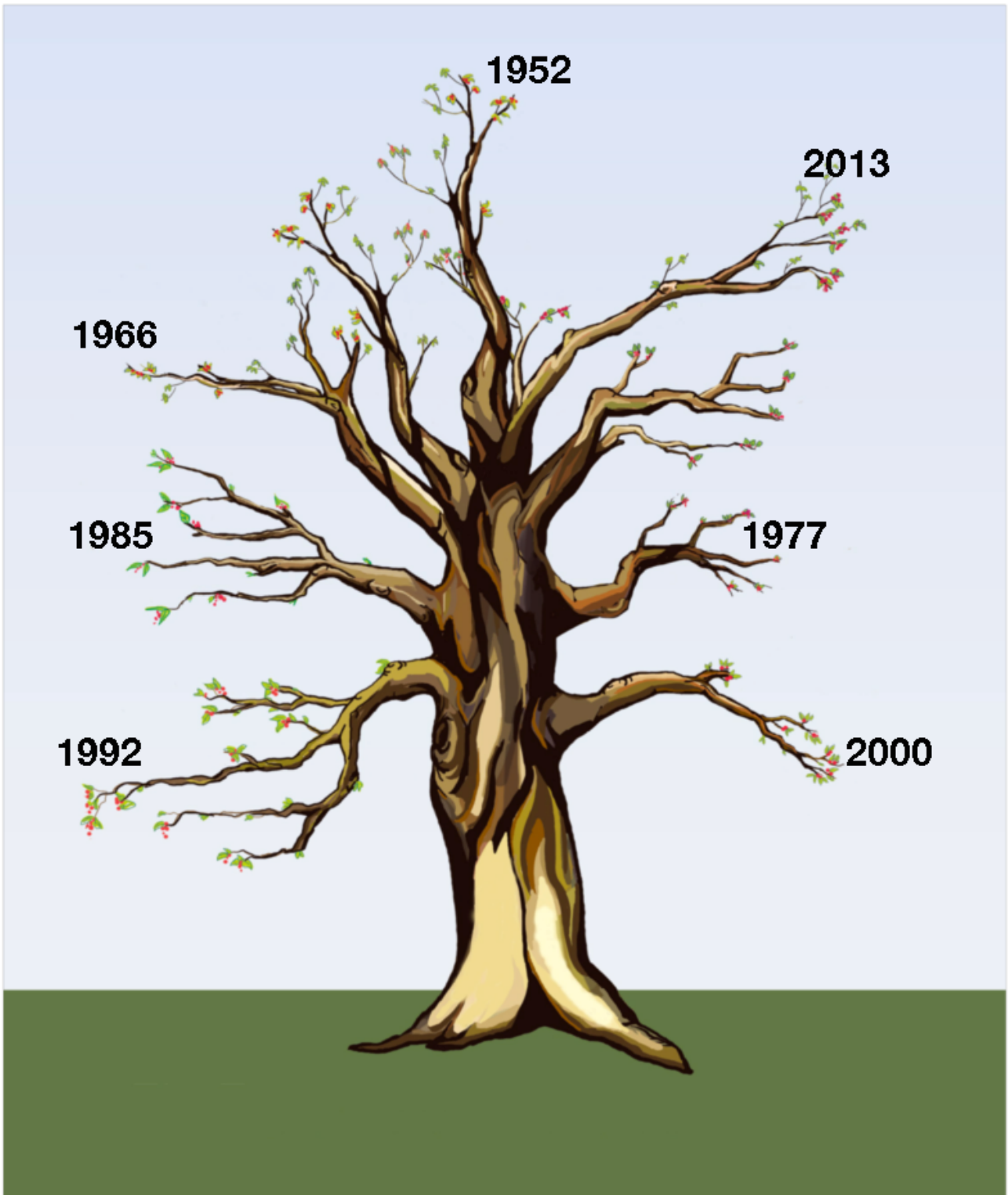


Aircraft Contaminated Air
The acknowledgments and denials.



