### SUMMARY

<table>
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<tr>
<th>Inquiry</th>
<th>UK</th>
<th>EU</th>
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<td>Inquiries</td>
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<td>Standards</td>
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<td>Public Law</td>
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<td>Research/Investigation</td>
<td>7</td>
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<tr>
<td>Total</td>
<td>10</td>
<td>15</td>
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</table>

No full/part resolution on cabin air contamination issue = 99

#### TOTAL = 100

### LEGEND

- X: action has not resolved problem or led to clear path to resolution (applies to entire box)

### YEAR | UK | EUROPE | USA | Australia
---|---|---|---|---

#### 2000/2001

  - "Passengers’ perception of general cabin air quality is one of the key factors in their assessment of the flight experience as a whole. We recommend that airlines collect, record and use at least some of the basic cabin environment data being continuously monitored, not only to give authoritative substance to their refutation of the common allegations, but also to provide a better basis for public confidence in these matters."

- **US National Research Council - The airiner Cabin Environment and Health of Passengers and Crew - 2001**: "FAA should rigorously demonstrate in public reports the adequacy of the current and proposed FARs related to cabin air quality and should provide quantitative evidence and rationales to support sections of the FARs that establish air quality-related design and operational standards for aircraft (standards for CO, CO2, O3, ventilation, cabin pressure). If a specific standard is found to be inadequate to protect the health and ensure the comfort of passengers and crew, FAA should revise it. For ventilation, the committee recommends that an operational standard consistent with the design standard be established."

- **Australian Parliamentary Senate Inquiry - Air Safety and Cabin Air Quality in the Bae 146 aircraft - October 2000**: Recommendation 3: Development of appropriate and accurate test for presence of chemical fumes during fume events; Recommendation 4: That the issue of cabin air quality be reviewed by the National Occupational Health and Safety Commission with a view to including aerotoxic syndrome in appropriate codes. Recommendation 5: The Committee recommends National Health and Medical Research Council to set up and undertake an appropriate research program on the effect of exposure to aircraft cabin air on air crew and passengers. Recommendation 7: Review of the use of MIO2

#### 2001

- **X FAA- Aviation Rulemaking Advisory Committee (ARAC); Transport Airplane and Engine Issues- Part 1: Ventilation--Heating and Humidity (Sec. 25.833(j)); (temperature)**
- **X ARAC review following NRC report was delayed until after Battelle/ASHRAE study completed (2007), but still not undertaken as of 2014**

- **X HEACE-Health Effects in Aircraft Cabin Environment- HEACE**: Project funding: 4.9 mill euros 2001-2005

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<tr>
<th>Year</th>
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<tr>
<td>2002</td>
<td>X FACE-Friendly aircraft cabin environment Project Funding:34 mill euros 2002-2007</td>
</tr>
<tr>
<td>2004</td>
<td>X EU Draft standard- pr EN 4618- Aircraft internal air quality standards, criteria and determination methods published 2009 Withdrawn 2013</td>
</tr>
</tbody>
</table>
2005
Committee of Toxicity: The Cabin Air Environment, Ill Health in Aircraft Cabins and the Possible Relationship to Smoke/Fumes Events in Aircraft. 2005-2007 (ongoing review to present day)

FAA: Aircraft recirculation filter research. Incident assessment - Kansas State University, Eckels, FAA grant - $140,928; FAA: Reduced partial pressure on commercial aircraft - Harvard University, Spengler, FAA grant - $293,807; FAA: Centre of Excellence for Airliner Cabin Environment ACER 3rd yr management & strategic plan, Auburn University, Gale, FAA grant - $336,224; FAA: Incident monitoring & reporting, Harvard University, Spengler, FAA grant - $657,405; FAA: Reduced partial pressure on commercial aircraft - Harvard University, Spengler, FAA grant - $293,807; FAA: ACER Decontamination tasks 23/yr 2 management, Auburn University, Gale, FAA grant - $3,980,289; FAA: In-flight sensor system development & deployment, Boise State University, Loo, FAA grant - $50,618; FAA: In-flight onboard monitoring, ACER's Component for ASHRAE 1261, Part II, Harvard University, Spengler, FAA grant - $524,021

2006
FAA: Aircraft recirculation filter research incident assessment - Kansas state University, Eckels, FAA grant - $150,000

