COMMENT RESPONSE DOCUMENT (CRD) TO ADVANCE NOTICE OF PROPOSED AMENDMENT (A-NPA) 2009-10

"Cabin Air Quality onboard Large Aeroplanes"

Executive summary

The Agency published the Advance Notice of Proposed Amendment (A-NPA) 2009-10, dated 28 September 2009, to initiate a discussion around a debate which deals with a specific source of cabin air quality degradation onboard Large Aeroplanes, i.e. air contamination by engine or Auxiliary Power Unit (APU).

The goal was to expose the Agency's understanding of the subject and also to collect from stakeholders detailed information on events and experiences involving cabin air contamination by engine or APU.

A confidential questionnaire was included at the end of the A-NPA, and stakeholders were invited to respond and provide supporting documents.

This CRD summarises the information and comments received by the Agency.

After the review of existing and on-going research studies and the analysis of the information collected by the A-NPA, the Agency concluded that:

- based on currently available reports and evidences, there is no safety case that would justify an immediate and general rulemaking action,
- a causal relationship between the reported health symptoms and oil/hydraulic fluid contamination has not been established. As there is no conclusive scientific evidence available, the Agency is not able to justify a rulemaking task to change the existing designs or certification specifications.

This topic will nevertheless be continuously monitored by the Agency, and some recommendations are provided to further improve the knowledge in the fields of toxicity and health impact of oil fumes, and bleed air filter and monitoring technologies.

Reactions to this CRD should be submitted via the CRT by clicking the '*add a general reaction*' button. Please indicate clearly the applicable paragraph.

Explanatory Note

I. General

1. The purpose of the Advance Notice of Proposed Amendment (A-NPA) 2009-10, dated 28 September 2009, was a discussion around an on-going debate which deals with a specific source of cabin air quality degradation onboard Large Aeroplanes, i.e. air contamination by engine or Auxiliary Power Unit (APU). The goal was to expose the Agency's understanding of the subject and also to collect from stakeholders detailed information on events and experiences involving cabin air contamination by engine or APU. This was intended to get a better assessment of the rate of occurrences and of the encountered symptoms. A confidential questionnaire was included at the end of the A-NPA, and stakeholders (flight crews, cabin crews, operators, large aeroplanes manufacturers, National Aviation Authorities (NAAs)) were invited to respond and provide supporting documents. This document provides a summary of the information and comments received by the Agency. After the review of existing and on-going research studies conclusions and the analysis of the information collected by this A-NPA, the Agency has performed an analysis and provides its conclusions.

II. Consultation

2. The A-NPA 2009-10 was published on the EASA web site (http://www.easa.europa.eu/) on 28 September 2009.

   By the closing date of 8 January 2010, the European Aviation Safety Agency ('the Agency') had received the following responses and comments.

   On-line questionnaires open to stakeholders (flight crews, cabin crews, operators, aeroplane manufacturers, NAAs): total 406 responses including flight crews (232), cabin crews (160), operators (7), NAAs (4), large aeroplane manufacturers (2).

   The A-NPA comments received through the CRT tool: 150 comments from 30 organisations and individuals (Operators and associations of operators (8), manufacturers and association of manufacturers (5), NAA (4), staff unions (8), other industry (2), individuals (3)).

   Other documents: 68 emails providing supporting documents or experiences, and 7 sets of papers and documents.

III. Publication of the CRD

3. All A-NPA comments received have been acknowledged and incorporated into this Comment Response Document (CRD) with the responses of the Agency.

4. In responding to comments, a standard terminology has been applied to attest the Agency's acceptance of the comment. This terminology is as follows:

   - **Accepted** – The comment is agreed by the Agency and any proposed amendment is wholly transferred to the revised text.
   - **Partially Accepted** – Either the comment is only agreed in part by the Agency, or the comment is agreed by the Agency but any proposed amendment is partially transferred to the revised text.
   - **Noted** – The comment is acknowledged by the Agency but no change to the existing text is considered necessary.
   - **Not Accepted** - The comment or proposed amendment is not shared by the Agency

5. The Executive Director Decision will be issued at least two months after the publication of this CRD to allow for reactions of stakeholders regarding eventual possible misunderstandings of the comments received and answers provided.

6. Such reactions should be received by the Agency not later than 1 August 2011 and should be submitted using the Comment-Response Tool at http://hub.easa.europa.eu/crt.

IV. EASA analysis and conclusions

7. Synthesis of stakeholders opinions

Two kinds of predominant and opposed opinions have been received, which may be summarised as follows. For more details on those statements, please refer to chapter V below.

Some flight crews, cabin crews and their staff unions, some passengers:

Some of them are concerned first by the risk for health, and also by the safety risk.

Very limited supporting documents were received by the Agency (12 sets) to justify claims raised through the on-line questionnaires.

They are convinced that events are underreported and some of them ask for more transparency as well as better information for crews and passengers.

They think the problem is minimised by their airlines and National Aviation Authorities (NAAs).

They ask for research studies (especially about health impact or contaminants toxicity) and regulatory action.

They request to mandate bleed air filtration and monitoring or the design of bleed free systems.

Operators, aeroplane manufacturers, NAAs:

Cabin air quality is very good most of the time.

Reporting systems are adequate.

Based on statistics, contamination events are rare and not a safety threat.

The reports are difficult to analyse because of a lack of details and traceability to causes (odours/smokes have many potential sources in the cabin or cargo).

They are concerned by the Agency's "unscientific" approach using the on-line questionnaire; the Agency should give priority to safety related subjects.

There is no safety or health justification/substantiation to launch a regulatory action or modification of existing fleets.

Some of them support scientific research studies to improve the knowledge of this issue.

8. EASA safety assessment

The Agency is not aware of any accident (involving injuries or loss of life or substantial aircraft damage) for which cabin air contamination by engine or APU has been identified as the root cause.

The known reported serious incidents (involving impairment or incapacitation of crews) are rare and the safety analysis objective for such hazardous event is not put into question. We believe these events are not underreported. A regulation is already in place for this category of events through Directive 2003/42/EC of 13 June 2003 on occurrence reporting in civil aviation: it clearly identifies failures of engines or APU resulting in "Dense visible fumes or concentrations of toxic products sufficient to

incapacitate crew or passengers". It is the responsibility of each Member State to ensure that stakeholders comply with this Directive. The Agency does not intend to create another mandatory reporting system.

In such cases, the potential safety risk can be mitigated by existing procedures and equipments (including the use of oxygen masks).

Therefore, the Agency concludes that, based on currently available reports and evidences, there is no safety case that would justify an immediate and general rulemaking action.

Currently, the Agency carefully monitors the in-service fleet, and if safety-related deficiencies, which are under the Agency's scope of competences, are identified on a particular type of aeroplane, dedicated corrective actions would be taken towards this type. In addition, several studies are still on-going which could provide further evidence to be used for the evaluation of a potential safety issue and of possible remedial actions in the coming years.

Other minor events occasionally occur as a result of different possible reasons (like inappropriate maintenance actions or engine/APU mechanical failures), which are not considered as a threat to aviation safety. This kind of events, which may be classified as nuisance (because most of the time they are perceived as temporary bad smells), could probably happen more often than the rare serious events, and the Agency agrees it is possible that they are underreported. Based on the information we have, the rate of bad smell/smoke/fume occurrences is not known precisely but is less than 1 every 10,000 flights.

Remedial actions, covered under the existing regulatory framework, have been successfully identified and implemented for these minor events.

9. EASA health effect assessment

Health issues are not within the primary scope of the Agency's mandate. However, the Agency would take action whenever a health case is evidenced by competent health authorities which would require a change in the design of aircraft.

The Agency has reviewed the 12 sets of supporting documents sent by pilots and cabin attendants; the following remarks are raised based on this review:

- Symptoms seem to be generic compared to what can be found in the general population; potential causes are thus probably not limited to cabin air contamination by oil/hydraulic fluid fumes or smokes,
- No standard seems to exist for the evaluation of reported symptoms or for examinations (no epidemiological study),
- The extent of exposure to contaminants is not known: how many events and what were the concentrations and durations?
- The medical examination is often performed days after exposure, and the time between exposure(s) and examination is not always known,
- Pre-disposition or individual susceptibility: these parameters probably greatly influence the individual symptoms, perception of smells/fumes and reactions (e.g. events are reported where only one pilot notices something abnormal).

According to the existing literature and study reports, it is the Agency's understanding that a causal relationship between the reported health symptoms and oil/hydraulic fluid contamination has not been established. As there is no conclusive scientific evidence available, the Agency is not able to justify a rulemaking task to change the existing designs or certification specifications.

Further knowledge and evidence are required in a first step.

However, it should be noted that the Agency's competences are restrained. It may conduct an investigation into what is happening in the entire bleed air passages up to the cabin and the cockpit with respect to the air quality requirements as provided in the certification specifications. The Agency does not directly investigate health aspects.

10. EASA recommendations

Although the Agency has not found a justification to launch a regulatory change activity, this topic will be continuously monitored, and some recommendations are provided below to further improve the knowledge on exposure health issues and on technologies for bleed air filtering monitoring.

If in the future new elements are available and show that the occurrences of engine or APU contamination of bleed air is a serious threat for safety or health, then the Agency will take adequate corrective actions including considering regulatory changes options.