A chronology of selected key events.

Dr. Susan Michaelis, PhD, ATPL

August 2013

Key acknowledgments.

* comment added by author

| | |
|-----------|---|
| 1930 | TOCP paralyses 10-50 thousand people in prohibition- Ginger Jake syndrome: Further understood 1954, 1959 1961 (<i>refer 2012 University of Washington findings</i>) |
| 1952 | Esso: More powerful turbine engines with higher compression ratios requires oils and bearings able to withstand higher temperatures and better seal compatibility to minimize oil seal leakage |
| 1953 | Boeing: B52 decontamination program - Smoke/odour repeatedly permeates through cabin, clothing, crew - toxic effect unknown |
| 1953 | Aero Medical Association: Pyrolysed engine oils highly toxic causing increased pilot error & hazards |
| 1954 | US Air Force (USAF): Decomposition of highly heated (>260°C) jet engine oils very toxic to breathe- degenerative changes to brain, liver, kidneys & pneumonitis - Further reported by USAF in 1956 that both military & civilian aviation aware of oil fume problems & decomposition products (obnoxious odours) were associated with adverse symptoms including headaches, eye & nasal irritations |
| 1956 | Oil bearing supplier: Oil bearing seals pressurised with air are responsive to variations in engine operating conditions - Zero oil leakage required due to use of bleed air and formation of toxic fumes but difficult to obtain under all engine operating conditions |
| 1960 | UK Military study: Oil heated in closed chamber produced mist containing decomposition substances, causing severe irritation & 'intolerable' symptoms very quickly |
| 1960's | NASA (1969); General Electric (1966); Rolls Royce (1969); Pratt & Whitney (1967)... Bleed air oil leakage- design & operational issue of using bleed air system. |
| 1966 | Douglas Aircraft Corp/ FAA: Future engines and aircraft unlikely to pass military or civilian bleed air purity requirements given hotter temperatures as distinct from the 'rather vague' US FAA regulations that would likely be revised to become more stringent (<i>this has not happened to date</i>) |
| 1966 | Esso: Avoid excessive skin contact and inhalation of mists and vapours of engine oils heated to high temperatures due to varying toxicity of decomposition products |
| 1966 | Douglas Aircraft Corp: Many cases reported of oil leaking into engine compressor which decomposes into extremely noxious and irritating substances; More advanced engines will use higher bleed air extraction temperatures during normal operations well above critical decomposition temperatures of oils; |
| 1969 | Rolls Royce: Primary source of engine oil loss includes loss into breathing air |
| 1973 | Certification standards: MIL E 5007D – oil leakage within the engine shall not cause contamination of the bleed air |
| 1977 | Air National Guard (USA): Inhalation exposure to aerosolized /vaporized jet oils containing complex mixture of organic compounds & TOCP: causes military flight crew incapacitation |
| 1981 | Royal Dutch Shell: Some commercially aviation lubricants are being stressed to the limits of the fluids capabilities: Higher engine temps reduce specific fuel consumption (<i>similar recognition by Mobil in 1985</i>) |
| 1983/1985 | Mobil: Odours from jet oils related to thermal degradation of oils: e.g. oil leaking past seal into compressor – Change of base stock formulation reduces this; can lead to eye, nose, throat irritation – linked to improper design, maintenance or malfunction |
| 1989 | US Navy recommends to ban Exxonturbo oil 2380 & calls for oil base stock research |