2007

FAA: Incident Monitoring & reporting, Harvard University, J Spengler, FAA grant - $117,111; FAA: Pressure on airline passengers, Harvard University, J Spengler, FAA grant - $174,101; FAA: In-flight sensor system development & deployment, Boise State University, Loo, FAA grant - $50,618; FAA: In-flight onboard monitoring, ACER's Component for ASHRAE 1261, Part II, Harvard University, Spengler, FAA grant - $524,021

2007


2008
FAA: In-Flight Project, Task 4, Kansas State University, B. Jones, FAA grant - $40,000; FAA: Air Contamination Measurement Methods, Kansas State University, B. Jones, FAA grant - $75,000; FAA: Onboard Measurements, Harvard University, Spengler, FAA grant - $180,000; FAA: Effects of Partial Pressure on Airline Passengers, Harvard University, Spengler, FAA grant - $72,362

http://www.faa.gov/about/office_org/headquarters_offices/ang/offices/management/coe/grant_awards/

2009
EU Draft standard- pr EN 4666- Aircraft integrated air quality and pressure standards, criteria and determination methods Withdrawn 2013


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<tr>
<td>2009</td>
<td>Oil Smells in Aircraft Cockpits: Findings of Statistical Analysis into Associated Parameters. In House Analytical Consultancy Department for Transport &amp; Professor Helen Muir, School of Engineering, Cranfield University.</td>
</tr>
<tr>
<td>2009</td>
<td>X ISPACE-Innovative systems for personalised aircraft cabin environment 2.9 mill euros 2009-2012</td>
</tr>
<tr>
<td>2010</td>
<td>X FAA - Sensors and Prognostics to Mitigate Bleed Air Contamination Events - FAA Grant No. 07-C-RITE-BSU-002, Boise State University 2010- $153,367; FAA - In-Flight Sensor System and Database Deployment - FAA Grant No. 07-C-RITE-BSU-003, Boise State University 2010- $70,327; FAA - Sensors and Prognostics to Mitigate Bleed Air Contamination Events - FAA Grant No. 07-C-RITE-BSU-004, Boise State University 2010- $92,220</td>
</tr>
</tbody>
</table>
2011  

**K Cranfield/ Crump D. (2011) Aircraft Cabin Air Sampling Study; Final report: Institute of Environmental Health, Cranfield University, 2011**

- Solbu K- National Institute of Occupational Health, Norway

**X FAA - Sensors and Prognostics to Mitigate Bleed Air Contamination Events - FAA Grant No. 10-C-RITE-BSU-003. S. Ming Loo, Boise State Univ., 2012-$100,009;**
- FAA - Research in the Intermodal Transport Environment (RITE)-Sensors and Prognostics to Mitigate Bleed Air Contamination Events - FAA Grant No. 10-C-RITE-AU-003. R. Overfelt, Auburn University 2012-$388,484;
- FAA - Sensors and Prognostics to Mitigate Bleed Air Contamination Events - FAA Grant No.10-C-RITE-KSU-006. B. Jones, Kansas State Univ. 2012-$198,221;
- FAA - In-Flight Sensor System and Database Deployment - FAA Grant No.10-C-RITE-BSU-004. S. Ming Loo, Boise State Univ, 2012-$118,892;
- FAA - Development of a Plan for a study of Bleed Air Quality in Aircraft Cabins - FAA Grant No.10-C-RITE-KSU-008. B. Jones, Kansas State University, 2012-$116,432;

2011

**X National Aeronautics and Space Administration (NASA)**

- Vehicle Integrated Propulsion Research (VIPR)
- VIPR 1- 2011
- VIPR II 2013
- VIPR III TBD
- VIPR partners include NASA, Air Force, Pratt & Whitney and a growing list of other government agencies (ACER/FAA) and industry partners
- VIPR test approach
  - A series of on wing engine ground tests
  - Includes "nominal" and "faulted" engine operating scenarios
  - Technologies under evaluation include advanced EHM sensors and algorithms

2012

**X FAA Modernization and Reform Act of 2012 - H.R. 658 – Section 320 - FINAL 2012 (Enrolled Bill [Final as Passed Both House and Senate]) - ENR**

