CAQ Government and indsutry studies since 2000 and early awarness ver 1.01

SUMMARY
Inquiries = 6
Research/investigations = 75 (2 unfunded)
Rulemaking / Advance notice of rulemaking = 2
Standards = 15 (2 withdrawn)
Public Law = 2

Total actions by Gov/Industry
UK = 10 - EU = 15 - US = 72 - Australia = 3 : TOTAL =100

Research/investigation activities by Gov/Industry
UK = 7 - EU =12 - US = 55 - Australia = 1 : TOTAL = 75

	UK	EU	Austr	USA	
Inquiries	3	-	2	1	= 6
Standards	-	2	-	13	=15
Rulemaking/ advanced Rulemaking	-	1	-	1	= 2
Public law	-	-	-	2	= 2
Research/ Investigation	7	12	1	55	=75
Total	10	15	3	72	= 100

No full/part resolution on cabin air contamination issue = 99 ? = 1

FAA Centre of Excellence (COE) ACER/RITE funded projects- FAA grants 2004-2013-USD $15,011,410 (specific to cabin air quality/cabin pressurization) ($23 million FAA grants- all areas of ACER/RITE research +$28million in matched partnership funding)
ACER FUNDED WORK 2003-2013- INCLUDING FAA GRANT & PARTNERSHIP FUNDING - USD $51 MILLION

EU funded projects - 47.8 MILLION euros

ACE/RITE - FAA Centre of Excellence Airliner research project grants= 49

(the above figures do not cover all studies as many studies/activities do not provide any funding value.

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

YEAR	UK	EUROPE	USA	Australia
2000/2001	X UK- House of Lords Inquiry - Science and Technology - Fifth Report 1999-2000: Air Travel and Health. November 2000 "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."		X US Nationaional Research Council - The airliner 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."	X 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. Reccommendation 7: Review of the use of MJO2
2001	X Marshman SJ. (2001) Analysis of the Thermal Degradation Products of a Synthetic Ester Gas Turbine Lubricant. DERA/FST/CET/ CR010527 (2001). RESTRICTED COMMERCIAL. 2001	X European Parliament- DIRECTORATE GENERAL FOR RESEARCH ENVIRONMENTAL AND HEALTH IMPACT OF AVIATION- Final study Directorate A, Division Industry, Research, Energy, Environment and STOA -STOA, Scientific and Technological Options Assessment -PE 96.693/Fin.St. March 2001	X FAA- Aviation Rulemaking Advisory Committee (ARAC); Transport Airplane and Engine Issues -Part 1: Ventilation--Heating and Humidity (Sec. 25.831(g))- *(temperature)* *http://www.faa.gov/regulations_policies/rulemaking/committees/documents/media/TAEmshT3-072601.pdf* *ARAC review following NRC report was delayed till after Batelle/ASHRAE study completed (2007), but still not undertaken as of 2014*	
2001	X Jenner J., Jugg B. et al. (2001) The Toxicity of Aircraft Lubricancy Pyrolysis Products Related to Cabin Air Quality Incidents (UC). DSTL/TR01591, UK Defence Science and Technology Laboratory, Porton Down, 2001	X HEACE-Health Effects in Aircraft Cabin Environment- HEACE Project funding: 4.9 mill euros 2001-2005		