| | |
|-----------|---|
| 1990 | Mobil: Reasonable to assume hazard exists by inhalation of mists & vapours of triaryl phosphate esters |
| 1992 | BAe: Filtering system introduced to “mask the rubbish coming from another vendor’s product” |
| 1993 | BAe: Allied Signal agree to pay Ansett & East West Airlines for adverse effects of oil fumes with confidentiality clauses |
| 1994 | Certification standards: MIL-PRF-23699E: Oil shall have no adverse effect on health when used for intended purpose |
| 1995 | USAF: Vaporization of TCP causing changes in compound results in potential neurotoxicity at lower levels |
| 1995 | Allied Signal: (NASA conference) Air Oil Seals Must Be Improved NOW!! |
| 1997 | Ansett to Air BC: sufficient evidence to classify TOCP as definitely neurotoxic to humans, which contradicts the information provided by the oil & engine manufacturers consistently concluding there are no bad effects from TCP in engine oils - until recently the tobacco companies stated smoking not addictive and doesn't cause cancer |
| 1999 | Mobil: TOCP exposure standards not adequately protective for TCP as a whole/ Incorrect assumptions promulgated by US Gov agency OSHA |
| 1999 | Mobil: Oil data sheet (MSDS) lists oil as hazardous in accordance with OSHA (<i>Other MSDSs list harmful effects related to TCP/ exposure to oil decomposition products</i>) |
| 2000 | Australian Senate Inquiry – Recognition of health & flight safety problems on various aircraft types related to contaminated air events (oil fumes) |
| 2001 | BAe: In the past oil fumes have been seen as a nuisance; while studies take place oil fumes must be seen as a potential threat to flight safety, not just a nuisance |
| 2002 | Federal Aviation Administration (FAA) No aircraft is in fact airworthy due to lack of detection systems |
| 2002-2010 | Contaminated air (oils/hydraulic fluids) can enter cabin air & adversely effect air quality – NRC 2002; ASHRAE 2007; EASA 2009; COT 2007 |
| 2003 | Rolls-Royce: Engine oil leakage entering air supply is classified as HAZARDOUS (<i>also UK HOC 1999 x 2</i>) |
| 2003 | FAA: Airworthiness Directive issued to address unsafe condition related to crew impairment from oil fumes exposure leading to reduced controllability of aircraft – design problem |
| 2004 | Techspace Aero, Snecma Group/ Burgmann, Germany: Knife edge seals: High air leakage gives high oil consumption- Reverse pressure gives oil pollution - High oil loss/ pollution in cabin |
| 2004 | Norsk Petroleum Institute: Over 40 years ago TCP toxicity concerns led to 90% of phosphate ester lubricant additives replacing TCP with alternative additives with ‘excellent’ health, safety and environmental properties: Two markets failed to change - Military and aviation |
| 2005 | TCP manufacturer: TCPs used in aviation oils only classified as harmful by EU regulations |
| 2005 | BALPA International Conference: Oils linked to workplace problem- Cabin environment causing crew acute & chronic illness – Concerns raised by BALPA about harm to the unborn |
| 2006 | Swiss Aircraft Accident Investigation Bureau: Oil fumes caused a toxic effect leading to limited capability on the co-pilot |
| 2007 | UK Aircraft Accident Investigation Bureau (AAIB): Recommendations made to FAA & EASA for flight deck warning system for oil smoke/mist should be implemented based on evidence of pilot impairment compromising safety – <i>*(ignored)</i> |
| 2007 | Boeing’s new 787 Dreamliner designed to be bleed free and eliminate oil leaks |
| 2007 | UK Committee of Toxicity (COT) admits 1% of flights report oil fumes. <i>More remain unreported (FAA 2006 & EASA 2012)</i> |
| 2007 | ASHRAE: Recommends oil fume sensors & bleed air cleaning/filtration: Voluntary |