10.1 Performing medical or toxicity studies

Objectives: cooperation/coordination with competent authorities or organisations in order to:

- gather information and, if necessary, participate in studies, and explore the possibility of agreeing or transposing actions which could be taken by such authorities or organisations;
- identify the need for conducting complementary studies or launch regulatory tasks on several topics which are not under the scope of competences of the Agency.

The identified studies/tasks should, therefore, be conducted by the competent health authorities and/or independent research institutes, although the chairmanship by an intergovernmental body or entity, or the European Commission or competent EU Agencies, would be an asset.

Benefits:

- Gather information and recommendations on health issues.
- It may provide guidance for complementary studies.
- It could identify the need for regulatory tasks to which the Agency could contribute.

Drawback:

- Health issues are not within the primary scope of the Agency's mandate; the Agency can only provide advice/recommendations.

The following topics are identified by the Agency as relevant:

a. Medical studies on pilots and flight attendants

Some independent studies of pilots and flight attendants would be performed, with the objective to better define the health impact of exposure to oil fumes on board commercial aircraft. This should not be limited to crews operating on a certain type of aircraft or territory; instead, a statistically relevant sample of pilots and flight attendants should be selected from different States.

This kind of study could help to determine whether a general health issue exists or not.

b. A study on chemical substances toxicities in aviation oils and hydraulic fluids

The goal would be to identify toxic substances that could be forbidden or restricted in the manufacturing process of these fluids. The study would particularly evaluate the inhalation toxicity of the pyrolysed products and take into account the eventual effect of a reduced pressure environment typical of the airliners' cabin.

The study should consider liaising with the oil manufacturer NYCO who has already done a study on organo-phosphates toxicity and identified less toxic variants.

c. Definition of medical tests to be carried out after a fume incident

Define generic medical tests which should be performed by hospitals when receiving a person affected by a serious fume/smoke event.

These tests could be approved by the relevant medical authorities and provided to hospitals toxicology departments.

Note: On this subject, a "guide for health care providers" was published in the USA in August 2008. This project was funded by the FAA Office of Aviation Medicine and is part of a collaborative project between the Occupational Health Research Consortium in Aviation (OHRCA) and the Airliner Cabin Environment Research (ACER) Center of Excellence. This guide provides information about the health effects that may result after exposure to aircraft bleed air contaminants and makes recommendations regarding treatment methods.

10.2 Identify bleed air filtering and monitoring system technologies

Objectives: cooperation/coordination with other organisations/authorities in order to:

- Identify the chemical substance(s) (e.g. carbon monoxide) which could be used to monitor the presence of pyrolysed oil and hydraulic fluid in the bleed air stream or in the air stream being released to the cockpit and cabin.

- Identify existing sensors technologies which could be used to monitor the marker substance(s) identified in the first step above (to be installed in the bleed air stream or in the air stream being released to the cockpit and cabin (downstream from the mixing unit)). Characterise the efficiency, reliability and cost of the sensors. The sensor should be able to inform on contaminant concentration which would be used to set cockpit alerts and to initiate flight crew operational procedures and maintenance procedures (refer also to ASHRAE 161-2007 standard which provides recommendations on how to use these sensors).

- Identify bleed air chemical substances which should be filtered. This should include normal flight conditions and failure case conditions (abnormal oil or hydraulic fluid release through the air conditioning system).
- Identify filter technologies able to filter the substances identified above in the aeroplane environment (ECS or air conditioning system).

The results of those studies could be used to set new certification requirements and means of compliance for new types and in-service aircraft (if a rulemaking action is decided in the future).

Benefits:

- Gather information from on-going studies (see examples below),
- It may provide ideas for complementary studies,
- The Agency may contribute,
- Identify solutions if a rulemaking action is decided (impose filtering and monitoring).

Drawback:

The cost of the studies may not be balanced by an industrial application in the future as the concerned equipments may never be required.

Note: Some relevant studies are already on-going and should be reviewed as soon as possible, because they would also contribute to the objectives above:

- Cranfield University (UK) Cabin Air Sampling Study, phase 2, the in-flight measurement campaign, which intends to characterise the contaminants and their concentrations in normal operation and in case of "fume event". The final report is expected in 2011.

Note: Cranfield University published their final report on 10 May 2011. The Agency had not fully reviewed the content of the report at the time of publication of this CRD. The two parts of the report can be accessed on the Cranfield website using the following links:
https://dspace.lib.cranfield.ac.uk/handle/1826/5305
https://dspace.lib.cranfield.ac.uk/handle/1826/5306

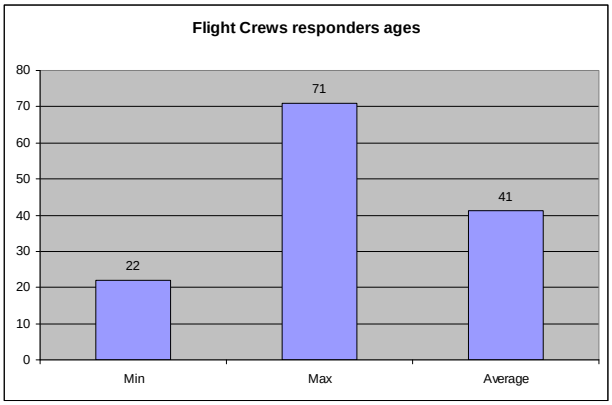
- FAA CoE RITE study "Aircraft air quality incidents" which will do an assessment of the frequency, severity and consequences of cabin air quality incidents where either engine oil or hydraulic fluid is inadvertently introduced to cabin air through the bleed air system.
- FAA CoE RITE study "In-flight measurements of cabin air quality" which will do an assessment of overall cabin air quality of aircraft during nominal operation.
- FAA CoE RITE study "Real time air quality sensing on aircraft" which will perform the "identification and enhancement of commercial off-the-shelf sensor technologies for application to real time measurements of air contaminants in aircraft (i) cabins, (ii) recirculation air systems and (iii) bleed air systems".

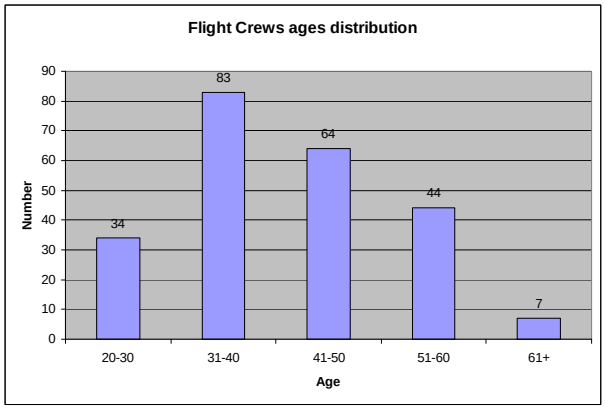
V. Comments and suggestions provided by stakeholders

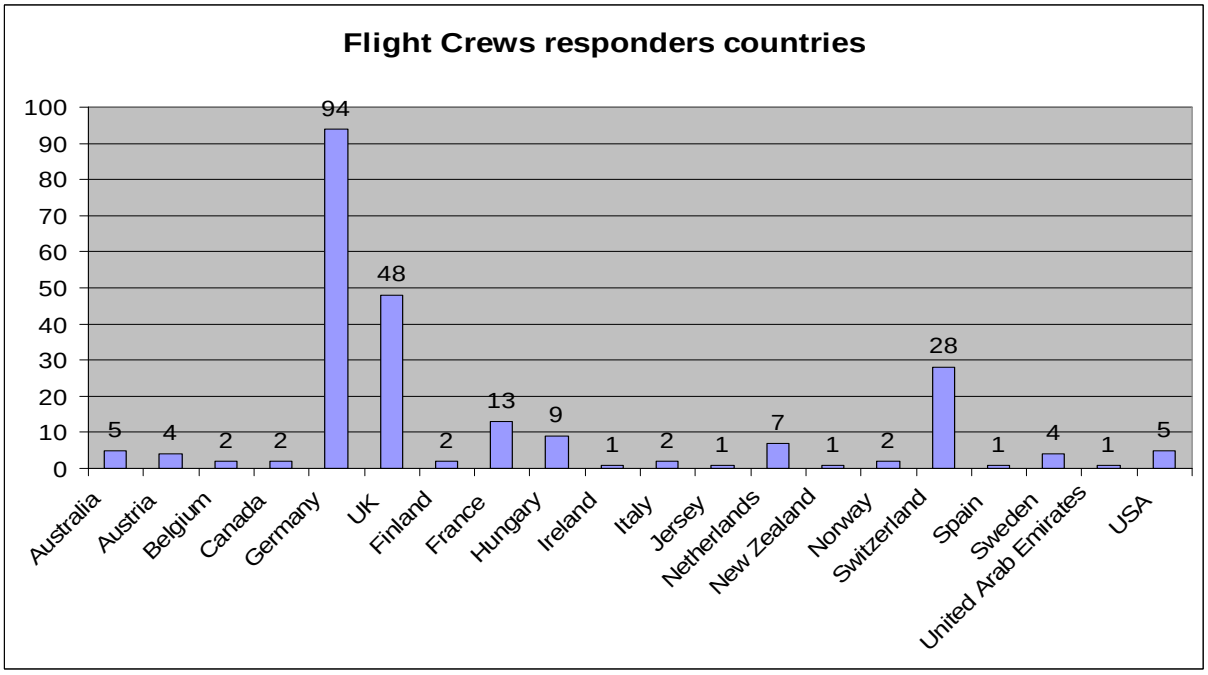
11. Flight Crews

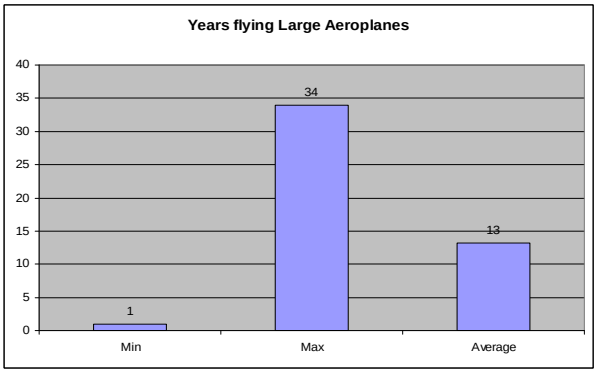
Responses to the on-line questionnaire:
232 responses were received.