2001		X SHK (2001) Statens Haverikommission, SHK Board of Accident Investigation. Report RL 2001:41e. Incident Onboard Aircraft SE-DRE, Sweden. + Honeywell (2000) Honeywell Aerospace.Test Report. 21-11509. Air Quality Tests Performed by R. Fox on BAe 146-200 Aircraft Registration Number SE-DRE for The Swedish Board Of Accident Investigation. 15 December 2000 & Report 21-11156. Engineering Investigation Report Customer Bleed Air Testing Engine Model ALF502R-5, S/N LF05311. (Includes Bleed Air Quality Test for LF 502 engine S/N 5311, Test Cell 956, December 1999). 3 March 2000	X Fox R. (2001) Thermal Decomposition Studies of Oils and Fuel Approved for use in the Honeywell ALF 502/507 Engine. Study Date Dec 2001 - Jan 2002. Compiled by Richard Fox PMP Senior Principal Engineer. Honeywell Aerospace. (presented to COT TOX/2006/39 Annex 11) 20 October 2006	
2002		X FACE-Friendly aircraft cabin environment Project Funding:34 mill euros 2002-2007		
2003	X BRE (2003) Building Research Establishment, UK. Extending Cabin Air Measurements to Include Older Aircraft Types Utilized in High Volume Short Haul Operations: BRE Report 212034. Watford, 2003		X Centre of Excellence (COE) - Research in the Intermodal Transport Environment (RITE) – Office of Aeromedical Research, Hdq. (Formerly: ACER: Airliner Cabin Environment/RITE) $51million 2003-2013 Omnibus Budget Reconciliation Act of 1990. Public Law 101-508 Title IX – Aviation Safety and Capacity Expansion Act Public Law 101-508 - 2003-Air quality in aircraft cabins. http://www.gpo.gov/fdsys/pkg/PLAW-108publ176/html/PLAW-108publ176.htm COE members and industry affiliates have provided more than $28 million in matching contributions. ($23 million in FAA grants) (COE presentation- FAA Air transportation Centers of Excellence: COE Organizational structures- Presented by Patricia Watts, Program Director, COE, 29/5/14) FUNDING FINISHED 2014 FOR ACER-RITE ACER publications: http://acer-coe.org/publications/index.html	
2004	X CAA (2004) Civil Aviation Authority, UK. Report: 2004/04. Cabin Air Quality.2004 (combination of Marshman & Jenner reports)	X **EU Draft standard- pr EN 4618- Aircraft internal air quality standards, criteria and determination methods** **published 2009** **Withdrawn 2013**	X ASHRAE - Spicer C., Murphy M., et al. (2004) Relate Air Quality and Other Factors to Comfort and Health Symptoms Reported by Passengers and Crew on Commercial Transport Aircraft (Part I) (ASHRAE Project 1262-TRP). Battelle Science and Technology International, Columbus, 2004	
2004			X FAA - COE for Airliner cabin Environment - Harvard University, Spengler, FAA grant - $100,000; FAA - COE for Airliner cabin Environment - Kansas State University, Jones, FAA grant - $100,000; FAA - COE for Airliner cabin Environment - Boise State University, Hartman, FAA grant -$100,000; FAA - COE for Airliner cabin Environment - Purdue University, Chen, FAA grant -$100,000; FAA - COE for Airliner cabin Environment - University of medicine & Dentistry New Jersey, FAA grant -$100,000; FAA - COE for Airliner cabin Environment - Auburn University, Gale, FAA grant - $400,000	
2005		X **EC 6th Framework: Ideal Cabin Environment : 2005-2008** **Project leader- BRE, 6 mill euros**		