- SEC. 320. STUDY OF AIR QUALITY IN AIRCRAFT CABINS (a) IN GENERAL.—Not later than 1 year after the date of enactment of this Act, the Administrator of the Federal Aviation Administration shall initiate a study of air quality in aircraft cabins to—
  1. assess bleed air quality on the full range of commercial aircraft operating in the United States;
  2. identify oil-based contaminants, hydraulic fluid toxins, and other air toxins that appear in cabin air and measure the quantity and prevalence, or absence, of those toxins through a comprehensive sampling program;
  3. determine the specific amount and duration of toxic fumes present in aircraft cabins that constitutes a health risk to passengers;
  4. develop a systematic reporting standard for smoke and fume events in aircraft cabins; and
  5. identify the potential health risks to individuals exposed to toxic fumes during flight.
### 2012


Continued:

| 2012 | X EU MAC 3 - EU Framework 7 initiative
An industry-led consortium of 15 organizations from airframe manufacturers, airlines, suppliers, research institutes and standards development bodies proposed a comprehensive initiative to address the issue of bleed air contamination for aircraft flying in Europe. Project unfunded |
| --- | |

**X 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.

(b) TECHNOLOGY REQUIREMENTS.—The technology referred to in subsection (a) shall have the capacity, at a minimum—

1. to remove oil-based contaminants from the bleed air supplied to the passenger cabin and flight deck; and

2. to detect and record oil-based contaminants in the portion of the total air supplied to the passenger cabin and flight deck from bleed air.

(c) REPORT.—Not later than 1 year after the date of enactment of this Act, the Administrator shall submit to the Committee on Commerce, Science, and Transportation of the Senate and the Committee on Transportation and Infrastructure and the Committee on Science, Space, and Technology of the House of Representatives a report on the results of the research and development work carried out under this section.

http://www.faa.gov/about/office_org/headquarters_offices/agi/reports/media/Report_to_Congress_on_Engine_and_APU_Bleed_Air_Supplied_on_Pressurized_Aircraft.pdf

### 2012

**X FAA/ACER - In-Flight/Onboard Monitoring: ACER’s Component for ASHRAE 1262, Part 2**
Harvard University, Battelle, FAA Grant no. 07-C-RITE-HU Final Report, 2005-2010 Report, April 2012

### 2012


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**2013 EU MAC 3** see above 2012 unfunded study & ACER proposal 2013
Includes 4 work packages
WP 1- sensor technology
WP 2- ground procedures for bleed-air testing of aero-engines/APUs
WP 3- in-flight measurement research to help establish the current air quality and the extent of the bleed air contamination problem in commercial passenger aircraft through WP4- draft performance specifications and guidelines for European and International Standards and testing procedures – with involvement of relevant stakeholders outside of the MAC 3 consortium. Including toxicological evaluation of detected compounds.

**Unfunded as of June 2014 but understood to be resubmitted via Horizon 2020 funding**

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X SAE STANDARDS

SAE ARP 1796 - Engine bleed air systems for aircraft-Aerospace Recommended practice- standard
SAE AIR 1168/7A - Aerospace pressurization system design - Aerospace Information Report- standard
SAE AIR 1116B - Fluid properties - Aerospace Information Report- standard
SAE ARP 4418A/B - Procedure for sampling & measurement of engine generated contaminants in bleed air supplies from aircraft engines - Aerospace Recommended practice- standard
SAE AIR 1539 A/B - Environmental control system contamination -Aerospace Information Report- standard
SAE AIR 4766 - Air quality for commercial aircraft cabins-Aerospace Information Report- standard
SAE AIR 4766/1 - Air Quality for Commercial Aircraft Cabin Particulate Contaminants - Aerospace Information Report- standard
SAE AIR 4766/2 - Airborne chemicals in aircraft cabins - Aerospace Information Report- standard

