SUMMARY OF DOCUMENTS THAT REFERENCE POTENTIAL FLIGHT SAFETY IMPACT OF EXPOSURE TO CONFIRMED/SUSPECTED OIL-CONTAMINATED VENTILATION AIR ON COMMERCIAL AND MILITARY AIRCRAFT, AND SUPPORTING DOCUMENTATION

Prepared by J. Anderson, AFA-CWA, AFL-CIO
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1. IFALPA (2018) “Cabin fumes,” Human Performance Briefing Leaflet 18HUPBL03 and Position Paper 18POS24, International Federation of Airline Pilots’ Associations, Montreal, Canada. (These publications describe the potential for pilots to breathe engine oil fumes inflight. IFALPA describes the long-term health consequences of breathing oil fumes inflight as “still subject to debate,” but clearly recognizes that a “fume event may result in incapacitation of crewmembers and jeopardize flight safety…” To this end, “IFALPA advocates bleed air free designs as an ultimate solution” and notes that “filters and detection systems should be improved and installed.”)

2. ASRS (2017) “Aviation Safety Reporting System incident ACN: 1437845” Aviation Safety Reporting System, National Aeronautics and Space Administration, Moffett Field, California (This is an example of a fume event incident report from a commercial pilot in Jan. 2017. Per their report: “During climb out, we noticed an odor in the cockpit that seemed to be like dirty socks or wet carpet…The captain went to the back of the aircraft to check [if the odor was present in the cabin]. When he returned, he determined that the fumes were starting to have an effect on both of us…We decided to divert. We began using oxygen…By this time, in my opinion, we both were becoming more and more incapacitated. Both of us were having problems concentrating on the tasks at hand. We were given priority landing by ATC...emergency equipment met the aircraft...By this time, it seemed that we were nearly unable to follow instructions, but managed the aircraft to a gate.” In 2016-17, the NASA Aviation Safety Reporting System logged 341 smoke/fire/fume events in 2016-17. Of those, 119 events involved the air conditioning system. And, of those 119 smoke/fume events, there were 19 emergency landings, 16 flight delays/cancellations, 13 precautionary landings, and eight aircraft were evacuated. (NIOSH presentation at the Aerospace Medical Association Annual Scientific Meeting, May 6, 2019))

3. AAIU (2016) “Report no. 2016-013: Serious incident Boeing 737-8AS, EI-EFB near Stansted, United Kingdom, 18 Sept. 2014.” Air Accident Investigation Unit of Ireland, Dublin, Ireland (This investigative report describes a flight during which noxious fumes were detected in flight deck during the descent phase which necessitated the pilots to don oxygen. The probable cause was “residual contamination in the air conditioning system” from an oil leak in the APU. The report describes the maintenance history of the APU and engines on that aircraft during the 18 days prior to this incident, and highlights the significant challenges in identifying and rectifying the source of the oil fumes, despite multiple reports.)

4. ICAO (2015) “Guidelines on education, training, and reporting practices related to fume events,” Circular 344-AN/202, International Civil Aviation Organization, Montreal Canada (This circular describes how ICAO member states can develop relevant advisory material to ensure that airline workers are trained to recognize and respond to the presence of oil/hydraulic fluid fumes inflight. ICAO notes that “there may be implications to flight safety from exposure to oil or hydraulic fluid fumes sourced to the aircraft air supply system if crew members are either impaired or incapacitated during a
flight. Therefore, there is an expected safety benefit to preventing the occurrence of fume events or reducing occupant exposure to fumes, should they occur.”

5. CIAIAC (2014) “Interim Statement A-008/2013: Accident occurred to aircraft Boeing B-757-300, registration D-ABOC, operated by Condor Flugdienst GmbH, at Gran Canaria airport on 22 March 2013,” Civil Aviation Accident and Incident Investigation Commission, Madrid, Spain (The Spanish aircraft accident investigation authority published an interim report into its investigation into a report on inflight exposure to fumes on a B757 during a flight from Hamburg, Germany to Gran Canaria, Spain. The crew had reported air supply system sourced fumes in the flight deck and cabin. The first officer had felt dizzy and donned his oxygen mask. After landing, the pilots and cabin crew had been instructed to stay onboard during system troubleshooting to identify the potential source of the fumes. When fumes again filled the cabin, two of the cabin crew developed symptoms serious enough to be administered oxygen and transferred to hospital, and they were later diagnosed with neurotoxin poisoning. Their symptoms were consistent with exposure to oil fumes, but the maintenance technicians only identified deicing fluid contamination in the APU on their aircraft, not oil. Four days later, during a positioning flight, intense fumes again filled the flight deck and cabin. The pilots donned oxygen and the purser and first officer both reported numb tongues and irritated throats. The cause of the second incident was not identified. The Spanish authority classified the first incident as an accident and is continuing to investigate, in partnership with the German BFU.)