2005	X **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)**		X 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 AirlinerCcabin 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- ACER Decontamination tasks 23/yr 2 management, Auburn University, Gale, FAA grant -$3,980,289; FAA- Cabin flow dynamics models & sensors, Purdue University, Chen, FAA grant- $1,256,189; FAA- Contaminant transport in airliner cabins, kansas State University, Jones, FAA grant - $252,857; FAA- Sensors & decontamination, Auburn University, Gale, FAA grant -$1,185,176; FAA- Sensors system integration, Boise State University, Loo, FAA grant -$400,000	
2006			X FAA- Aircraft recirculation filter research incident assessment - Kansas state University, Eckels, FAA grant -$150,000	
2007	X UK House of Lords (2007) Session 2007-2008 1st report HL 7- Select Committee On Science and Technology - Air Travel and Health – An Update, December, 2007		X 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	X Cranfield (2011) Aircraft Cabin Air Sampling Study; Final Report. Institute of Environment and Health, Cranfield University. March 2011- Funded by UK Dept of Transport (2007-2011) (includes FUNCTIONALITY TEST REPORT (Institute of Environment and Health, Cranfield University 2008)		X ASHRAE (2007) American Society of Heating, Refrigerating, and Air Conditioning Engineers. Air Quality Within Commercial Aircraft: Standard 161-2007. Atlanta, GA. 2000 (1995 - ongoing)	
2008			X 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 -$72,962 http://www.faa.gov/about/office_org/headquarters_offices/ang/offices/management/coe/grant_awards/	X CASA (2008) Civil Aviation Safety Authority, Australia. Expert Panel on Aircraft Air Quality (EPAAQ) (2008-2012)
2009		X **EU Draft standard- pr EN 4666- Aircraft integrated air quality and pressure standards, criteria and determination methods" Withdrawn 2013**		

2009	X Oil Smells in Aircraft Cockpits: Findings of Statistical Analysis into Associated Parameters. In House Analytical Consultancy Department for Transport & Professor Helen Muir, School of Engineering,Cranfield University, 2009	**X EASA- ANPA-2009-10: "Cabin Air Quality onboard Large Aircraft" EASA (2012) European Aviation Safety Agency. Decision No 2012/001/R of the Executive Director of the European Aviation Safety Agency of 27th January 2012**	X FAA - Chemical Sensors for Cabin Air Quality- Boise State University, S. Loo- FAA grant - $150,000 ; FAA - Chemical Sensors for Cabin Air Quality - Auburn University , R. Overfelt - FAA grant - $250,000; FAA - Aircraft Recirculation Filter for Air Quality and Incident Assessment, Kansas State University, S. Eckels- FAA grant - $120,000; FAA - Contamination Transport in Aircraft Cabins, Phase 2, Kansas State University, B Jones- FAA grant -$80,000; FAA - Improvements on the advanced models for predicting contaminant and infectious disease virus transport in airliner cabin environment, Purdue University, Chen- FAA grant -$250,000	
2009		X ISPACE-Innovative systems for personalised aircraft cabin environment 2.9 mill euros 2009-2012		
2010			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 - In-Flight Sensor System and Database Deployment - FAA Grant No.07-C-RITE-KSU-009, Kansas State University 2010-$29,999; FAA - Sensors and Prognostics to Mitigate Bleed Air Contamination Events - FAA Grant No. 07-C-RITE-AU-003, Auburn University 2010-$351,240; FAA - Sensors and Prognostics to Mitigate Bleed Air Contamination Events - FAA Grant No 07-C-RITE-KSU-012 , Kansas State University, 2010 -$ 192,220	
2010			X FAA - Exposure to Flame Retardants in Commercial Aircraft - FAA Grant No.07-C-RITE-UMDNJ-008. University of Medicine and Dentistry of New Jersey, 2010-$81,067; FAA - Exposure to Flame Retardants in Commercial Aircraft - FAA Grant No. 07-C-RITE-HU-005. Harvard University, 2010-$231,584; FAA - Exposure to Flame Retardants in Commercial Aircraft - FAA Grant No.07-C-RITE-KSU-013. Kansas State University , 2010-$27,957	

