARD: Product assessed in accordance with OSHA 29 CFR 1910.1200 and determined to be hazardous.
EFFECTS OF OVEREXPOSURE: This product is not expected to produce neurotoxic effects under normal conditions of use and with appropriate personal hygiene practices. This product contains Tricresyl phosphate (TCP). Overexposure to TCP by swallowing, prolonged or repeated breathing of oil mist, or prolonged or repeated skin contact may produce nervous system disorders including gastrointestinal disturbances, numbness, muscular cramps, weakness and paralysis. Paralysis may be delayed. Refer to emergency and first aid procedures for additional information.
EMERGENCY RESPONSE DATA: Brown Liquid. DOT ERG No. - NA. SSC: 9

VENTILATION SUPPLY AIR TAKEN OFF ENGINES THAT SOMETIMES LEAK TOXIC OIL.

BUT NOT FILTERED!

Oils toxic?



- Toxic effects of inhaling heated engine oil published in USAF-commissioned paper in 1954 (Treon, 1954)

- Part of toxicity explained by presence of tricresylphosphates (TCPs) - added to all aviation engine oils used on the US fleet

Health impact of exposure to TCPs

- Neurological/psychiatric symptoms may include balance problems, tremors, memory deficits, slurred speech, difficulty finding the right word, mental confusion, profound fatigue, blurred or double vision, depression, anxiety, etc.

- Some symptoms can be delayed by days or weeks post-exposure.

Not “just” exposed to TCPs

	Exxon 2380		
1051	8-Benzylquinoline	973	28748-19-8
	3-Benzylquinoline	970	37045-16-2
	2-naphthylamine, N-phenyl-	958	135-88-6
1275	Phosphoric acid, tris(3-methylphenyl)ester	987	563-04-2
1288	Phosphoric acid, tris(3-methylphenyl)ester	987	563-04-2
1303	Phosphoric acid, tris(3-methylphenyl)ester	984	563-04-2
1318	Phosphoric acid, tris(4-methylphenyl)ester	968	78-32-0
	Phosphoric acid, tris(methylphenyl)ester	966	1330-78-5
1330	1,3-Dioxane, 5-(hexadecyloxy)-2-pentadecyl-,trans-	890	34315-34-9
1379	3,3-dimethyl-5-(2,2-dimethylpropyl)tetrahydrofuran-2-on e	975	0-00-0
1438	Gallium, tetraethyl-di.mu.-1-piperidinyldi-	898	42777-03-7
	Silane derivative	845	56771-62-1
1506	1,8-Dihydroxyanthraquinone	900	7336-68-7
1591	Decanoic acid, 1,2,3-propanetriyl ester	851	621-71-6
1693	Decanoic acid, 1,2,3-propanetriyl ester	824	621-71-6
1809	1,8-Dihydroxyanthraquinone	924	7336-68-7
1958	8-methoxy-2-(p-methoxyphe nyl)-1,2,4,5-tetrahydro-1-benzazocine-3,6-dion e	882	90732-26-6
	Decanoic acid, 1,2,3-propanetriyl ester	827	621-71-6
2133	Naphthalene, 2-(1,1-dimethyl)decahydro-4a-methy l	873	54934-96-2
	4-hydroxyanthraquinone-2-carboxyli c acid, di-TMS	871	0-00-0
2615	Methanone, (4-ethoxy-3-methoxyphenyl)(6-methyl-1,3-benzodioxol-5-yl) -	887	52828-42-9
3639	Octadecanoic acid, 8,9,11,12-tetrakis[trimethylsilyl)oxy]-, methyl estert	843	35437-04-8

- Example: Five TCPs and 17 other chemicals, plus carbon monoxide measured in Exxon 2380 heated to 525°C (van Netten, 2000)

Exposures vary, responses vary

- Fume events can be low-level, transient, occur during routine ops (such as during engine start up) or less-frequent but higher-level and longer-lasting (such as failed oil seal inflight)

- People react differently to fumes based on genetics, gender, medications, diet, whether exposed before, and ??

How often does this happen?