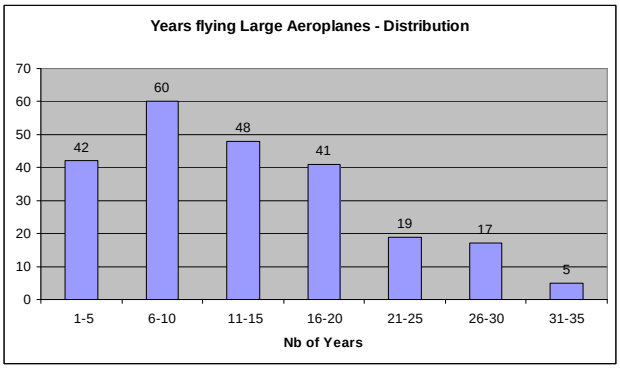
a. Information on responders

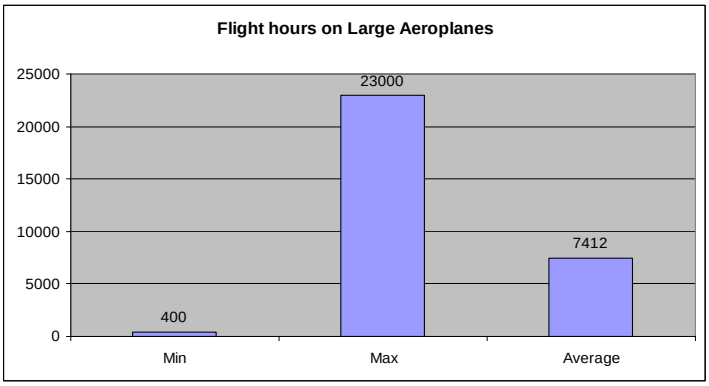








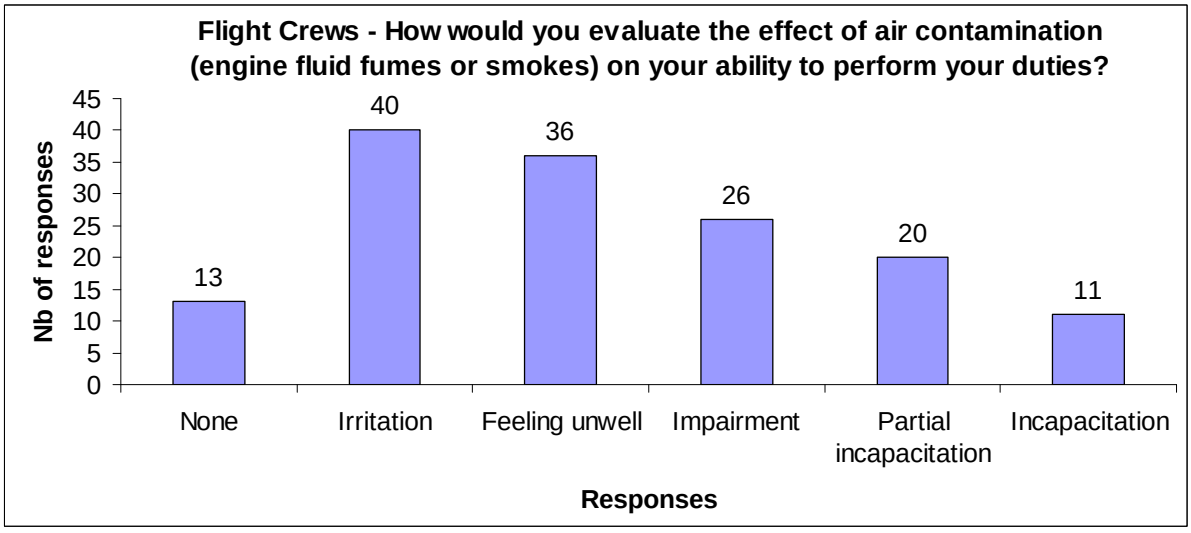




b. Responses to questions

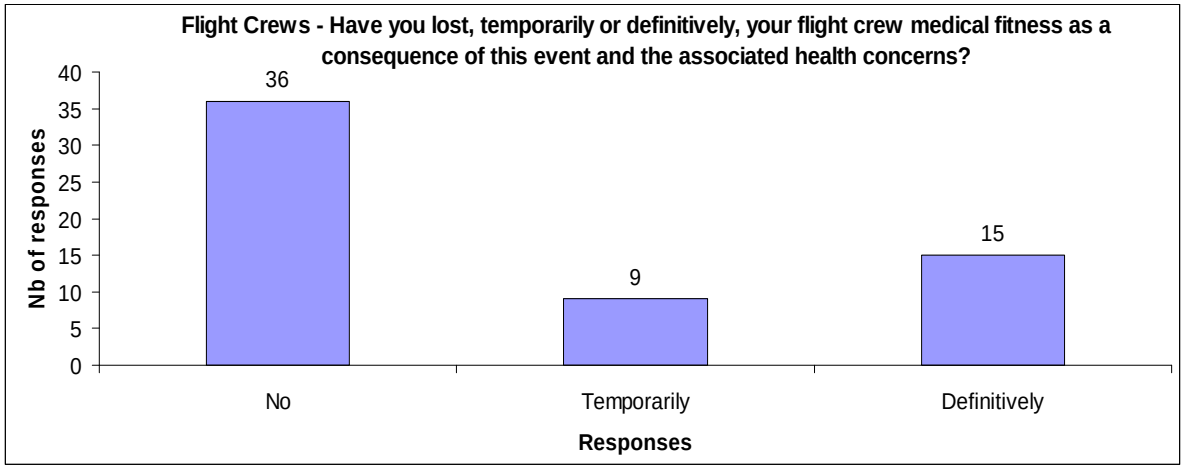
1. Cabin air contamination events

- Among the 232 responders, 146 (62.9%) pilots encountered a situation where cabin air was contaminated by engine or APU.
- Among these 146 pilots:
  - 42 (28.8%) assert they have evidence documents they can share with the Agency,
  - The worst case event had the following effects on their duties performance:
    - None: 13 (8.9%),
    - Irritation: 40 (27.4%),
    - Feeling unwell: 36 (24.7%),
    - Impairment: 26 (17.8%),
    - Partial incapacitation: 20 (13.7%),
    - Incapacitation: 11 (7.5%).



2. Health effects

- Among these 146 pilots, 60 (41.1%) of them declared having experienced a serious health concern directly linked to the exposure to air contamination, and 27 (45%) of them assert having detailed factual evidence available.
- Following these events and health concern, 39(65%) pilots are still suffering from health concerns, 36 (65%) of them never lost their crew medical fitness, 9 (15%) lost it temporarily and 15 (25%) lost it definitively.



However, only 8 pilots sent documents to the Agency to support their responses.

3. Reporting systems

- Among the 146 pilots having encountered a cabin air contamination, only 46 (31.5%) reported their event to their NAA.
- Overall, 102 (44%) pilots consider that their reporting system is adapted to cabin air contamination event, and 130 (56%) pilots believe it is not adapted.