SAE Cont....
SAE AS 6263- Bleed air contamination limits for safety, health and comfort of aircraft occupants- WIP/ cancelled
SAE ARP85F - Air conditioning systems for subsonic planes - Aerospace Recommended practice- standard
SAE 5780A - Specification for Aero & Aero derived gas turbine engine lubricants - Specification/ standard
<table>
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<tr>
<th>DATE</th>
<th>REPORT</th>
<th>FINDINGS</th>
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<tbody>
<tr>
<td>1952</td>
<td>Johnson R., Swickert M. A. et al. (1952) National Advisory Committee for Aeronautics. Technical Note 2846. Effective Lubrication Range for Steel Surfaces Boundary Lubricated at High Sliding Velocities by Various Classes of Synthetic Fluids. December 1952</td>
<td>Higher operating temperatures with newer engines require the use of synthetic oils with &quot;speculation about probable toxicity and corrosiveness at elevated temperatures; these properties have not yet been adequately studied... The phosphate esters as well as certain phosphate esters maybe useful in future lubricant problems.&quot;</td>
</tr>
<tr>
<td>1953</td>
<td>Boeing Airplane Company - Decontamination program: BS2</td>
<td>&quot;The observations of the flight crews constitute the first evidence of the existence of the problem. They have repeatedly reported presence of smoke and odor in the occupied compartments of the airplane...... The possible toxic effect of the contamination is still unknown.&quot;</td>
</tr>
<tr>
<td>1953</td>
<td>Stovell W., Boysen J. I. et al. (1953) Aviation Toxicology: An Introduction to the Subject and a Handbook of Data. Committee on Aviation Toxicology, Aero Medical Association. The Blakiston Company. N.Y. 1953</td>
<td>&quot;oil can contain irritant and toxic aldehydes and other dangerously toxic products of incomplete combustion... Even a small degree of bodily impairment from toxic gases would lead to increased pilot error and so be hazardous in aviation.&quot;</td>
</tr>
</tbody>
</table>
| 1954 | Douglas Aircraft Company (1954) Engine compressor bleed air contamination study XC-132 project. Report No. SM 15195. R. Waddock, 15 January, 1954 | "The basis of any purification program should be to establish, with certainty, that everything that can be done to avoid contaminating the air has been done......In general it is felt that much more could be done to reduce the contamination at its source."
"it was emphasized that only a small quantity, as low as 3ppm was sufficient to cause intense eye irritation and stomach trouble or nausea, in a matter of minutes. It was also noted that the contamination did not appear to affect everyone to the same degree..."
"the temperature at which cracking (of the oil) starts to take place is between 650 & 700 degf. The rate of thermal decomposition is found to rapidly increase with temperature." |
| 1954 | Treon JF., Cappel JW. et al. (1955) The Toxicity of the Products Formed by the Thermal Decomposition of Certain Organic Substances. American Industrial Hygiene Association Quarterly. 16: 3, 187-195, 1955 | "Both the military services and industry have become increasingly cognizant of the need for toxicological information concerning the products formed from organic substances on contact with metals at elevated temperatures"
"The products of thermal decomposition have been more toxic than the vapors or mists of the undecomposed material." The toxicity of the products arising from the thermal decomposition of a formulated synthetic lubricant is largely from the breakdown of the lubricant base stock. Mistls formed at 400-550 degf were much less toxic than those formed at 700 degf.
"These fogs produced pneumonitis, and degenerative changes of the brain, liver and kidneys."
"In the case of the esters and the hydrocarbon, aldehydes, carbonyle, carbon mono oxide and undecomposed particulate matter were found in the atmosphere of the chamber. In the case of the tricresyl phosphate, free cresols, undecomposed tricresyl phosphate and carbon mono oxide were found."
Refer original report - Treon JF., Cleveland F. et al. (1954) Toxicity Of Certain Lubricants, Engine Oils, and Certain of their Constituents, with Particular Reference to the Products of their Thermal Decomposition. WADC TR 54-344. Corporate Author: Kettering Laboratory, University of Cincinnati. Aero Medical Laboratory Contract No. AF33(608)-26456. RDO No. 698-31, Wright Air Development Center, Air Research And Development Command, United States Air Force - Wright-Patterson Air Force Base, Ohio. 1 November 1954 |
| 1955 | Lusis M T (1955) Cabin Air Contamination in RBS7A Aircraft. Special Report: MSLR No 61. Chemical Corps Medical Laboratories, Army Chemical Center, Maryland. February 1955 | "The results of experiments ( conducted at the engine test facility demonstrated that no significant illness or impaired physiological or psychological function would result in the human subject from breathing the engine air......Under the several conditions of this study, the normal engine air of the RB-57A aircraft was found to be safe for human use. The air contains a definite odour but no visible smoke... Smoke does not appear in the cabin until amounts of the lubricant greater than that necessary to produce illness are present. The earliest signs of excessive lubricant, or its breakdown products in the air are eye, nasal and pharyngeal irritations. Longer exposure results in nausea and 'tightness in the chest.'" The fact that one subject did develop nausea and lightheadedness is well within the possibility of accidental or coincidental occurrence of such illness in any group of this size. Headache also occurred in an insignificant number of subjects. Furthermore, repeated exposure of one of the authors for sixty to eighty minute periods for seven nearly consecutive exposures (four exposures daily for four days then with no exposure, then two days with exposure, then one day with no exposure, followed by a final exposure day) failed to produce any symptoms other than the fatigue which is described in the results."
Report contains statements from 3 pilots concerning illness in the RB-57A aircraft. Pilot 1 describes dry mouth, feeling of faintness, inability to co-ordinate eye movements, nausea & increased breathing rate. Symptoms came on gradually & disappeared rapidly on opening the clear vision window. Pilot 2 described 'headaches & a 'cool smell' in the cockpit, which disappeared on changing the ventilation source air to ram air. Pilot 3 reported a dry mouth and a 'tinny taste' and disappeared on changing the ventilation air to ram air. |
| 1955 | Redhal H. Elimination of engine bleed air contamination. North American Aviation Inc. presentation at SAE Golden Anniversary Aeronautic meeting, Los Angeles, February 11-15, 1955 | "Air bleed from the compressors of some high compression turbojet engines is contaminated because of internal engine oil leakage into the compressor air. External leakage of oil or other fluids wherein such fluids can leak into the engine air inlet can also cause contamination. There are two positive methods of elimination: 1) a catalytic filter which oxidizes the contaminants to carbon dioxide and water 2) a separate cabin compressor that compresses free stream ram air for cabin air conditioning and pressurization." |