| | |
|------|---|
| | standard/ <i>*(effectively ignored)</i> |
| 2008 | Rolls-Royce: Significant number of engine removals driven by fume events with primary cause related to oil leakage through the front air/oil seals due to inadequate sealing margin |
| 2008 | OHRCA (Occupational Health Research Consortium): FAA funded medical protocol published – Exposure to aircraft bleed air contaminants |
| 2009 | German Government: Inhalation of heated engine oil is not harmless for crew/passengers |
| 2009 | Oil company (NYCO) acknowledges hazards of its oil and commercial TCP & advises of potential harm to the unborn child and infertility <i>*(developing new oil)</i> |
| 2009 | European Aviation Safety Authority (EASA) – vast majority of fume events associated with engine/APU oil leakage <i>(similar from Rolls-Royce 1991)</i> |
| 2010 | Legal Precedent Set in High Court of Australia. Inhaling oil fumes causes harm |
| 2011 | Boeing settles legal case for oil fume exposure out of court |
| 2011 | Rolls Royce “Toxic cabin air is sixth biggest engine problem” |
| 2011 | USAF (Wright Patterson AFB) contacts Dr Susan Michaelis to ask if USAF had ever undertaken any studies on bleed air contamination: Concerns due to F22 raptor incidents & possible connection with bleed air contamination: Advised that original 1954 USAF studies undertaken at WPAFB |
| 2011 | Michaelis PhD: Aircraft contaminated air: 32% of contaminated air events show crew (pilots & cabin crew) impairment; 13% of pilot health survey pilots retired with chronic ill health associated to cabin air environment- rate of permanent ill health/loss of pilot medical certification 37-433% higher than other military & civilian loss of medical certification; engineering/design & operational problem explains frequency of lower level fume events |
| 2011 | Liyasova, Furlong, Lockridge, et al. (2011). Exposure to tri-o-cresyl phosphate detected in jet airplane passengers. Toxicology and Applied Pharmacology, 256 (3); 337-347 |
| 2012 | European Cockpit Association (ECA): Design of engines using bleed air systems allows oil fumes to enter the air supply & can cause short-term effects & compromise flight safety |
| 2012 | BFU: German Air Accident Bureau report reports TOCP found in pilots blood after incapacitation & report of strong fumes in flight deck. |
| 2012 | University of Washington: Confirms Triaryl Phosphsate (including TCP & Durad 125, the commercial aviation TCP formulation) exposure inhibits enzymes changing their functionality; <i>*(shows TCP as a whole & other isomers previously & continuing to be considered safe by the aviation industry, are not so)</i> (Chemico-Biological Interactions. Volume 203, Issue 1, 25 March 2013, Pages 257–264) |
| 2013 | International Federation of Air Pilots (IFALPA): fume event causing cabin air contamination can cause short-term physical effects which compromise flight safety. |
| 2013 | ExxonMobil: Exposure limits for decomposition product of synthetic jet engine oils not established by ACGIH/OSHA |
| 2013 | Most recent statement from the UK House Of Lords that there is no requirement to inform passengers |
| 2013 | EU classification (CLP) regulations: Oil substances fall under numerous hazard classifications: nervous system toxicity; harmful if swallowed/dermal; may damage fertility & the unborn child; eye/skin irritant, skin sensitizer; very toxic if inhaled; germ cell mutagenicity; irritating to respiratory system |
| 2013 | Duke University: possible development of neuronal injury in flight crew members exposed to cabin air emissions containing organophosphates; increased circulating serum autoantibodies resulting from neuronal damage may be used as biomarkers for chemical-induced CNS injury. (Journal of Toxicology and Environmental Health, Part A Vol. 76, Iss. 6, 2013) |

Key denials.