4. Suggestions for improvements

The following remarks and suggestions were made (mainly by pilots believing that their system is not adapted):

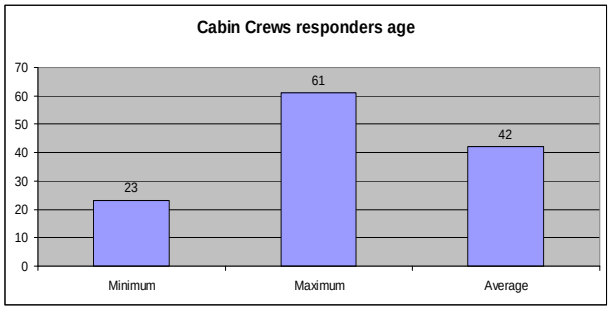
- There are different points of view among airline staff or manufacturer staff; some of them, including some pilots, tend to consider fume/smoke events as normal, or a nuisance, or non-events; however, other individuals take them more seriously considering that the most severe events may induce safety or health issues,
- Events are underreported to the civil aviation authorities, because of the portion of airline staff who consider fumes events as a nuisance or low priority item; hierarchy may not agree with crews willing to report a fume event,
- Reporting systems lack transparency, they should permit direct and maybe anonymous direct reporting by the employees to the civil aviation authorities or investigation office (instead of going through the airline); some pilots suggested that the Agency collects reports too,
- Some pilots suggest having a standard reporting form (for the airline) dedicated to this issue, maybe with a check-list helping crews to mention all the relevant details; alternatively, a special section could be created in the standard reporting form;
- Some pilots believe the reporting form should not be too complicated; however, to encourage crews reporting,
- If possible, the reporting form should be standardised by ICAO/EASA,
- An internet platform feeding a database has also been suggested,
- A good reporting system is not enough; crews should also be better informed on fumes/smokes events risks, medical symptoms from serious events, and guided on the reporting criteria and on what to do in case of serious events,
- Data on fume events is difficult to collate; troubleshooting on ground to reproduce and identify the failure is not always successful, which can leave the aeroplane still flying with a potential risk of new fume event; this also contributes to the underreporting,
- Some aircraft show a higher smoke/fume events rate than others,

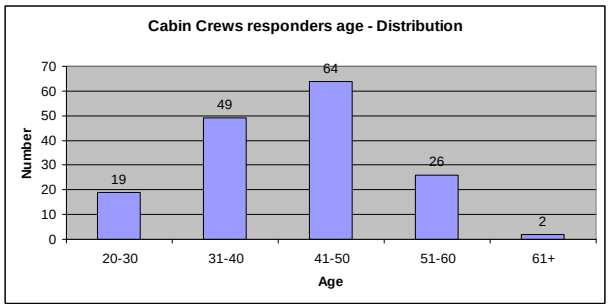
- Some pilots would like to have a cabin air monitoring system able to detect air contamination (type and origin if possible) with associated operational and maintenance procedures,
- Passengers are often not advised of the problem,
- Hospitals toxicology departments should be provided with the tests to be carried out after a fume incident; these tests should be approved by the relevant authorities.

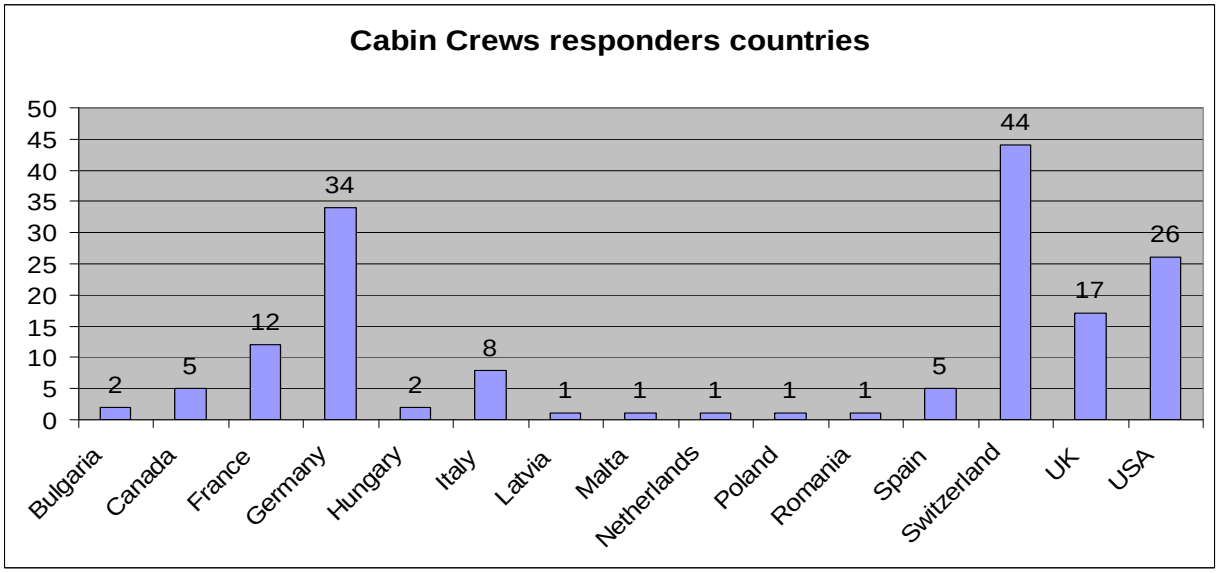
12. Cabin Crews

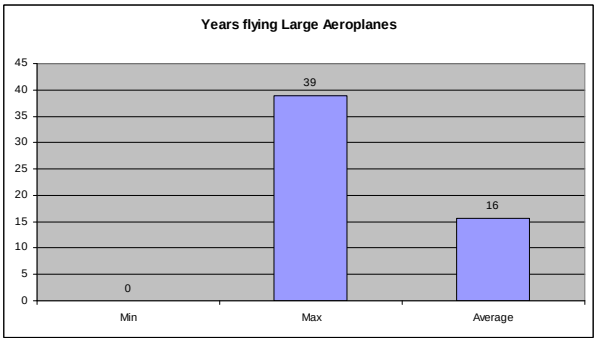
Responses to the on-line questionnaire:
160 responses were received.