US data, 470 events, 18 months, 47 a/c types

TABLE 3—*Aircraft type listed in documented events (N = 470).*

Airbus 300	6	Bombardier BD700	1	Embraer RJ-145	38
Airbus 310	3	Bombardier CRJ700	1	Embraer RJ-170	2
Airbus 319	8	Bombardier Dash 8	17	Embraer RJ-190	2
Airbus 320	8	Canadair CL600	54	Falcon 2000[a]	2
Airbus 321	4	Canadair CRJ200	2	Gulfstream GV[a]	1
Airbus 330	6	Cessna 402	1	Gulfstream 200[a]	1
ATR-72	2	Cessna 525	2	Hawker 800XP	4
Beech 400[a]	6	Cessna 560	13	McDonnell Douglas MD10	1
Beech 1900	10	Cessna 650	3	McDonnell Douglas MD11	1
Bell 407	1	Cessna 680	1	McDonnell Douglas MD80	42
Boeing 717	1	Cessna 750	26	McDonnell Douglas MD88	18
Boeing 727-200	2	Convair CVAC580	2	Saab 340	3
Boeing 737[b]	29	Douglas DC8	1	Skrsky 576	2
Boeing 747[c]	9	Douglas DC9	53	Not reported	8
Boeing 757[d]	28	Embraer RJ-120	5		
Boeing 767[e]	13	Embraer RJ-135	19	TOTAL	470
Boeing 777-200	7	Embraer RJ-140	1		

[a]Aircraft operated under 14 CFR 135, otherwise operated under 14 CFR 121.

[b]The model was specified for 23 of the 29 B737 aircraft as follows: three B737-300, ten B737-400, two B737-500, two B737-700, four B737-800, and two B737-900.

[c]The model was specified for eight of the nine B747 aircraft as follows: one B747-200 and seven B747-400.

[d]The model was specified for 16 of the 28 B757 aircraft as follows: 16 B757-200.

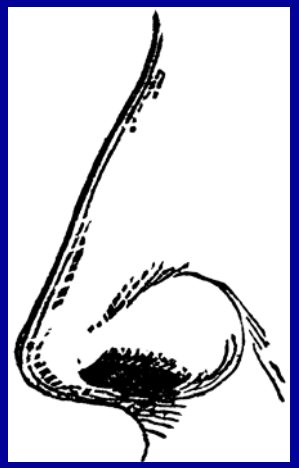
[e]The model was specified for ten of the 13 B767 aircraft as follows: two B767-200, five B767-300, and three B767-400.

Murawski & Supplee, 2008

More ”how often” estimates

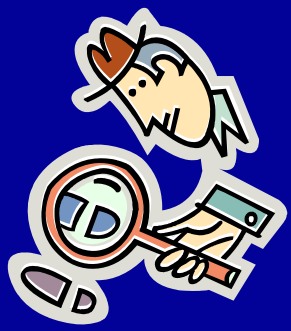
- AFA-CWA documented avg. 7.6 events per 10K flights at one airline over a nine year period (0.2 events/d) (1989-98)
- Boeing cited 738 airline-reported smoke events for MD80/90, DC9s over 7.5 years (0.3 events/day) (2003)
- US NRC committee published range of estimates per aircraft type; even the lowest estimate translates into 2.6 events/day if applied fleet-wide (2002)

Challenges in proving exposure: May not recognize it -



- May see/smell something. May not.
- Odor CAN help to determine source of fumes. But not always the most reliable...
- Example: Fume event on Sept 10; FAs described dirty socks, heated garbage, burned oil; CA described "parmesan cheese gone bad"
- Boeing has acknowledged that BP2197 has "distinct electrical smell"

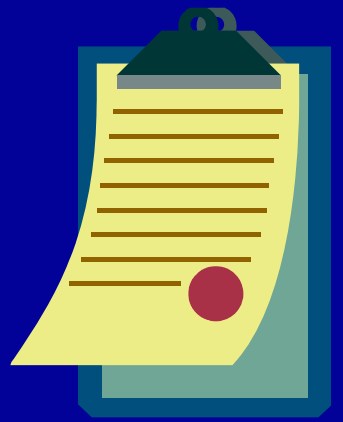
Challenge: Initial symptoms may be mistaken for flu, bad sushi



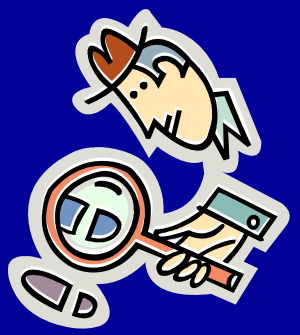
- Exposure to TCPs may initially cause chills, body aches, fatigue (mistaken for flu), stomach cramping (mistaken for food poisoning), etc.

- Exposure to carbon monoxide/oil fumes may cause acute headaches, nausea, disorientation, dizziness, respiratory symptoms, etc.

Challenge: AC mtce. records important, but not accessible



- Pilot must enter any maintenance irregularity in the pilot log book (14 CFR 121.563).