| | |
|-----------|---|
| 1998 | Ansett: Short-term symptoms associated with reported odours on the BAe 146 and other aircraft types are substantiated. Long-term symptoms are denied <i>*(similar globally within the industry)</i> – BAe 146 odour Inquiry committee: (1991-1998) |
| 2000 | BAE: There is no doubt that there is a general health issue with weight of human evidence & suffering but it is a health and safety issue, not a safety issue |
| 2000 | Mobil: Exposure to oil vapors and aerosols in aircraft cabins are not normal use, but neurotoxicity should not pose a hazard under realistic exposure conditions (<i>Exxon 1996</i>) |
| 2000 | House of Lords (HOL): “ TOCP exposure is unsubstantiated (<i>based upon London Poisons Unit evidence that data was not being collected; *(Henschler 1958 –Term ‘TOCP poisoning should no longer be used)</i> - Airlines should monitor air to ‘refute’ common allegations of poor cabin air quality (<i>led to the industry air monitoring studies & investigations</i>) |
| 2000 | BAe: Modification introduced on BAe 146 aircraft so that oil fumes occur now at industry standard levels |
| 2000 | CAA (UK): Contaminated air events only make an aircraft unairworthy if aircraft precluded from safe flight & landing & events leading to discomfort are not considered a failure of ventilation airworthiness regulations JAR 25.831 (2004) – <i>*(2 legal opinions obtained by BALPA disagreed with this with similar view held by EASA)</i> |
| 2002 | National Research Council (NRC, USA): oil and hydraulic fumes can leak into cabin air supply adversely affecting the cabin air; symptoms too diverse to accept term ‘Aerotoxic Syndrome’ |
| 2003 | British Airways (Dr M Bagshaw, CMO): TCP only harmful if swallowed in large enough quantity but not harmful if absorbed by the skin or inhaled |
| 2004 | UK Civil Aviation Authority (CAA)/DERA/DSTL: Pyrolysis products of leakage can enter cabin air supply exerting toxic effect on crew, passengers; oil leakage most likely cause of incidents, with no weight of evidence otherwise found- Accept irritant effects, deny toxicity related to oils |
| 2004 | ExxonMobil: oil MSDS citation issued by OSHA (fine \$1700USD) - cancelled 2005 |
| 2005 | Rolls-Royce: Bleed air quality on Rolls-Royce engines assessed at engine certification and while in service; correctly maintained and operated engines comply with all certification requirements |
| 2005 | UK HOL: No statutory requirements to fit air quality monitoring systems – Ventilation systems are designed to supply air of suitable standard which is confirmed at initial certification and during scheduled maintenance. Air quality studies confirm suitability of the air. <i>*(EASA & FAR certification standard1309c requires warning system for any potential unsafe condition)</i> |
| 2007 | Committee of Toxicity (COT) – No causal association between cabin air exposures and ill health in aircraft crews: temporal relationship between exposure reports and acute health symptoms suggest an association is plausible |
| 2007-2013 | CAA/HSE (UK): HSWA (1974) & COSHH apply to aircraft cabin, however is not enforced in cabin due to MOU (memorandum of Understanding) between HSE & CAA: <ul style="list-style-type: none"> • CAA takes lead on matters of aircraft safety including cabin • HSE gives ‘lesser priority’ to aircraft cabin environment– defers enforcement to CAA under Working time regulations (2004) • CAA responsible for OH&S for crew under CAA working time regulations (2004) and for all persons on board under CAA Act 1982 • CAA does not enforce COSHH, HSWA 1974 • CAA: COSHH of little relevance & relying on COT to determine level of risk • <i>*(= HSWA & COSHH not applied to aircraft cabin (crew or passengers) with</i> |