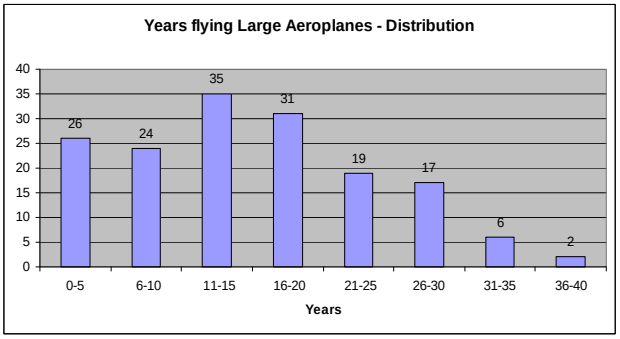
a. Information on responders

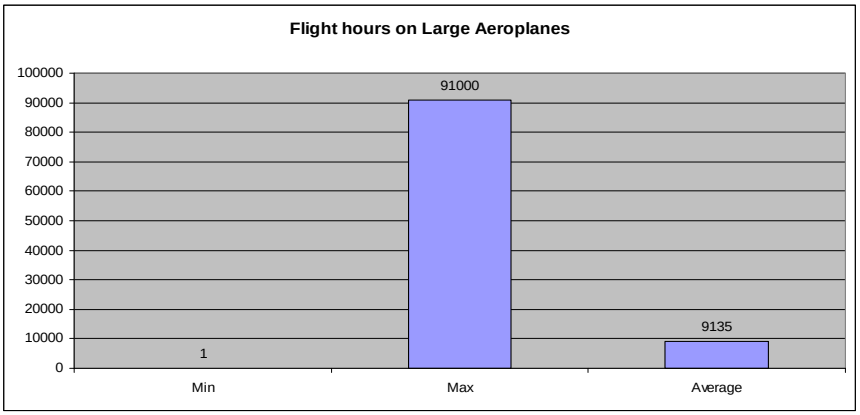








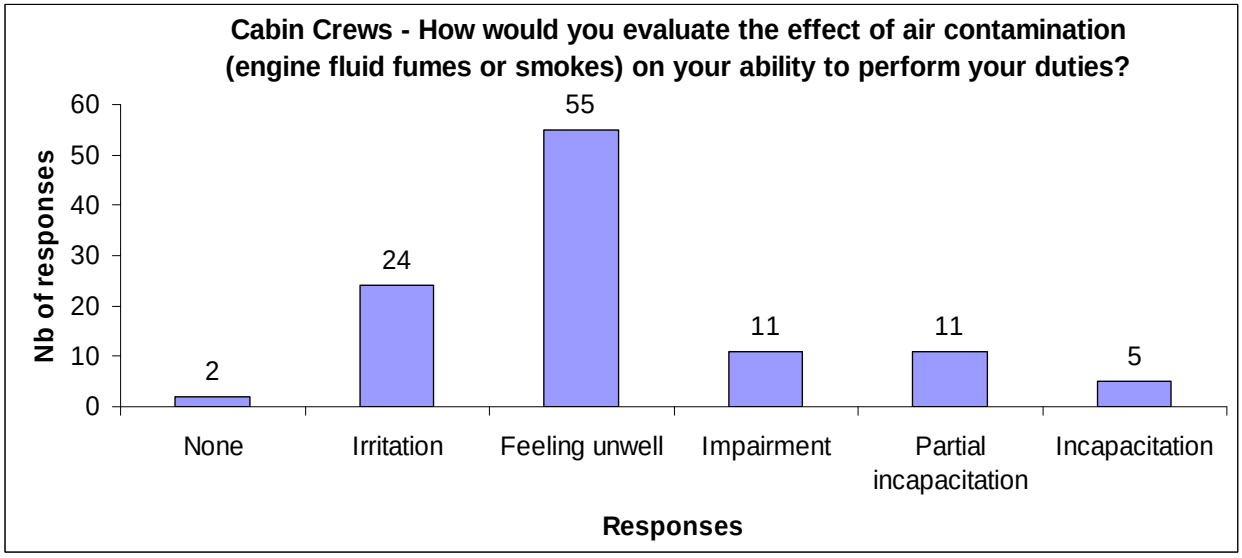




b. Responses to questions

1. Cabin air contamination events

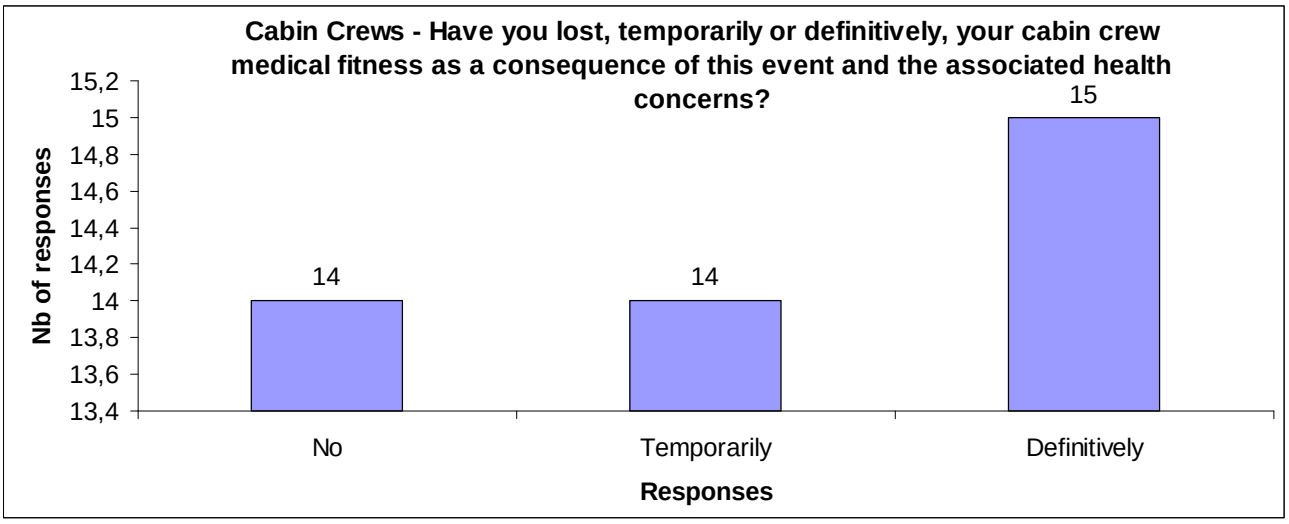
- Among the 160 responders, 108 (67.5%) Cabin Crews (CC) encountered a situation where cabin air was contaminated by engine or APU.
- Among these 108 CC:
  - 34 (31.5%) assert they have evidence documents they can share with the Agency,
  - The worst case event had the following effects on their duties performance:
    None: 2 (1.9%),
    Irritation: 24 (22.2%),
    Feeling unwell: 55 (50.9%),
    Impairment: 11 (10.2%),
    Partial incapacitation: 11 (10.2%),
    Incapacitation: 5 (4.6%).



2. Health effects

- Among these 108 CC, 43 (39.8%) CC declared having experienced a serious health concern directly linked to the exposure to air contamination, and 26 (60.5%) of them asserts having detailed factual evidence available to share with the Agency. Following these events and health concern, 29(67.4%) are still suffering from

health concerns, 14 (32.6%) of them never lost their crew medical fitness, 14 (32.6%) lost it temporarily and 15 (34.9%) lost it definitively.



However, only 4 cabin crews sent documents to the Agency to support their responses.

3. Reporting systems

- Among the 108 Cabin Crews having encountered a cabin air contamination, only 19 (17.6%) reported the event to their NAA.
- Overall, 62 (38.8%) Cabin Crews consider that their reporting system is adapted to cabin air contamination event, 98 (61.2%) believe it is not adapted.

4. Suggestions for improvements

The suggestions and remarks from Cabin Crews are included in the Flight Crews' list of suggestions (refer to previous chapter), and the following specific points are added:

- There should be approved bleed air filters in addition to a cabin air monitoring system.
- Some Cabin Crews feel pressured by Pilots and management, thus they would like being able to report incidents by filling in an online form; one of them suggested that it should also be accessible to passengers,
- Some Cabin Crews are also concerned by odours coming from ingestion on ground by the air conditioning system of exhaust gases from engine/APU of their own aeroplane, or from nearby aeroplanes (e.g. when taxiing towards the runway),
- Cabin Crews are mostly unaware of how and when to report a smoke/fume event.

13. Flight Crews and Cabin Crews supporting documents

The Agency received 12 sets of documents from pilots (8) and cabin crews (4). Some of them are retired or have lost their medical fitness.

These documents were requested by the Agency to support fume/smoke event occurrences and their consequences on flight safety and health concerns.

Note: This limited number has to be compared to the EASA on-line questionnaire responses: 27 pilots and 26 cabin attendants declared that they have detailed factual evidence showing that they experienced a serious health concern directly linked to the exposure to cabin air contamination.

Crew members generally complain about one or several of the following health symptoms: dizziness, headache, fatigue, disturbed cognitive function, memory

problems, tingling sensations (e.g. in fingers), balance problems, depression, gastro-intestinal problems.

The nature of the received documents included:

- Flight crew report,
- Technical Log Book copies,
- Medical laboratory tests results: blood tests (chemicals, pesticides, specific enzymes), urine tests, DNA tests, Brain-specific proteins, Volatile Organic Compounds in fat cells, Neuronal and Glial antibodies, Electromyography and Nerve Conduction Studies, Single Fibre Electromyography, Neuropsychometric Battery Assessment, Autonomic Nervous System testing,
- Examination reports: Psychiatry, Neurology, Psychology, Neuropsychology.

The following diagnoses were provided:

- Loss of fine motor dexterity,
- Anomalies in working memory,
- Chemical-induced nervous system injury,
- Toxic chronic encephalopathy and autonomic neuropathy,
- Exposure to toxic substances, probably engine oils.

The Agency notes that the nature of the submitted documents seems to be similar to the submissions received by the UK COT in 2006-2007 for doing their "review of the cabin air environment, ill-health in aircraft crews and the possible relationship to smoke/fume events in aircraft".

14. Staff Unions

The information was received through the following channels: comments on the A-NPA posted through the EASA CRT tool and two letters sent separately.

a. General highlights

CFDT (Confédération française démocratique du travail, France), CDU (Cabin Union Denmark), ETF (European Transport Workers' Federation), FSC-CCOO (Federación de Servicios a la Ciudadanía de CCOO, Spain), CGT (Fédération des Transports CGT, France), KAPERS (Swiss Cabin Crew Union), UNIONEN (Trade union, Sweden) provided identical comments. They support the intention of the Agency to collect detailed information in order to evaluate the threat for the health of aeroplane occupants and create new airworthiness standards.

ECA (European Cockpit Association) also welcomed the Agency initiative "to identify if a problem with cabin air quality exists or not".

VC (Vereinigung Cockpit, Germany) recognises that some of their members are worried about the potential risk from cabin air contamination by engine oil and that in case of doubt about any risk for health it should be scientifically investigated. For this reason, they began their own investigation in 2006.

UFO (Independent flight attendants organisation, Germany) does not agree that "Bleed Air Event/Fume Event" are seldom incident that would not lead to degradation of flight safety.

GCAQE (Global Air Quality Executive, UK) support the Agency's action and they proposed research items and recommended that future jet and turboprop have a bleed free architecture.

IPA (Independent Pilots Association, UK) opinion is that limited testing currently being undertaken and proposed, together with mandating adherence to servicing procedures, is not adequately addressing its members concerns or the problem. Unless the problem is addressed and corrected, further incapacitations will occur and impact on flight safety.

b. Events and frequency

CFDT, CDU, ETF, FSC-CCOO, CGT, KAPERS, UNIONEN believe that it cannot be stated with certainty that air contamination events are rare as there is not enough research or reporting on these events. They believe that events are underreported (see next chapter on "Reporting").

They believe that there are more than 2 single incapacitations reported by UK CAA. The Agency verified the data available between 1999 and 2006 which shows 2 cases of incapacitation and 3 cases of partial incapacitation. UK CAA provided the Agency with events figures for 2007- June 2009, but the severity level of each event is not available.

ECA recognised that it is a challenge to find reliable data on cabin air quality. They think that the open EASA questionnaire would probably lead to non-statistically relevant and "polluted" data. "ECA suggests the Agency to run a dedicated study, with similar questions as in the A-NPA, based on a limited but statistically relevant sample of pilots. This would allow the Agency to base its evaluation on a scientific and relevant set of data."

UFO declared that airlines do not provide air contamination reports to the BFU and the LBA. They believe that the occurrences are not rare; this is based on the 31 reports they have received from an airline operating 13 B757-300, between 1 January and 31 August 2009.

Since 2009, because of media attention and communication on this subject, they observe an increase in the number of reports.

They also referred to the list of events in the book entitled "Aviation Contaminated Air Reference Manual," from Captain Michaelis S., dated 2007.

VC explained that, according to their investigation and comments from pilots and flight attendants, bleed air contamination events happen frequently although they are often not reported and not taken seriously. The first documented and published case of flight crew incapacitation caused by engine oil contamination would be dated 1977 ("Human intoxication following inhalation exposure to synthetic jet lubricating oil", Clinical toxicology, pp 423-426).