- If pilot logged the problem then maintenance must investigate. Paper trail!
- But crews and passengers have no rights to access aircraft maintenance records.

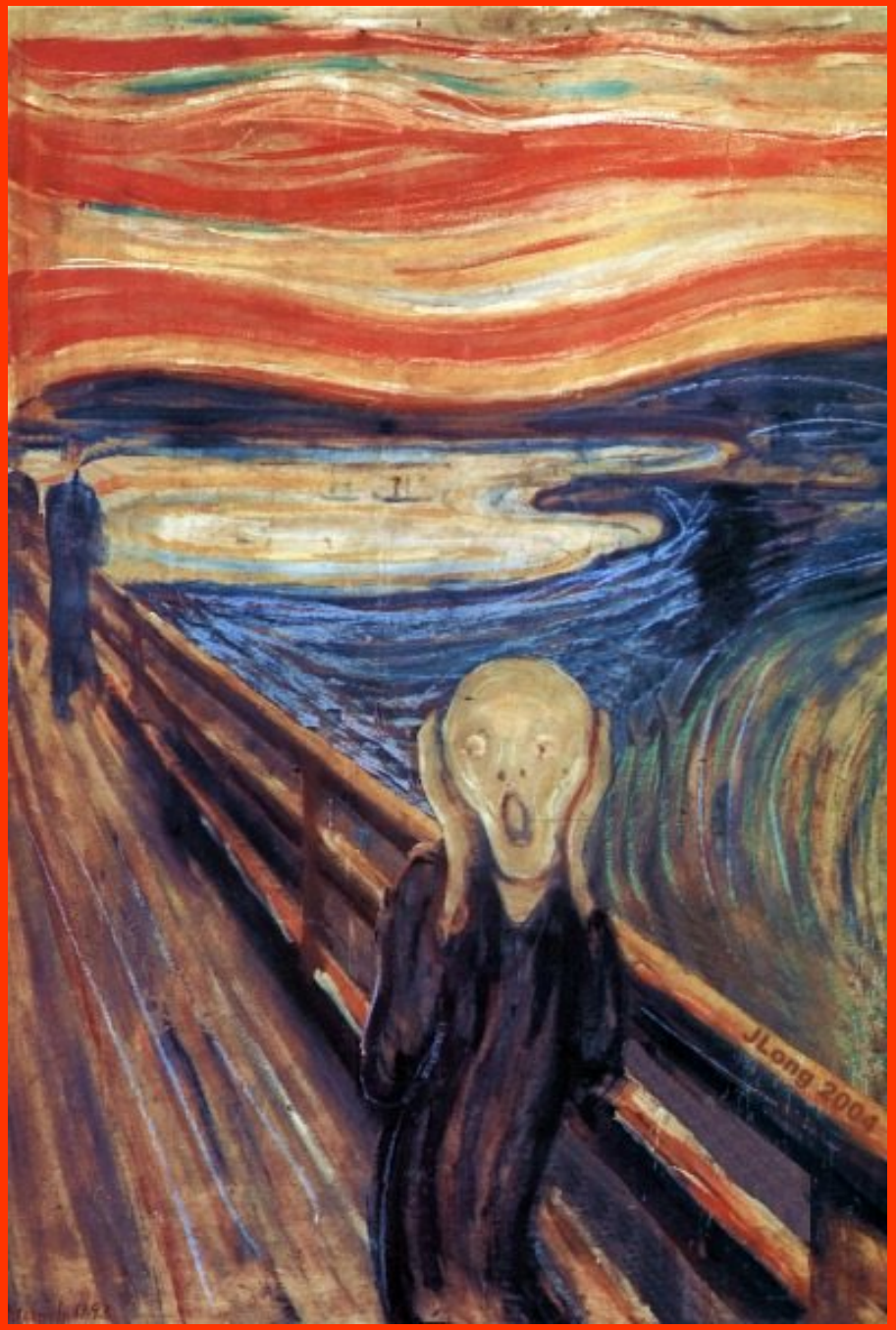
Challenge: No air monitoring data to review

- FAA says can't be exposed to > 50 ppm carbon monoxide, but too high and not monitored anyway (14 CFR 121.219)
- Various recommendations for continuous monitoring (AAIB, 2007; ASHRAE, 2007; NRC, 2002; PCA, 2000) of oil-based contaminants have been ignored

Challenge: Airlines underreport events, despite regulations

- In the US, airlines must report “accumulation of toxic or noxious gases” to FAA (see FARs 121.703, 135.415, 21.3), but...