6. AAIB (2013) Bulletin no. 3/2013, Boeing 757-28A, G-FCLA (EW/G2012/10/09), UK Air Accidents Investigation Branch, UK Department for Transport, Aldershot, England (UK accident investigator report describes an aircraft that filled with oil fumes/smoke from a faulty APU after arrival, requiring the cabin crew to evacuate the aircraft. The next day, oil fumes contaminated the flight deck air supply on takeoff, but the pilots did not don their oxygen masks until they had symptoms at the top of climb, at which time they initiated an emergency diversion.)

7. BFU (2012) “Bulletin: Accidents and incidents during operation of civilian aircraft, November 2011” German Federal Bureau of Aviation Accident Investigation, Braunschweig, Germany (German investigative report describes a commercial airline flight on Nov. 18, 2011 during which the engine oil contaminated the aircraft supply air and the first officer was partially incapacitated. The first officer’s blood tested positive for one form of tricresyl phosphate (TCP), a neurotoxic additive in aviation engine oil.)

8. AAIB (2009) Bulletin no. 6/09, Boeing 757, G-BYAO (EW/C2006/10/8), UK Air Accidents Investigation Branch, UK Department for Transport, Aldershot, England (UK accident investigative report describes incident during which pilots donned oxygen and declared MAYDAY upon exposure to oil fumes inflight. Maintenance staff returned the aircraft to service prematurely because their efforts to identify the fumes source on the ground did not include high-power engine runs. The fumes returned on the subsequent flight. AAIB recommended that Boeing explicitly include high power engine runs in its “fault isolation manual” for maintenance in response to oil fume exposures, and reiterated its 2007 recommendations to EASA/FAA for a flight deck warning system for oil fumes in the bleed air.)

flugslysa), Reykjavik, Iceland (Icelandic authority reported on a smoke/fumes incident during the climb phase of flight on a B757. A worn fuel pump failed during climb, which allowed fuel to contaminate the engine oil reservoir. The engine seals could not contain the fuel/oil mixture, so it leaked into the engine compressor and contaminated the bleed air. The cabin and flight deck filled with white smoke and the captain initiated a diversion. The report notes that “aircraft system design weakness was revealed, as smoke could travel unnoticed and unhindered from the engine and to the flight deck.”

10. CAA (2008) “Flight Operations Department Communications (FODCOM) 17/2008” UK Civil Aviation Authority, Safety Regulation Group, Aviation House, Gatwick, West Sussex, England (UK aviation regulator recommends that airlines ensure that flight crew are trained to immediately don oxygen masks if smoke/fumes are suspected.)

11. AAIB (2007) Bulletin no. 4/2/07, Bombardier DHC-8-400, G-JECE (EW/C2005/08/10), UK Air Accidents Investigation Branch, UK Department for Transport, Aldershot, England (UK accident investigative report recommends that the FAA and EASA require a flight deck detection and warning system for oil smoke/mist given evidence of compromised flight safety when pilots are exposed to oil fumes.)

12. ATSB (2007) “Pilot incapacitation: analysis of medical conditions affecting pilots involved in incidents and accidents 1 January 1975 to 31 March 2006” Australian Transport Safety Bureau, Aviation Research & Analysis Report – B2006/0170 (Australian aviation safety authority reports that the second most common cause of pilot incapacitation was due to toxic smoke/fumes, of which 25% were due to carbon monoxide.)

13. SAAIB (2006) “Investigation report concerning the serious incident to aircraft AVRO 146-RJ 100, HB-IXN operated by Swiss International Air Lines Ltd. Under flight number LX1103 on 19 April 2005 on approach to Zurich-Kloten airport” Swiss Aircraft Accident Investigation Bureau, Berne, Switzerland (Swiss aviation safety authority attributes inflight incident of copilot incapacitation on approach to exposure to oil fumes that could have been prevented.)


15. CAA (2004) “Cabin air quality” CAA Paper 2004/04, Research Management Department, Safety Regulation Group, UK Civil Aviation Authority, Aviation House, Gatwick Airport South, West Sussex, England (As part of an investigation into pilot incapacitation, UK regulator sampled duct linings on two commercial aircraft and identified TCP oil additives.)


recommends that the US aviation regulator require bleed air monitoring with flight deck indication and investigate/report on the need for and feasibility of installing air cleaning equipment to address bleed air contamination during ground operation, normal flight, and air-quality incidents.)