Concerning the UK CAA figures presented in the A-NPA (104 flight deck occurrences between 1999 and 2006), VC also referred to an AAIB bulletin 04/2007 which summarised the outcome of a CAA database review: they identified 153 cases of fumes, abnormal odour or smoke or haze in the flight deck in the three-year period to 1 August 2006, among which 119 cases "probably" resulting from conditioned air contamination; details on a number of cases were "limited", and "in many of the cases the crew members had found it difficult or impossible to establish the source of the contamination". In 40 cases adverse physiological effects were reported by one or both pilots, and a diversion was made in 31 cases.

The same AAIB bulletin also indicated that "in December 2006 the Flight Operations Group of the United Kingdom's Royal Aeronautical Society and the Guild of Air Pilots and Navigators (GAPAN) published a specialist paper entitled 'Smoke, Fire and Fumes in Transport Aircraft'" and this report states that: "during the 36 months examined (by IATA), there occurred an average of two and a half smoke events each day."

VC also added that in Germany, such statistical figures have not yet been published by LBA. However in March 2009, the answer to a parliamentary question said that since

2004, 156 reports of fumes or odours have been received by the LBA, which represents 4.3% of the 3620 received reports.

GCAQE acknowledged that in the absence of a reliable reporting system or air quality monitoring requirements, it is difficult to estimate the frequency of smoke/fume events on commercial aircraft. However, they believe that events are not rare; they refer to the UK COT study that estimated that pilots experience smoke/fume events on 1% of flights and that maintenance identifies the smoke/fume source on 0.05% of flights.

On the USA fleet, it has been estimated 0.86 documented events per day (study over an 18 months period based on publicly available smoke/fume event data). In Canada, data from three airlines have shown a range from 0.09 to 3.88 events per 1000 flight cycles depending on aircraft type and airline.

GCAQE mentioned surveys in UK concluding that only a small portion (4-5%) of the events are reported.

c. Reporting of events

According to CFDT, CDU, ETF, FSC-CCOO, CGT, KAPERS, UNIONEN, reporting events is not done very often because of ignorance as to the signs of oil leakage and subsequent cabin air contamination (pervading smell like that of "old socks" or "smelly feet", blue mists in the cabin, etc…) or because of fear of reporting an incident.

To justify this statement, they refer to the book entitled "Aviation Contaminated Air Reference Manual," from Captain Michaelis S., dated 2007, particularly chapter 12. It is stated that less than 4% of contaminated events are reported to aviation authorities, based on a 2001 BALPA (British Air Line Pilots Association) survey (600 short haul pilots in a major UK airline).

They would like the Agency to initiate a mandatory reporting system for fume events and to legislate on the training of both pilots and cabin crew to recognise and respond to fume events.

UFO believes that events are underreported because many events are undetected for lack of knowledge, and also the fear for restrictions.

VC also explained that contamination events are underreported and not taken seriously enough in their view, and they also recommend that pilots could report directly these events to the Agency who should then regularly publish the data.

VC recommends better informing flight crews, cabin crews, maintenance staff, accident investigation organisations, doctors about cabin air contamination issues.

GCAQE explained that events are underreported and recommended enforcing current regulations on supply air quality and incident reporting.

IPA also received feedback from its members that events are clearly underreported.

d. Safety implication

CFDT, CDU, ETF, FSC-CCOO, CGT, KAPERS, UNIONEN believe that it cannot be stated with certainty that air contamination events' impact on flight safety is very low as there is not enough research or reporting on these events.

They provided a list of 5 references with statements about the toxic effects of oil fumes which may impair the performance of flight crews after inhalation, and even lead to hazardous effect:

2001: "Incidents have been reported of impaired performance of flight crew…events could have been caused by inhalation of agents… leaking from oil or APU and contaminating the Environmental control system." (CAA AD 002-03-2001)

2002: "oil leaks and cabin / flight deck odours must be regarded as a potential threat to flight safety, they should not be dismissed as a mere nuisance and should be addressed as soon as possible."(BAe ISB 21-150 2001 / ISB 21-156, 2002)

2003: "Any oil leaking from an engine, entering the aircraft customer bleed offtake, is classified as HAZARDOUS" (Rolls Royce, Germany 2003, BRE air quality Conference, London)

2004: "This amendment adopts a new airworthiness directive (AD), applicable to all BAE Systems (Operations) Limited Model BAe 146 series airplanes, that requires repetitive detailed inspections of the inside of each air conditioning sound-attenuating duct, and corrective actions as necessary. This action is necessary to prevent impairment of the operational skills and abilities of the flightcrew caused by the inhalation of agents released from oil or oil breakdown products, which could result in reduced controllability of the airplane. This action is intended to address the identified unsafe condition." (FAA AD 2004-12-05)

2006: "The serious incident is attributable to the fact that on approach to Zurich Airport the cockpit filled with fumes which caused a toxic effect, leading to a limited capability of acting of the copilot. These fumes were caused by an oil leak as a result of a bearing damage in engine No. 1." "The medical examination of the copilot after the flight showed that during the flight toxic exposure took place." (Swiss Federal Department of Environment, Transport Energy and Communications Investigation Report No u1884 by the Aircraft Accident Investigation Bureau, 2 March 2006)

GCAQE provided a list of references of cabin air contamination events and investigations (between 1970 and 2007) which illustrates that "smoke or fume in the cockpit is a threat to flying safety because of acute toxic effects".

e. Health effects

CFDT, CDU, ETF, FSC-CCOO, CGT, KAPERS, UNIONEN consider that studies are now available giving indications that the health of aircraft occupants may be severely affected by the inhalation of and contact with gases and vapours of lubricants, anti-freeze agents and others. They provided a list of statements and references of various natures mentioning the potential health effects of contaminants, in particular organophosphates; included is the reference to the book entitled "Aviation Contaminated Air Reference Manual," from Captain Michaelis S., dated 2007, which itself provides a compilation of references aiming at justifying that a public health problem exists.

UFO stated that findings on possible health risks exist for more than 40 years and made reference to the WHO task group on Environmental health criteria for Tricresyl Phosphate (WHO EHC 110, 1990) as well as to three professors (D.Henschler, M. Abou-Donia, C.van Netten).

GCAQE provided a list of references of cabin air contamination events and investigations (between 1970 and 2007). In general reports "focus on neurological symptoms which are the primary complaint".

Chronic effects are mentioned from some studies references: "the primary symptoms reported and documented by exposed crew and passengers indicate central nervous system (CNS) damage (e.g., chronic headaches, difficulty concentrating, memory problems, slowed mental processing and response time, balance problems, depression, and visual irregularities)".

GCAQE also explained that: "A proportion of the crews and passengers exposed to oil fumes have reported symptoms consistent with peripheral nervous system damage (e.g., paraesthesias, tremor, abnormal gait). These symptoms are consistent with exposure to the six "ortho" isomers of TCP (of which the tri-ortho isomer, TOCP, is one)

which have been affirmed as being highly toxic to the peripheral nerves in animal studies, both by a German toxicologist in the late 1950s (D. Henschler) and the worlds' leading aviation engine oil manufacturer, Mobil Oil (now Exxon-Mobil), forty years later (Mackerer, C.R., Barth, M.L., Krueger, A.J.; et al (1999) "Comparison of neurotoxic effects and potential risks from oral administration or ingestion of tricresyl phosphate and jet engine oil containing tricresyl phosphate," J. Toxicol. Environ. Health). TOCP has received the most public attention because of its role in some mass accidental poisonings (Morgan, JP and Penovich, P (1978) "Jamaica ginger paralysis: forty-seven year follow up" Arch. of Neurol.), although the sources referenced in the previous sentence have both recognized that the mono- and di-ortho isomers of TCP are five to 10 times more toxic than TOCP".

"In addition to the neurological symptoms described above, damage to the upper airways and lungs have been reported and documented, causing symptoms including chest tightness, difficulty taking a full breath, wheezing, coughing, and shortness of breath. As well, some crewmembers report symptoms such as skin rash/sensitization, gastrointestinal upset, muscle weakness, and joint pain, and psychiatric symptoms such as depression."

IPA declared that they have "nine members who have lost their aviation medical certificates and are undergoing medical investigations due to problems they have reason to believe emanate from cabin air contamination linked to engine oil leaks, their symptoms having manifested themselves either during or immediately after such events". In addition, "Many other members have reported suffering less severe symptoms and have recovered relatively quickly". The concerned members are currently operating or have operated the BAe146 or B757 aircraft.

f. Research and studies

CFDT, CDU, ETF, FSC-CCOO, CGT, KAPERS, UNIONEN commented that there has been and is still great difficulty in collecting and interpreting the mounting data and identifying toxic/irritant products in oil substances used in the airline industry. The physiological effects of gases and vapours in cabin air are now becoming clear and the defining of maximum acceptable quantities or concentrations must become a subject for legislation and standards.

They also referred to previous studies on engine oil toxic components (including pyrolysis products), pointing to:

- TCP (Tricresyl phosphate) and in particular the ortho-isomers (TOCP, DOCP, MOCP)
- TMPP (trimethylolpropane phosphate) which may be formed under certain conditions after heating of oils containing both TCP and TMP (trimethyl phosphate)
- Sensitisers like N-phenyl-L-naphthylamine, PAN
- Carbon monoxide

They ask that studies include the potential impact of exposure to the mixture of these and other chemicals in a reduced pressure environment.