2011	X **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 Solbu (2011) Organophosphates in aircraft cabin and cockpit air method development and measurements of contaminants, Journal of Environmental Monitoring, Issue 5, 2011 Solbu (2010) - Journal of Environmental Monitoring Issue 12, 2010 Solbu (2010) - Journal of Environmental Monitoring Issue 5, 2010 Solbu (2010) -Journal of Chromatography A Volume 1161, Issues 1–2, 17 August 2007, Pages 275–283	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 - Exposure to Flame Retardants in Commercial Aircraft - FAA Grant No. 10-C-RITE-HU-002. J Spengler, Harvard, 2012-$239,290; 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.Watson 10-C-RITE-AU-005. R. Overfelt, Auburn University, 2012-$109,076; FAA-Sensors and Prognostics to Mitigate Bleed Air Contamination Events 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 www.nasa.gov 1 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 riskbto 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: (b) AUTHORITY TO MONITOR AIR IN AIRCRAFT CABINS.—For purposes of conducting the study required by subsection (a), the Administrator of the Federal Aviation Administration shall require domestic air carriers to allow air quality monitoring on their aircraft in a manner that imposes no significant costs on the air carrier and does not interfere with the normal operation of the aircraft. http://thomas.loc.gov/cgi-bin/query/z?c112:H.R.658.ENR 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 of a pressurized aircraft.	
2012	X **IOM (2012) Cabin Air – Surface Residue Study Report. Research report TM/11/06, March 2012. Institute of Occupational Medicine, Edinburgh**	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**	Continued. (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, Batelle, FAA Grant no. 07-C-RITE-HU Final Report, 2005-2010 Report, April 2012	
2012			X Fox R (2012) Assessing Aircraft Supply Air to Recommend Compounds for Timely Warning of Contamination. Dissertation for PhD	

2013		X Institute for Prevention & Occupational medicine of the German Social Accident Insurance, Institute of the Ruhr-Universitat Bochum (IPA) Germany papers: Schindler B (2013) Occupational exposure of aircrews to Tricresyl phosphate isomers and organophosphate flame retardants after fume events; Arch Toxicol (2013) 87:645-648 Schindler B (2014) Exposure of aircraft maintenance technicians to organophosphate hydraulic fluids and turbine oils: A pilot study; Int J of Hygiene and Environ Health (2014) 217: 34-37		
2013		X TNO- Report: TNO 2013 R11976, The Netherlands Investigation of presence and concentration of Tricresyl phosphates in cockpits of KLM Boeing 737 aircraft during normal operational conditions	X FAA - 10-C-RITE-UMDNJ-003 Bleed Air Characterization in Commercial Aircraft UMDNJ Dr. Clifford Weisel 1/9/2013 $116,909; FAA - 10-C-RITE-KSU-009 Sensors and Prognostics to Mitigate Bleed Air Contamination Events Kansas State University Byron Jones 05/13/13 $174,854; FAA - 10-C-RITE-AU-006 Research in the Intermodal Transport Environment (RITE)- Sensors and Prognostics to Mitigate Bleed Air Contamination Events Auburn University R. Overfelt 05/13/13 $175,000; FAA - 10-C-RITE-KSU-010 Sensors and Prognostics to Mitigate Bleed Air Contamination Events Kansas State University B. Jones 06/18/13 $64,800; FAA- 10-C-RITE-AU-007 Sensors and Prognostics to Mitigate Bleed Air Contamination Events Auburn University R. Overfelt 06/18/13 $65,691; FAA- 10-C-RITE-BSU-005 Sensors and Prognostics to Mitigate Bleed Air Contamination Events Boise State University Dr. Sin Ming Loo 06/18/13 $182,694; FAA- 10-C-RITE-UMDNJ-005 Bleed Air Characterization in Commercial Aircraft Rutgers Biomedical and Health Sciences C. Weisel 06/18/13 $186,609	
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**	X ACER - Proposed Test Plans for a Study of Bleed Air Quality in Commercial Airliners. National Air Transportation Center of Excellence for Research in the Intermodal Transport Environment (RITE) Airliner Cabin Environment Research Program Auburn University / Kansas State University Report No. RITE-ACER-CoE-2013-2 Funding requested- project A- $2.9 mill or project B- $18 mill **unfunded as of July 2014**	
2014			X Study of Reported BFU (2014) -German Federal Bureau of Aircraft Accident Investigation. Occurrences in Conjunction with Cabin Air Quality in Transport Aircraft, Bundesstelle für Flugunfalluntersuchung BFU 803.1-14, May 2014	X "ATSB- Australian Transport Safety Bureau- An analysis of fume and smoke events in Australian aviation. 2008-2012. A joint initiative of Australian safety agencies. ATSB Australian transport Safety Report, AR 2013-213, Final 20 May 2014"