Both the military aviation services and the aircraft industry have recently become aware of similar if not the same problems in newly developed high-speed aircraft. In the Air Force test pilots complained of obnoxious odors, eye and nasal irritations, and headache associated with the presence of smoke in the aircraft cabin during flight operations. Preliminary investigations revealed that the smoke, including fumes and gases, were a result of the thermal decomposition of engine oil which had leaked into the compressor both the military aviation services and the aircraft industry have recently become aware of similar if not the same problems in newly developed high-speed aircraft. In the Air Force test pilots complained of obnoxious odors, eye and nasal irritations, and headache associated with the presence of smoke in the aircraft cabin during flight operations. Preliminary investigations revealed that the smoke, including fumes and gases, were a result of the thermal decomposition of engine oil which had leaked into the cabin during flight operations. Preliminary investigations revealed that the smoke, including fumes and gases, were a result of the thermal decomposition of engine oil which had leaked into the compressor of the gas turbine engine. The oil itself is relatively non-toxic; however, the decomposition products were found to be toxic to laboratory animals. The effects were proportional to the rate of decomposition, the time of exposure, and the temperature of decomposition. Health hazards to aircrew personnel are not anticipated unless excessive oil leakage into the compressor and prolonged exposure are obtained. Eye and nasal irritation and obnoxious odors have been reported as objectionable. Smoke, fumes, and physiologically active chemical materials cannot be tolerated in the cabin of high-speed aircraft and may constitute a flight hazard by: (1) affecting the efficiency of the aircrew; (2) obscuring in-flight configurations; (3) hindering instrument visibility; and (4) affecting sensitive instrumentation and other aircraft materials.


The primary requirement for zero oil leakage, which is difficult to obtain in practice under all operating conditions, is necessary chiefly because of the common practice of using compressor bleed air to pressureize or refrigerate aircraft cabins. Any oil leakage into the compressor air flow can 'cause serious cockpit contamination problems due to the formation of toxic fumes.' The commonly used synthetic oil decomposed beyond 400 degf with the formation of various vapors. 'It should be mentioned that the positive air pressure gradient... is not a guarantee of zero oil leakage. Indeed it is most disconcerting to observe low pressure oil leaking into a highly pressurized zone on the seal test stand.'


The inhalation of synthetic turbo oil mists is believed to constitute no more of a hazard than that associated with conventional petroleum lubricating oils. Fogs generated at temperatures on the order of 600-700 degf were found to be toxic to experimental animals, but when generated at temperatures on the order of 400 degf, they were well tolerated.... The problem of cabin fogs or smokes seems to resolve itself into an engineering control of a nuisance.'

'In addition to the occasional contamination of cabin air with thermally generated oil fogs introduces the further question of toxic effects from thermal decomposition products. Such contamination may occur in planes which utilize compressor bleed air for cabin pressurization and heating; under certain conditions of power development of the engine, there may be some leakage of oil from the engine into the compressor air, where it can be subject to temperatures as high as 700 degf.'