They suggest that the Agency review all data and determine if a less toxic alternative oil can be recommended that would be compatible with given aircraft engines/APUs. Ultimately, all of the engine oils should be analysed for their base stock content (rather than relying on the analysis of the oil companies), as well as for the potential to form TMPP, and temperature range of TMPP formation.

Concerning cabin air contaminants measurement studies, they reported the position of a professor in applied toxicology in Australia who says that "the only effective method is active, real-time analysis of the suspended chemicals and their concentration using a "direct reading machine on the aircraft during flight"".

"ECA suggests the Agency to run a dedicated study, with similar questions as in the A-NPA, based on a limited but statistically relevant sample of pilots. This would allow the Agency to base its evaluation on a scientific and relevant set of data."

UFO suggested an epidemiological study on the effects of cabin air contaminated with organophosphates.

VC recommended using the knowledge and recommendations from international experts in toxicology, for example: Prof. Chris Winder (AUS), Prof. Abou-Donia (USA), Prof. DeBoer (NL). This should include measurements of Pyrolisis products and human toxicology.

GCAQE explained that "Trying to identify a single contaminant that is responsible for the diverse neurological and respiratory symptoms reported by exposed aircraft occupants, and to define a "safe" level for all occupants is an impossible task", because "hundreds of chemicals have been identified in the supply air of commercial aircraft contaminated with engine oil and others, like the neurotoxin trimethylolpropane phosphate (TMPP), have been proposed as a potential exposure risk when ingredients in the engine oil base stock react with TCPs at elevated temperatures. TMPP formation has been recorded at temperatures as low as 250ºC, which is within the range of an operating aircraft engine".

Thus GCAQE urges the Agency to not attempt to define "safe" exposure limits for a subset of individual chemicals that may or may not even be monitored, as recently attempted by the authors of European Standard EN4618.

Meanwhile they recommend funding research on the inhalation toxicity of pyrolysed synthetic jet oils and hydraulic fluids in a reduced pressure environment.

GCAQE also made reference to "NYCO-sponsored research undertaken at the University of Washington investigating selected neurotoxicity of various organophosphate additives including TCPs and triisophenylphosphate (TIPP). Both sets of additives were found to produce "a non-negligible potential" of neurotoxicity, while the newly discovered Nyco-proposed alternative organophosphate additive is claimed to be significantly less neurotoxic. This matter should be fully investigated and supported by the Agency to further reduce the health and safety risks associated with inhalation and dermal exposure to pyrolyzed/heated synthetic jet engine oils."

GCAQE recommend health studies of pilots and flight attendants to better define the health impact of exposure to oil fumes on commercial aircraft, starting with crew members who fly or have flown on the BAE146 or RJ aircraft.

IPA commented the on-going cabin air sampling study at Cranfield University and reported that the veracity and effectiveness of this testing is questioned by various experts in the field. They advice research on the toxicity of some constituents in aircraft engine lubricating oils when they become pyrolised (little research on this subject has been found).

g. In-service aeroplanes measures

CFDT, CDU, ETF, FSC-CCOO, CGT, KAPERS, UNIONEN don't agree that "Most of the modern Large Aeroplanes use a fine High Efficiency Particulate Air (HEPA) filtration".

They also believe that the nature and concentrations of all hazardous compounds to which filters may be exposed need to be established in order that such filters are effective and effective over long periods.

"Another consideration with the use of filters or converters is that they could possibly mask the evidence of an oil leak by the removal of the odour normally associated with such events, but fail to remove any contamination which could affect flight crews". CFDT "feels that filtration should only ever be used in conjunction with good

maintenance practices/design and less toxic oils in reducing the likelihood of the oil leakage in the first place, and not as a substitute".

CFDT, CDU, ETF, FSC-CCOO, CGT, KAPERS, UNIONEN ask the Agency to issue a directive requiring bleed air cleaning to prevent fume events.

Seeing that BAE Systems and Quest International (both UK firms) developed an active air purification system (which eliminates contaminants and pathogens), they conclude that there is still a preoccupation in UK with continued "leaking of oil into the cabin air".

VC recommends extending the BAE146 airworthiness directives (AD) LTA-Nr 2001-349/2 to all other type of aeroplanes.

This in fact corresponds to CAA UK ADs: CAA AD 002-03-2001 and AD 003-10-2002. The first AD requires inspecting engine oil seals, APU and ECS jet pump and air conditioning pack for signs of oil contamination. The second AD requires inspecting air conditioning sound attenuating ducts for signs of oil contamination.

They also recommend improving checklists by including the term "Smell" and providing clear procedures for the flight crew in such situations (fire, smoke, fumes and smell).

GCAQE recommend for bleed air aircraft, to mandate the installation and operation of air cleaning and monitoring equipment intended to remove and monitor pyrolysed engine oil and hydraulic fluid, either in the bleed air stream or downstream of the mix manifold in real time and with flight deck indication. The equipment should be proven effective to remove and monitor what may be routine "low level" exposures (e.g., may be characterised by an odour without any visible smoke or fumes) as well as less-frequent but higher level exposures (e.g. may be characterised by visible and irritating smoke/fumes).

GCAQE recommend that airlines be required to train crew members to recognise and respond to potential fume events, whether characterised by an odour, a visible smoke/fume, particular symptoms, or any combination thereof, and require airlines to report such events to the Agency.

h. Regulation

CFDT, CDU, ETF, FSC-CCOO, CGT, KAPERS, UNIONEN stated that there is "a sizable (and growing) body of literature on the association between exposure to oil fumes and acute and chronic symptoms reported globally by crews and passengers alike (ACARM, 2007)."

Note: ACARM stands for "Aviation Contaminated Air Reference Manual", S. Michaelis.

They "believe there is ample justification for regulations that dictate bleed air cleaning and monitoring with flight deck indication to:

(1) prevent exposure to oil fumes;

(2) alert crew members if they are exposed in flight; and

(3) enable maintenance workers to more effectively identify and remedy the contamination upon landing."

Reference is made to the ASHRAE (American Society of Heating, Refrigerating, and Air-Conditioning Engineers) standard 161-2007 which has the same recommendations.

VC, UFO provided a similar recommendation.

CFDT, CDU, ETF, FSC-CCOO, CGT, KAPERS, UNIONEN believes that the terms "harmful" and "hazardous" products used in the EASA Certification Specifications (CS-25, CS-E, CS-APU) should be identified and maximum concentrations specified.

CFDT, CDU, ETF, FSC-CCOO, CGT, KAPERS, UNIONEN made comments on ASD (AeroSpace and Defence Industries Association of Europe) standards EN 4618 and pr

EN 4666. This includes a request to decrease the proposed limit for formaldehyde in pr EN 4666 and to add a limit for other oil toxic agents, in particular TCP, in both standards.

CFDT, CDU, ETF, FSC-CCOO, CGT, KAPERS, UNIONEN also expressed their concern that existing standards and safety recommendations are not binding.

GCAQE propose that:

- the Agency recommends that all future commercial jet and turboprop aircraft be built with bleed free architecture (like the B787).
- For bleed air aircraft, mandate the installation and operation of air cleaning and monitoring equipment intended to remove and monitor pyrolysed engine oil and hydraulic fluid, either in the bleed air stream or downstream of the mix manifold in real time and with flight deck indication. The equipment should be proven effective to remove and monitor what may be routine "low level" exposures (e.g., may be characterised by an odor without any visible smoke or fumes) as well as less-frequent but higher level exposures (e.g. may be characterised by visible and irritating smoke/fumes).

15. Operators

The information was received through the following channels: the on-line questionnaire, comments on the A-NPA posted through the EASA Comment Response Tool (CRT), one letter sent separately by email.

a. General highlights

Responses to the on-line questionnaire:

The Agency received 8 responses from 7 companies: CAI First (Italy), KLM (Netherlands), Flybe (UK), Ryanair (Ireland, 2 identical responses recorded), TAP (Portugal), TUIfly (Sweden), Air Southwest (UK).

The operators' fleet sizes ranges from 5 to 206 large aeroplanes.

The age of the companies varies from 1 to 90 years.

The number of flight hours per year ranges from 1400 to 400,000, with an average of 116,757 FH.

Operators agreed with the statement of the A-NPA and the results of previous studies that cabin air quality is generally very good.

The AEA (Association of European Airlines), British Airways, KLM, SWISS (Swiss International Airlines) expressed their concern about the Agency "unscientific" approach by opening an on-line questionnaire where flight crews and cabin crews can provide their own "reports of anecdotal events" and "promote their personal views".

The AEA, KLM, SWISS also considers that this subject should be of a lower priority for the Agency and that resources should be allocated to subjects which would bring safety improvements. They consider that there is no safety justification to launch such regulatory actions "which are driven by social agenda's or public perception/media".

IACA (International Air Carrier Association) provided similar opinion as AEA.

British Airways do not believe that there is evidence to support new regulation in this area. In addition, they consider that online surveys open to anyone can only provide anecdotal information and cannot, therefore, be used as evidence to justify a decision on the need (or lack of need) for additional regulation.