			X SAE STANDARDS SAE ARP 1796 -1996B - Engine bleed air systems for aircraft-Aerospace Recommended practice- standard SAE AIR 1168/7A - Aerospace pressuriztion 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 AIR 5784 - A Review of Literature on the Relationship Between Gas Turbine Engine Lubricants and Aircraft Cabin Air Quality - Aerospace Information Report- standard 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	

DATE	REPORT	Findings
1952	Johnson R., Swikert M. 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	Higher operating temperatures with newer engines require the use of synthetic oils with 'speculation about probable toxicity and corrosiveness at elevated temperatures; these properties have not yet been adequately studied... The phosphonate esters as well as certain phosphate esters maybe useful in future lubricant problems.'
1953	Boeing Airplane Company - Decontamination program: B52	" 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."
1953	Stovell W., Boysen J. 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. NY, 1953	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.'
1954	Aldridge WN. (1954) Tricresyl Phosphates and Cholinesterase. Biochem. J. 56:185-189, 1954	Tri- meta and Tri-para isomers of TCP (TMCP, TPCP) DO NOT SHOW PARALYSIS BUT SHOWED TRACES OF DEMYELINATION IN THE SPINAL CHORD
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 effect 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 !ubricant is largely from the breakdown of the lubricant base stock. Mists 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, carbonyls, carbon monoxide 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 monoxide 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(038)-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	Loomis T (1955) Cabin Air Contamination in RB57A Aircraft. Special Report- MLSR 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 necessaary to produce illness are present. The earliest signs of excessive lubricant or its breakdown products in the air are eye,nasal and pharygeal 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 two days 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 describedlight headedness & 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	Reddal 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 bled 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 oxidises the contaminants to carbon dioxide and water 2) a separate cabin compressor that compresses free stream ram air for cabin air conditioning and pressurization."

1956	Kitzes G. (1956). Presentation by USAF Aero medical Laboratory. Wright-Patterson Air Force Base, ohio at 26th annual meeting of the Aeromedical Association, Washington DC. February 1956	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 theBoth 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 presenceBoth 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 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 of the gas turbine engine. The oil itself is relatively non-toxlc; 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 air of high speed aircraft and may constitute a flight hazard by: (1) affecting the efficiency of the aircrew; (2) obscuring in-flight conflagrations; (3) hindering instrument visibility; and (4) affecting sensitive instrumentation and other aircraft materials.
1956	Palsulich J., Riedel RH. (1956) Dynamic Seals for Aircraft Gas Turbine Engines. Aircraft and Allied Products Dept., Cleveland Graphite Bronz. SAE 560171, 1956	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 pressurize 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. Ineed it is most disconcerting to observe low pressure oil leaking into a highly pressurized zone on the seal test stand.'
1956	Esso (1956) Memorandum on the Toxicity of Synthetic Turbo Oils. RE. Eckardt, L. McTurk. Medical Research Division, Esso Research and Engineering Company, June 7 1956	The inhalation of synthetic turbo oil mists is believed to constitute no more of a hazard than that associated with conventioneal 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, 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 beleived 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 lesslikely 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 irritiation is not desirabel during flight. It appears to be principally a nuisance but shoulkd be eliminated by whatever means, engineering or otherwise, seem best suited for the individual circumstances involved.'
1960	Ensor E (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 hot the quantity of oil in the compressor air may be considerably increased.' Animal experiemnts undertaken in 1955 at Chemical Defense 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 intollerable, 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'; 'intollerable, all anxious 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 sealedin 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 1 synthetic lubricant)*