'In view of these test results and the intermittent nature of exposures during flight, it is believed that no serious hazard is associated with the seepage of oil into the cabin of planes using compressor bleed air for cabin pressurization and heating.'

The eye irritation, which consistently accompanies the appearance of fogs in the cabin, may be due to some unknown irritant... or to the less likely possibility of free organic acid, used as a starting material in the preparation of the diester, and present in the undecomposed fine particles of diester. Whatever the cause, the eye irritation is not desirable during flight. It appears to be principally a nuisance but should be eliminated by whatever means, engineering or otherwise, seem best suited for the individual circumstances involved.'

1960 Esso 6 (1960) The acute Inhalation Toxicity of the Products of Pyrolysis of several synthetic lubricants. Porton Technical paper No. 723. signed by S Callaway, Head Toxicology section, Chemical Defence Experimental Establishment, 19 April, 1960

Cabin pressurisation in jet aircraft is obtained by bleeding off part of the air delivered by the engine compressor. This air may contain a small quantity of lubricating oil, which may become pyrolysed at the temperature of the compressor and so give rise to irritating products such as ladehydes. Should an oil seal fail or a bearing run the oil quantity in the compressor air may be considerably increased.

Animal experiments undertaken in 1955 at Chemical Defence Experimental Establishment and again in 1958 with animals & humans. Series 6 1958 study - Effects of oil tested on humans in chambers exposed to heated oils. Results included 'nasal irritation & lachrymation'; 'discomfort evident on re-entry'; 'most unpleasant within a few seconds'; 'immediate onset of sharp eye & nose irritation with lachrymation'; 'rapidly intolerable, more aggressive than previous oils and more alarming as produces a denser smoke with a smell like burning candle grease'; 'severe eye irritation with 10 seconds'; 'intolerable, all previous to get out within 10 seconds.'

These oils, when heated rapidly in the open, volatise with very little pyrolysis, giving a dense but harmless mist. The same oils heated in a closed tube, undergo considerable decomposition, giving rise to a thin and very irritant smoke containing formaldehyde and carbon monoxide...... Even with an oil concentration as low as 0.2mg/l, the maximum production of formaldehyde would be extremely unpleasant for a pilot & lachrymation would interfere seriously with reading of the instruments, but there would be no significant danger of a sudden loss of consciousness...... While the pyrolysis of these synthetic lubricants does produce significant quantities of these two toxic agents, a sudden exposure to a concentration sufficient to cause a pilot to lose control does not appear to be a real danger.

1962 Lockheed Georgia Company (1962). C-141

The utilization of engine compressor bleed air for cabin pressurization and air conditioning exposes the crew to air which could possibly be contaminated with decomposition products of MIL-L-7808 lubricant... a small leak in the front compressor section of the engine may allow the lubricant to escape from the engine and pass into the compressor bleed air section where under high compression and temperature the oil breaks down chemically forming toxic compounds, thus contaminating the bleed air going into the cabin... The extent of the contamination would be governed by the small amount of lubricant sealed in the bearings. The engine is the main source of bleed air contamination and the extent of the contamination is governed by the oil leakage rate of the front compressor seals.

(MIL-L-7808 lubricant is a type 2 synthetic lubricant)
1966 Esso (1966) Esso Medical Research Division. 2380 Turbo Oil – Statement of Toxicity. March. At temperatures in excess of 500-700°F, synthetic lubricants ‘will probably undergo pyrolysis and release decomposition products of varying degrees of toxicity. Care should be taken to avoid exposure to mists or vapors of oils heated to extreme temperatures.’ 2380 Turbo oil ‘may cause skin irritation and dermatitis after prolonged excessive contact... Avoid excessive skin contact and inhalation of mists and vapors released on heating. ‘No threshold limit (maximum allowable concentration) for the 8 hour working day has been established for synthetic lubricants.’

1966 Esso (1966) Esso Medical Research Division. 2380 Turbo Oil – Statement of Toxicity. March. At temperatures in excess of 500-700°F, synthetic lubricants ‘will probably undergo pyrolysis and release decomposition products of varying degrees of toxicity. Care should be taken to avoid exposure to mists or vapors of oils heated to extreme temperatures.’ 2380 Turbo oil ‘may cause skin irritation and dermatitis after prolonged excessive contact... Avoid excessive skin contact and inhalation of mists and vapors released on heating. ‘No threshold limit (maximum allowable concentration) for the 8 hour working day has been established for synthetic lubricants.’