| | <i>CAA relying upon industry studies to determine risk)</i> |
|-----------|---|
| 2007 | DHL/CAA: No need to report fumes that are not unusual and 'normal' at low concentration after start, taxi, take-off, climb & descent & landing <i>*(similar statements from UK Government Cranfield study, EASA & others, yet oil/noxious fumes under EU Directive must be reported)</i> |
| 2008/2011 | Theresa Villiers MP (UK) – Opposition- Shadow Secretary for Transport 2008: Press release: 'The Government's dithering on air cabin quality, with secret studies behind closed doors, has put airline crews and passengers at risk. 'There must now be a full public enquiry to ensure the air we breathe in aeroplanes is truly safe. Another hushed up internal review will not be acceptable.' Minister of State for Transport (2010-2012) 'main conclusion of Cranfield's research was that there was no evidence of pollutants occurring in cabin air at levels exceeding available health and safety standards and guidelines. Levels observed in the flights that formed part of the study were comparable to those typically experienced in domestic settings... The department will always take the health of persons on board aircraft very seriously and I hope the publication of this thorough and independent analysis by Cranfield University will provide reassurance on this issue.' |
| 2009 | British Airways: No need to carry out risk assessments as studies had shown no evidence that toxic chemicals or hazardous substances were present |
| 2009 | FAA: Remains interested in enhancing aircraft air quality; Waiting for results of ASHRAE studies & FAA funded Air Cabin Environment Research (ACER) studies |
| 2010 | Airbus: Airbus are designed to avoid contaminated cabin air in normal operating conditions |
| 2010 | Boeing: Air quality studies over the years have shown contaminants are generally low, however continue to work with scientists to improve understanding of the cabin air environment; bleed air contamination events are very low and minimized with proper airline maintenance. Do not agree that bleed air filtration or sensors are required |
| 2010 | BP: oils meet all applicable standards when used in applications for which designed, developed & approved; |
| 2010 | ICAO: ICAO believes that its limited resources should be directed at monitoring the work being undertaken by the states & when EASA work is complete, it may be necessary to revisit the subject |
| 2010 | Aerospace Medical Association (AsMA) – has been concerned about cabin air quality for many years; closely following research (e.g. Cranfield study) hoping studies will provide the scientific evidence needed to understand any associated health issues |
| 2011 | Cranfield Study: No evidence for target pollutants occurring in the cabin air at levels exceeding available health and safety standards and guidelines. <i>(*despite TCP in 23% of flights - Many organizations deny harm based on contaminants being found at levels below established exposure standards/safe levels, despite standards where they exist not being applicable above ~5000 ft.</i> <ul style="list-style-type: none"> • <i>ACGIH- Exposure standards not protective >5000ft</i> • <i>HOL 2005: No exposure standards exist for oils in fume event</i> • <i>Mobil 2013: No exposure standards for synthetic jet oils)</i> |
| 2012 | EASA: Causal relationship between the health symptoms reported and oil/hydraulic fluid contamination has not been established. As there is no conclusive scientific evidence available, EASA is not able to justify a rulemaking task to change the existing designs or Certification Specifications. <ul style="list-style-type: none"> • Events involving impairment/incapacitation are rare & not under-reported – dense visible fumes or toxic fumes sufficient to incapacitate crew or passengers must be reported. Occasional minor events/ bad smells (1 every 10,000 flights) are a nuisance and are possibly under-reported – no accidents with cabin air as root cause <i>*(EU Directive 2003/42/EC requires</i> |