18. CAA (2002) “Flight Operations Department Communications (FODCOM) 21/2002” UK Civil Aviation Authority, Safety Regulation Group, Aviation House, Gatwick, West Sussex, England (UK aviation regulator recommends that airlines ensure that flight crew are trained to immediately don oxygen masks if smoke/fumes are suspected and that flight/cabin crew are advised of necessary post-flight actions following exposure to smoke/fumes. Note: In Feb. 2011, the CAA republished part of this document as “CAP 789: Requirements and guidance material for operators.”)

19. SHK (2001) "Report RL 2001:41e "Accident investigation into incident onboard aircraft SE-DRE during flight between Stockholm and Malmo M County, Sweden," Statens Haverikommission Board of Accident Investigation, Stockholm, Sweden (Report on pilot incapacitation during a commercial flight in Sweden involving an engine oil leak. Because measured levels of oil-based contaminants were below occupational exposure limits, the report did not definitively attribute pilot incapacitation to oil fumes, but rather, exposure to “probably polluted air.” Investigators recommended that flight crew be trained to immediately don oxygen and that airlines develop an action plan for crews and aircraft after landing.)

20. CAA (2001) "Flight Operations Department Communication (FODCOM) 14/2001" UK Civil Aviation Authority, Safety Regulation Group, Aviation House, Gatwick, West Sussex, England (UK regulator recommends that airlines train flight deck and cabin crew to recognize and respond to toxic fumes caused by engine/ECS malfunction that could incapacitate them inflight. This includes training cabin crew to monitor the flight deck if smoke/fumes are present or suspected.)

21. CAA (2000) "Flight Operations Department Communication (FODCOM) 17/2000" UK Civil Aviation Authority, Safety Regulation Group, Aviation House, Gatwick, West Sussex, England (UK aviation regulator notes that one or both pilots can be incapacitated by exposure to oil fumes and recommends that airlines educate flight deck and cabin crew that one or both pilots can be incapacitated by exposure to smoke/fumes, and train flight deck crew to don oxygen masks immediately.)

22. PCA (2000) “Technical report on air safety and cabin air quality in the BAe146 aircraft,” (excerpt) Parliament of the Commonwealth of Australia, Senate Rural and Regional Affairs and Transport Legislation Committee, Senate Printing Unit, Canberra, Australia (Australian Senate committee report concluded that health/safety problems reported by crewmembers are not unique to the BAe146 aircraft (Sec. 6.2), that pilots underreport fume events (Sec. 6.18), and that the Australian aviation authority should introduce regulations specifying air quality monitoring and compulsory reporting requirements for all passenger jet operators (Ch. 6, Rec. 1 and 3).)

23. ATSB (1999) “British Aerospace Plc BAe 146-300, VH-NJF. Occurrence brief no. 199702276,” Australian Transport Safety Bureau, Canberra, Australia (Australian accident investigator reported on an incident during which two of three flight crew members experienced symptoms that prevented them from carrying out their flying duties. The report noted that oil fume events are not new, rare, or
specific to one aircraft type. It expressed “particular concern” over flight safety implications of
exposure and recommended further investigation into the health impact on passengers and crew.)

         Directorate, Toxicology Division, Wright-Patterson Air Force Base, Ohio (USAF-commissioned study
         exposed rats to oil fumes. Report notes a greater neurotoxic impact associated with inhalation of TCP
         oil additives than with oral dosing. Authors recommend particular caution when working with vapor
         phase lubricants that contain TCPs.)

25. Kelso, AG; Charlesworth, JM; and McVea, GG (1988) "Contamination of environmental control
         systems in Hercules aircraft: MRL-R-1116, AR-005-230," Australian Government Department of
         Defence, Defence Science and Technology Organisation, Melbourne, Australia (Royal Australian Air
         Force report describes air sampling conducted on Hercules aircraft. Measurements confirm exposure
         to hydrocarbons as well as TCPs in the air filter bags. Authors recommend that charcoal filters for the
         bleed air supply be investigated.)

         54(8): 738-740 (Review of 89 smoke/fume events on US military aircraft from 1970 to 1980, many of
         which were described as “incapacitating to some degree.” Article concludes that “smoke/fumes in the
         cockpit is not a rare event and is a clear threat to flight safety.”)