1966 Suitability of Engine High Pressure Bleed Air for Environmental Control Usage – Assurance Tests

To date FAA approval of commercial jet aircraft using bleed air from environmental control systems has been obtained for each different aircraft by submission of analyses (ref 2) which attempt to show that: 1) during normal operating conditions proper bearing seal design will prevent lubricating oil from ever entering the compressor air stream. 2) In the unlikely event of a bearing seal failure, the bleed air temperature will either be below the critical level (above which harmful contaminants begin to form) or the exposure will be so short that even extremely high oil leakage rates can be tolerated without ill effects to crew or passengers (ref 3).

It is considered doubtful that similar arguments will be adequate for establishing compliance with either civil or military bleed air purity and safety requirements of aircraft now in the conceptional design stage. These aircraft will have advanced technology engines with much higher compression ratios resulting in bleed air extraction temperatures, even for the lower bleed stages, well above the critical decomposition temperature of conventional engine lubricating oils. (ref 4) These higher bleed temperatures will prevail during most normal operating conditions.... In addition the existing, rather vague FAA regulations in this regard are very likely to be revised and made more stringent (ref 1).


Ref 2: - Troen JF., Cleveland F. et al. (1954) Toxicity Of Certain Lubricants, Engine Oils, and Certain of their Constituents, with Particular Reference to the Products of their Thermal Decomposition. WADC TR 54-344. Corporate Author: Kettering Laboratory, University of Cincinnati. Aero Medical Laboratory Contract No. AF33(038)-264556. RDO No. 69B-31, Wright Air Development Center, Air Research and Development Command, United States Air Force- Wright-Patterson Air Force Base, Ohio. 1 November 1954

1966 Esso (1966) Esso Medical Research Division. 2380 Turbo Oil – Statement of Toxicity. March. At temperatures in excess of 500-700°F, synthetic lubricants ‘will probably undergo pyrolysis and release decomposition products of varying degrees of toxicity. Care should be taken to avoid exposure to mists or vapors of oils heated to extreme temperatures.’ 2380 Turbo oil ‘may cause skin irritation and dermatitis after prolonged excessive contact... Avoid excessive skin contact and inhalation of mists and vapors released on heating. ‘No threshold limit (maximum allowable concentration) for the 8 hour working day has been established for synthetic lubricants.’


Esso and Humble Oil research, exposed animals via inhalation to Esso Turbo oil 15 and 2380 that had been heated to 500°F (260°C) or 700°F (371°C). The animals exhibited paralysis in the hind quarters while autopsies revealed ‘gross changes of edema, inflammation and gross hemorrhage into the bronchioles and alveoli...’ Greater toxicity was shown at the higher temperatures.

1968 Haugher H., Creeves V et al. (1968) DC-9 Environmental Control Design and First Year’s Service Experiences. Journal of Aircraft. 5: 1, 1968

Since the DC-9 engine manufacturer ‘had taken special precautions to prevent oil leakage past the engine shaft bearing seals into the compressor inlet, the compressor bleed air was judged to be acceptable as breathing air.’


Evaporation loss of oil 'constitutes only a minor part of the oil consumption in Rolls-Royce gas turbines, the major part of the consumption representing loss of oil arising from permissible leakage past certain seals, escape of mist or aerosol through breathers and losses incurred during filter inspections in service. These are made good by "topping up" the system with fresh oil.'


Contamination of engine bleed air by engine oil, once a serious problem, has been almost eliminated, by the efforts of engine manufacturers. Nevertheless, the possible consequences of a severe oil leak are sufficiently serious to make additional knowledge of the subject desirable. Current Douglas design practice is to guard against the possibility of toxic products of oil decomposition occurring in the air conditioning system by taking only low temperature bleed air.'

1973 Gaume D. Analytical considerations concerned with cephalgia on the DC-10. J. Gaume, M.D., Manager Aviation Medicine and Safety Research Science Research. 20 February 1973

Since the DC-10 has been put into operational airline service... a number of complaints of cephalgia (headache) have been made by cabin attendants: ... After preliminary examination of these possible sources, it appeared to be quite probable that the source of the headaches could be contaminants derived from the engine bleed air source for cabin pressurization.’