- Self-policed, and FAA has acknowledged limited airline compliance with fume reporting rules (FSAW 0605-A)


JLong 2004

Developments in proving exposure

- Wipe samples collected in FD and cabin globally have identified TCPs; some published (van Netten, 2005)
- Cranfield University measured low levels of airborne oil and hydraulic fluid on B757 and BAe146 (for DfT, 2008)
- Research professor at University of Washington (US) working to identify three “biomarkers.”

How can we prevent exposure?

- Filter the air before crew/passengers breathe it
- Monitor the air, with flight deck indication
- Use less toxic oils
- Train crews to recognize/respond to fumes
- Implement preventive, proactive maintenance
- Operate non-bleed aircraft!

Does any aviation regulator require these preventive measures to protect crew/pax from exposure to fumes?

Answer: No.

Regulators response to oil fumes
(globally)

FAA recognized flight safety impact of exposure to oil fumes on one aircraft type

Preamble Information
Preamble Information
AGENCY: Federal Aviation Administration, DOT.

ACTION: Final rule.

SUMMARY: This amendment adopts a new airworthiness directive (AD), applicable to all BAE Systems (Operations) Limited Model BAe 146 series airplanes, that requires repetitive detailed inspections of the inside of each air conditioning sound-attenuating duct, and corrective actions as necessary. This action is necessary to prevent impairment of the operational skills and abilities of the flightcrew caused by the inhalation of agents released from oil or oil breakdown products, which could result in reduced controllability of the airplane. This action is intended to address the identified unsafe condition.

Excerpt from Airworthiness Directive 2004-12-05 (FAA, 2004)

But remember: oil fume events reported on all aircraft types

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Murawski & Supplee, 2008

Prevent: Filter/monitor bleed air

- Various technologies have been considered
- At least one air cleaner being marketed for bleed air, but will not remove oil fumes; sensor pictured is for monitoring during ground ops
- Ultimately, market will be limited unless/until airlines required to install and operate them

Prevent: Use less toxic oils

- French oil company (Nyco SA) has developed and tested an additive that is considerably less neurotoxic than TCPs

- New oil meets certification requirements for military aircraft; needs airlines/OEM support to certify for commercial aircraft

Prevent: Train crewmembers

- Recognize flight safety risk and not dispatch a contaminated aircraft
- Identify fume event (odors, symptoms)
- Don oxygen if symptoms, even if no obvious exposure and communicate
- Report and be aware of potential for delayed symptoms

Prevent: Maintain and clean systems

Figure 1 Section of Duct 1

Figure 2 Section of Duct 2

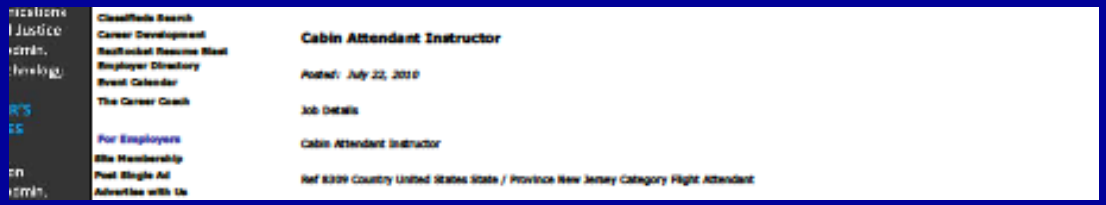
Photos from CAA Paper 2004/04 “Cabin Air Quality.” Page 14, Appendix A to Chapter 2 (Feb 2004)

Money would be well-spent

- Seat belts, oxygen masks, inflatable slides, flame retardants, reinforced flight deck doors – all cost money, all deemed to expensive at some point, all possible, all making aviation safer.

- Can not risk pilot impairment or crew/pax ill health. Crews need to be trained and technology needs to be packaged for bleed air system.

Excerpt from “Cabin Attendant Instructor” job posting on www.jobcircle.com, July 2010



Cabin Attendant Instructor

Posted: July 22, 2010

Job Details

Cabin Attendant Instructor

Ref 8309 Country United States State / Province New Jersey Category Flight Attendant

The employee occasionally works in high, precarious places and in outside weather conditions and is occasionally exposed to wet and/or humid conditions, fumes or airborne particles, toxic or caustic chemicals, extreme cold, extreme heat, risk of electrical shock, risk of radiation and vibration.

Thank you for your attention.

FOR MORE INFORMATION, contact:

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Email: judith@afaseattle.org
Website: http://ashsd.afacwa.org (“health”, “air quality”)