| | <i>fumes/oil leaks to be reported... not just incapacitation)</i> |
|-----------|--|
| 2012 | BRE (UK): BRE Cabin Air Workshop - no causative association between fume events & short or long term nerve damage; reported symptoms consistent with hyperventilation <i>*(industry partners only & BALPA)</i> |
| 2012 | Professor Michael Bagshaw: Perceived oil fume events consistent with hyperventilation; many of the acute symptoms are normal symptoms experienced by most people frequently; some 70% of the population experience one or more of them on any given day. |
| 2012 | UK Dept of Transport (DfT): Various studies undertaken: Various studies... have shown that normally the levels of chemical and biological contaminants in aircraft are less than in many work environments such as office buildings... https://www.gov.uk/government/publications/cabin-air-quality-faq |
| 2012 | UK DfT sponsored Institute of Occupational medicine (IOM) surface residue study: Organophosphate found - estimated concentrations were low and comparable to those found in other research studies considering airborne cabin contaminants. <i>*(TCP found in numerous samples)</i> |
| 2012 | The Australian Aviation Regulator CASA (EPAAQ- Expert Panel on Aircraft Air Quality) Defined the issue as "Aircraft Related Illness"; accepted irritant symptoms related to oil fumes, yet neurological/cognitive & toxic effects were put down to hyperventilation & symptoms 70% of the population get on any given day |
| 2013 | ExxonMobil: Global industry committees and government agency cabin air studies have found no link between oil fumes in aircraft and ill health <i>*(similar by BP and many others- inhalation studies of heated oils not done)</i> ; ingestion animal studies conclude no neurotoxic hazard under realistic conditions of exposure including dermal and inhalation exposure |
| 2013 | BALPA Fumes cause hyperventilation but generally not harm; don't know if there are substances in cabin which cause harm to health |
| 2013 | BALPA (Prof M Bagshaw): TCP found below the TOCP workplace exposure limit (valid to 8000ft); Aerotoxic Syndrome is not recognized in aviation medicine; hyperventilation offers a plausible explanation for some "well publicized events"; don't know if there are substances in cabin air which cause harm. |
| 2013 | EU cabin air quality draft standards developed by ASD-STAN (Aerospace and Defense Industries Association of Europe–Standardization) for CEN (European Committee for Standardization) under public enquiry review in all member states; Standards developed by professional trade organizations under leadership of BRE (UK) – Oil is ignored & all unions involved recommended no vote under CEN except BALPA which voted with industry (projects undertaken as part of the ASD-STAN standards took place in 2003-2009 with funding split between industry & EU. |
| 2012/2013 | SAE: Cabin air quality standard development: Recognition that previous air standards (including EU ASD_STAN) failed to address heated mixture of engine oils in aircraft cabin environment or address toxicological issues – Standard canceled by Industry manufacturers in April 2013 |
| 2013 | Inspectie Leefomgeving en Transport (ILT), Holland (aviation regulator): No idea at what dosage TCP causes harm, TCP does not cause a flight safety problem (as does not incapacitate crew) <i>*(total focus on TCP only which is common practice but wrong)</i> KLM –no proof toxins making people ill, will not measure toxins/not relevant |

KEY recent actions to highlight/ Inhibit contaminated air issue

| HIGHLIGHT | INHIBIT |
|--|---|
| 2000: Australian cabin air conference: UNSW/ADFA | 2000: House of Lords Inquiry (UK) |
| 1999-2000: Australian Senate Inquiry | 2002: NRC Inquiry (USA) |
| 2005: BALPA International conference | 2007: House of Lords Inquiry (UK) |
| 2006: Global Cabin Air Quality Executive (GCAQE) – established drawing together unions & consumer groups globally addressing cabin air contamination | 2007: Committee of Toxicity (UK) |
| 2007: ASHRAE cabin air standard | 2007-2013: BALPA cabin air position |
| 2007: Formation of the Aerotoxic Association | 2011: DfT sponsored Cranfield University Study (UK) |
| 2008: OHRCA (USA)- Medical protocol | 2003-2012: FAA funded ACER research \$18million USD, 66 grants (ongoing) |
| 2010: Susan Michaelis- PhD completed, UNSW, Australia | 2012: CASA EPAAQ (Australia) - Cabin air Inquiry |
| 2012: International Transport Federation (ITF) – Cabin air quality campaign | 2012: DfT sponsored Institute of Occupational Medicine Study (UK) |
| 2012: European Cockpit Association – Position statement - oil fumes are a flight safety problem | 1999-2012: Various ASHRAE studies |
| 2012 – Countess of Mar submits complaint to Head of UK Civil Service | 2012: BRE cabin air quality workshop |
| 2013: IFALPA - briefing Leaflet, Cabin Air Quality – Oil fumes are a flight safety problem | 2012: EASA- Decision No 2012/001/R, Advance Notice Of Proposed Amendment (A-NPA) No 2009-10 |
| 2007-2011: 3 x Documentaries - Welcome Aboard Toxic Airlines (2007); Angle Without Wings (2011); Broken Wings (2011) - Fact Not Fiction Films | 2003-2013: ASD-STAN (Europe) - cabin air quality standards & related studies (CabinAir, HEACE, FACE, ICE – 56million euros) |
| 2014: Feature Film: A Dark Reflection – Fact Not Fiction Films | 2003-present: FAA funded ACER research (USA) |
| | 2012-2013: SAE cabin & bleed air standards (USA) |