1966	Douglas Aircraft Corporation (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 fro environmental control systems has been obtained for each differrent aircraft by submittal 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 eent of a bearing seal failure, the bleed air temperature will either be below the critical level (above which harmful contaminants begine 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 (ref3). 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 conceptual 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 1- FAA (1966) Federal Aviation Administration Report. Bleed Air Contamination in Military and Civil Aircraft. T.C. Du Four. 14 June 1966 (Project 66-213-140) ref 4 - 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(038)-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
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 exposures 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.'
1967	Levenson T., Shelanski M. (1967) Report – Synthetic Lubricants. Industrial Biology Laboratories Inc. Sponsored by Medical Research Division, Esso Research and Engineering Company. 29 November 1967	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 suggesting severe irritation of the respiratory tract consisting of edema, inflammation and gross hemorrhage into the bronchioles and alveoli.....' Greater toxicity was shown at the higher temperatures.
1968	Haugher H., Cleeves V et al. (1968) DC-9 Environemtnal 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.'
1969	Edge RG., Squires ATBP. (1969) Lubricant Evaluation and Systems Design for Aircraft Gas Turbine Engines. Rolls-Royce. SAE 690424, 1969	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 liquid 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.'
1970	Douglas Aircraft Company (1969) Letter from W. Skillman, Chief Design Engineer, Power Plant and Environmental Engineering, Douglas Aircraft Company to JD. Robinson, Manager Western Markets, Pratt and Whitney Aircraft. 6 February 1969	'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 on 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 bleedair.'
1973	Gaume D. Analytical considerations concerned with cephalagia on the DC-10. JG 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 cephalagia (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."
1977	Montgomery MR., Wier GT. et al. (1977) Human Intoxication Following Inhalation Exposure to Synthetic Jet Lubricating Oil. Clinical Toxicology 11: 423-426, 1977	'The inhalation toxicology 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 fliught 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 fligh 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 toxicology 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.'
1979	Paciorek K., Nakahara B. et al. (1979) Fluid Contamination of Aircraft Cabin Air and Breathing Oxygen, Report No. SAM-TR-79-34 for the USAF School of Aerospace Medicine. Ultrasystems Inc, Irvine. 1979	Heated engine oils and hydraulic fluids produced 'significant quantities of highly toxic compounds.'

1981	SAE (1981). SAE Aerospace. Aerospace Information Report, AIR 1539, 30/1/81, Environmental Control System Contamination: Sources of Vaporous Contamination. Warrendale, PA. 1981	Engine compressor bearings upstream of the bleed ports are the most likely sources of lube oil entry in 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.'
1983	Rayman R., McNaughton G. (1983) Smoke/Fumes in the Cockpit. Aviation, Space and Environmental Medicine 67: 738-740,1983	a number of toxic substances used in aircraft including oils had 'acute and long-term effects.'
1983	Mobil (1983) Correspondence from E. Ladov, Environmental Affairs and Toxicology Department, Mobil Oil Corporation to J. Aveni. Mobil Jet Oil II. 24 January, 1983.	'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.'
1983	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	'There are certain instances in which chronic or repeated exposure may sensitise a person to certain chemicals so that later concentrations in the ppb may later illicit an acute hypersensitivity type reaction.'
1983	Crane CR., Sanders DC. et al. (1983) Inhalation Toxicology: III Evaluation of Thermal Degradation Products from Aircraft and Automobile Engine Oils, Aircraft Hydraulic Fluid and Mineral Oil: Report No:FAA-AM-83-12. US Federal Aviation Administration/US Department of Transportation. Washington. 1983	'NTSB approach did not eliminate the possible presence of an additional component with significant animal toxicity.'
2013	Report to Congress Pub. L. No. 112-95, 126 Stat. 11 (2012) FAA Modernization & Reform Act OF 2012 Section 917 Research & development of equipment to clean and monitor the engine and auxiliary power unit (APU) bleed air supplied on pressurized aircraft.	"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" "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."