The inhalation toxicity of these synthetic oils has received little attention, perhaps due to the obvious complications of dealing methodically with such a complex mixture of organic compounds.'

Not infrequently commercial airline flight crews have complained of a 'plastic' odor on the flight deck prior to engine compressor failures. The presence of this 'plastic' odor which is characteristic of synthetic oils may lead to headache & nausea in flight personnel. These clinical complaints were not routinely noticed until the advent of synthetic oils.'

A 34-year-old Caucasian male in good health, was flying as navigator in a military C-130A aircraft when he noticed the gradual onset of headache, followed by slight dizziness, nausea, vomiting, incoordination, and diaphoresis. By the time the plane could be landed he had difficulty standing.... etiology of his symptoms was related to an inhalation exposure to aerosolized or vaporized synthetic lubricating oil arising from a jet engine of his aircraft.

Inhalation exposure to aerosolized or vaporized synthetic lubricating oil stated that ‘in cases of jet engine seal failures, these oils are subjected to high temperatures and pressures and contact with hot metal surfaces before they are presented for inhalation. These conditions may catalyze reactions that yield toxic products...’ The inhalation toxicity of these synthetic oils has received little attention, perhaps due to the obvious complications of dealing methodically with such a complex mixture of organic compounds.'

Further investigation into the potential hazards from inhalation of synthetic oil fumes that are generated by these circumstances is definitely warranted.'


Heated engine oils and hydraulic fluids produced `significant quantities of highly toxic compounds.'
<table>
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<tr>
<th>Year</th>
<th>Citation</th>
<th>Text</th>
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<tbody>
<tr>
<td>1981</td>
<td>SAE (1981) SAE Aerospace. Aerospace Information Report, AIR 1539, 30/1/81, Environmental Control System Contamination: Sources of Vaporous Contamination. Warrendale, PA. 1981</td>
<td>Engine compressor bearings upstream of the bleed ports are the most likely sources of lube oil entry to the engine air system and thence into the bleed system contaminating the cabin/cockpit air conditioning system ...at temperatures above 320 deg C this oil breaks down into irritating and toxic compounds.</td>
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<td>1983</td>
<td>Mobil (1983) Correspondence from E. Ladov, Environmental Affairs and Toxicology Department, Mobil Oil Corporation to J. Aveni. Mobil Jet Oil II. 24 January, 1983.</td>
<td>If cabin air becomes contaminated with any lubricant and/or its decomposition products, in sufficient quantities, some degree of discomfort due to eye, nose and throat irritation could be experienced. Problems like these can be generally traced to improper design, improper maintenance or malfunctioning of the aircraft.</td>
</tr>
<tr>
<td>1983</td>
<td>NTSB (1983) National Transportation Safety Board. Special Investigation: An Evaluation of the Potential for Turbine Oil By-product Contamination of an Aircrafts Cabin Environmental System, Edward Wizniak. Special Investigation TESI 218104. 25 April 1983</td>
<td>‘There are certain instances in which chronic or repeated exposure may sensitize a person to certain chemicals so that later concentrations in the ppb may later illicit an acute hypersensitivity type reaction.’</td>
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<tr>
<td>2013</td>
<td>Report to Congress. Pub. L. No. 112-95, 126 Stat. 11 (2012) FAA Modernization &amp; Reform Act of 2012 Section 917 Research &amp; development of equipment to clean and monitor the engine and auxiliary power unit (APU) bleed air supplied on pressurized aircraft.</td>
<td>Given the very high air flow rates and high temperatures in the upstream portion of the bleed air system, the specific nature and extent of potential decomposition reactions of engine oils and hydraulic fluids are largely unknown. Additionally, the resulting nature and potential toxicity of any contaminants in the aircraft cabin from such events are highly speculative at the present time. The FAA has sponsored cabin air environment research since 2004, the specific nature and extent of potential decomposition reactions of engine oils and hydraulic fluids are largely unknown. Additionally, the resulting nature and potential toxicity of any contaminants in the aircraft cabin from such events are highly speculative at the present time* &quot;</td>
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* "The efficiency and effectiveness of aircraft environmental control systems have not kept pace with the increasing demands on air quality in modern air transportation. Bleed air contamination events have been attributed to engine oils and hydraulic fluids contaminating the fresh air from the bleed air system."