27. Paciorek, KL; Nakahara, JH; Kratzer, RH (1978) “Fluid contamination of aircraft cabin air and
         breathing oxygen” SAM-TR-79-34, Report by Ultrasystems Inc. for USAF School of Aerospace
         Medicine, Aerospace Medical Division, Brooks Air Force Base, Texas (USAF-commissioned
         investigation into the impact of fluid contamination on aircraft cabin air and breathing oxygen.
         Researchers measured “significant quantities of toxic compounds” when a line rupture was simulated
         onto a hot surface.)

28. Montgomery, MR; Wier, GT; Zieve, FJ; et al (1977) "Human intoxication following inhalation
         intoxication by a navigator on a C-130A aircraft due to exposure to engine oil fumes inflight. He
         experienced neurological impairment and gastrointestinal distress and “by the time the plane landed,
         he had difficulty standing.”)

         for turbine oil byproduct contamination of an aircraft cabin environmental system” NTSB/SIR-84/01,
         PB84-917006, National Transportation Safety Board, Washington, DC (The NTSB reviewed the reports
         of 10 unexplained crashes, all on turboprops equipped with the same engine type, and launched an
         inquiry into whether or not exposure to aerosolized engine oil could explain the pilot incapacitation.
         The agency acknowledged that “the potential flight safety issue concerns all turbine engines using
         synthetic turbine oil and supplying compressor bleed air for the aircraft cabin environmental control.”
         The NTSB partnered with the two parties that had the most to lose if a positive association was found,
         and introduced a known quantity of Exxon 2380 engine oil into the compressor section of a Garrett
         TPE331 engine. The team measured the oil-based airborne contaminants downstream of the
compressor section that, on an aircraft, would be released into the flight deck air. However, in all but one trial, they installed a glass filter in the sampling line and only measured the gaseous contaminants, even though bleed air on the incident aircraft had not been filtered. In that one trial, the researchers collected unfiltered oil mist on a filter, but for a shorter duration (15 minutes) and at a low temperature (160°F). Even though the test conditions did not reflect the on-aircraft conditions, the study concluded that “no evidence was developed to support the hypothesis of pilot incapacitation due to bleed air contamination.”

30. Crane, CR; Sanders, DC; Endecott, BR; et al (1983) "Inhalation toxicology: III. Evaluation of thermal degradation of products from aircraft and automobile engine oils, aircraft hydraulic fluid, and mineral oil," Aviation Medicine Report FAA AM-83-12, Civil Aeromedical Institute, US Federal Aviation Administration, Oklahoma City, Oklahoma (FAA researchers exposed rats to smoke/fumes generated by heating 3ml samples of engine oils from 300-600°C, and noted time to incapacitation and death. The team assumed that carbon monoxide (CO) was the most toxic constituent of oil fumes, and surmised that there would have been inadequate CO to explain pilot incapacitation on the 10 crashed planes. They did not appear to consider that the pilots would have been exposed to CO under reduced cabin pressure (and, thus, reduced oxygen) conditions, and with likely co-exposure to PAN which would have further impaired oxygen-carrying capacity of hemoglobin. The researchers did acknowledge that if the oil fumes in the bleed air tested by the NTSB study had not been filtered – as on the crashed aircraft - then “a significant toxicity could be associated with breathing oil mist.”

31. Treon, JF; Cappel, JW; Cleveland, FP; et al. (1955) “The toxicity of the products formed by the thermal decomposition of certain organic substances.” Am Ind Hyg Assoc Quarterly, 16(3): 187-195 (US Air Force-commissioned study with test animals inhaling pyrolyzed aviation engine oils. Authors concluded that inhaling the heated oils increased the toxicity considerably and that exposure to the oil fogs “produced pneumonitis and degenerative changes of the brain, liver, and kidneys.”

32. Armstrong, HG (1939) “Noxious fluids and gases in aviation: hot oil fumes” (pp. 178-180), In: Principles and Practice of Aviation Medicine, Aero Medical Research Laboratory, United States Army, Published by The Williams & Wilkins Company, Baltimore, Maryland (The author of this aviation medicine textbook is a Captain in the Medical Corps of the US Army. He notes “several cases” of breathing hot oil fumes that pilots had brought to his attention. The symptoms were “similar to carbon monoxide poisoning and were at first mistaken for it.” He notes that the high concentrations of oil fumes referenced in animal studies would not occur in aircraft, but “the effects of lower concentrations are obviously sufficient to be dangerous to safety in flight.”)

For copies of these reference materials or related questions, contact
J. Anderson, Industrial Hygienist
AFA-CWA, AFL-CIO
judith@AFAnet.org or 206-932-6237.