IATA (International Air Transport Association) did not support the A-NPA or the on-line questionnaire, considering that the Agency should wait for on-going research outcome.

ATAA (Air Transport Association of America) explained that in their view air contamination events are very rare, based on US reporting system data; they also support research to be conducted first.

b. Statistical data

From the on-line questionnaire, 3 Operators (out of the 7 who replied) have statistical data on air contamination by engine or APU. However, only 1 Operator answered that it would share these data with the Agency, but no data has been received by the Agency.

Eurowings made a comment that they managed to drop down their smell complaints on BAE146 fleet by putting in place cleaning procedures for the air conditioning system and cabin/cockpit ducts. During cleaning procedure experimentation, they have noted after analysis that the cleaning residues were de-icing fluids contaminants and that they smelt like "old socks" (description often reported in the frame of bad smell of fume events).

Norwegian Air Shuttle has not had any reports regarding bad cabin air due to airleak from APU.

Moreover, IACA (International Air Carrier Association) stated that bleed air contamination incidents are very infrequent.

ATAA indicated an events rate of 2.7 events per million departures based on US airlines reporting system data (Service Difficulty Reports reported to FAA).

c. Safety implication

From the on-line questionnaire, the 3 Operators (KLM, Flybe, Air Southwest) having statistical data were asked what is the safety implication that comes out from the analysis of these events. The following answers were received:

- KLM declared that events involving crew incapacitation has never occurred at the airline,
- Flybe has not been able to conclude due to the variety in nature of reports involving smells and odours complaints/reports; a detailed work of records analysis and sorting would probably be necessary,
- Air Southwest provided a response which suggested that the issue is about some people being more sensitive to fume or smoke than the average. The responder suggested that a test is established to assess flight crews and cabin crews sensitivity; a test could also be done on a public sample to set a reference point. Then if these tests conclude that a significant portion of people (public and crews) are sensitive to fume or smokes, further investigation would be launched.

In addition, AEA, IACA comment to the A-NPA stated that there is no safety justification to launch a regulatory action. Reference was made to the inconclusive past studies and to the UK COT report conclusions.

British Airways shares the same opinion that there is no safety case.

d. Health effects

The AEA, as well as British Airways, KLM, SWISS underlined "the report of the UK Government's Committee on Toxicity, a comprehensive review of the scientific and technical evidence, which concluded that the available evidence does not support claims of long term ill-health attributable to cabin air contamination. Where there were some minor issues in the past (which had no impact on health), they have been addressed through Airworthiness Directives for those specific types of aeroplanes".

e. Reporting events

From the on-line questionnaire:

- Criterion for reporting to the Type Certificate Holder

Generally, the responses provided are not specific to the cabin air contamination. Instead, general criteria were mentioned: mandatory reporting occurrences, out of standard snags, reliability reports (in particular when complaints occur repeatedly), pilot reports, cabin crew reports, engineer's special report, passenger report, significant aircraft operation interruption.

One operator responded that smoke, fume and smell events are reported only when a component failure is identified.

- Criterion for reporting to the National Aviation Authorities

2 Operators use the same criteria as for reporting to the TCH.

3 Operators explained they will report only safety related events: 1 of them referred to criteria from the EASA and EU-OPS regulations, the other 2 companies referred to the company Flight Safety Department assessment based on a national directive for mandatory occurrence reporting (e.g. CAP 382 in UK which incorporates the requirements from EC Directive 2003/42/EC of 13 June 2003 on occurrence reporting in civil aviation),

1 Operator mentioned the reporting of technical incident reports and quality department decision,

1 Operator did not have a criterion to provide.

- Reporting system

5 out of the 7 Operators consider that their reporting systems are adapted to cabin air contamination events.

The following suggestions were made by the 2 other Operators:

- 1 declared that the events are very rare and have not shown the need to improve the reporting systems,

- 1 suggested updating directive 2003/42/CE to make it mandatory.

Note: Directive 2003/42/CE already mentions in its Annex 1 list of events to be reported

B (ii) (k) Systems "Leakage of hydraulic fluids, fuel, oil or other fluids which resulted in a fire hazard or possible hazardous contamination of aircraft structure, systems or equipment, or risk to occupants".

And B (iii) (c) 8. Propulsion "dense visible fumes or concentrations of toxic products sufficient to incapacitate crew or passengers".

British Airways confirmed, as stated in the A-NPA, that existing reporting requirements have enabled the identification and rectification of specific problems on certain aircraft

types. They also agree that these events have not resulted in any catastrophic accidents or fatalities and that the reported symptoms are variable in nature and usually minor in nature.

ATAA described the reporting requirement in USA based on 14 CFR 121.703(a)(5) which calls for reports made of:

"the occurrence or detection of each failure, malfunction or defect concerning… [a]n aircraft component that causes accumulation or circulation of smoke, vapor, or toxic or noxious fumes n the crew compartment or passenger cabin during flight."

Reports are made in the form of Service Difficulty Reports, and according to ATAA, the criteria are broad enough to cover contamination events by oil/hydraulic fluid/de-icing fluid. There is no need to develop or adopt a new regulation to track these occurrences. The SDR database is even considered over-inclusive because it contains reports of smoke/fume/vapour incidents that are not related to failure, defect or malfunction (conclusion after closer examination of the report).

Moreover, USA airlines have well-established internal procedures to submit FAA mandated reports; both cabin and cockpit crew is trained on these procedures in accordance with company manuals.

f. CS-25 improvement

From the on-line questionnaire:

Operators were asked if it would be beneficial to amend the current CS-25 certification specifications to better protect Large Aeroplanes from cabin air contamination by engine or APU.

3 Operators out of 7 considers that CS-25 needs to be amended:

- 1 suggested requiring a monitoring of engine and APU bleed air contaminant,

- 1 suggested requiring to draw air from outside instead of engines (like on the Boeing 787),

- 1 had no idea and would leave the decision to a working group.

The AEA, British Airways consider that there is no safety justification to launch a regulatory action.

g. Measures on in-service aeroplanes

From the on-line questionnaire:

Operators were asked if they would envisage proposing a modification of in-service aeroplanes to better protect from engine and APU bleed air contamination.

None of them envisaged this requirement.

The AEA, British Airways considers that there is no safety justification to launch a regulatory action.

Eurowings made a comment that they managed to drop down their smell complaints on BAE 146 by putting in place cleaning procedures for the air conditioning system and cabin/cockpit ducts.

SWISS informed that they are modifying their Avro RJ fleet installing the "Air Quest Manager" kit (provided by Quest International Ltd) to improve their cabin air quality.

h. Research

From the on-line questionnaire:

Operators were asked if they consider that further research should be conducted first.

4 Operators believe that research should be conducted:

- 1 suggested a cost/benefit analysis and a statistical analysis,

- 2 referred to the Cranfield university on-going study (in-flight measurement campaign), considering that this study has to provide guidance for measures and possible further research,

- 1 stressed that an accredited and impartial body should be selected but does not provide directions. In his view: "much research to date has been conducted by manufacturers whose aircraft types have been under question, manufacturers who claim they can supply filtration systems and medical bodies initiated by those who claim to have become medically effected - these naturally will not lead to an objective conclusion".

IATA referenced to the extensive scientific work and conclusions done by the UK COT. For them, this is the current reference point, and the Agency should monitor the on-going independent research by the UK Cranfield University launched following the COT recommendations; the conclusions would then be used to decide if further action is needed.

AEA, IACA, British Airways, KLM, SWISS, ATAA encourage the Agency to monitor on-going research (such as the one taking place in the UK Cranfield University) and/or conduct further research.

ATAA however acknowledges that, given the rarity of air contamination events, it is difficult for research to rely on in-flight testing to capture a statistically significant number of samples.

When the research has reached a conclusion, then, if there is scientific evidence that actions are required either in general or for specific aircraft types, the Agency should act accordingly.

16. National Aviation Authorities (NAAs)

a. General highlights

The information was received through the following channels: the on-line questionnaire, comments on the A-NPA posted through the EASA CRT tool, letters sent separately (mail or email).

Responses to the on-line questionnaire:

4 responses received: CAA UK, FAA (Federal Aviation Administration, USA), CAA Sweden, FOCA Switzerland

In addition, CAA Czech Republic provided by email some answers to questions without recording in the IPM questionnaire. These additional responses are nevertheless mentioned below.

In addition to the information presented below, the following general statements were received.

Austrocontrol (Austria) supported the decision to start a pre-rulemaking phase, especially starting by a better assessment of the rate of occurrences and of encountered symptoms.

LBA (Luftfahrt-Bundesamt, Germany) had no comments on the A-NPA.

b. Statistical data

Generally, all NAAs have databases in which they can track the reported cabin air quality events. Some of them have provided events data information to the Agency, as summarised in the following lines, after a review of their databases.

FAA

FAA performed, in July 2009, an internal review of events in their databases. FAA sent to the Agency the outcome of this review through a letter dated 10 Dec 2009. The main results are presented below.

Two types of databases were used, focusing on the time between January 1999 and November 2008: AIDS (Accident/Incident Data System) and SDRS (Service Difficulty Reporting System).

The search was conducted on "Air carrier/Commercial" operations within the USA using a search string that included the following keywords: "smell", "odor", "fume".

Summary: These investigations revealed that the number of events per flight is statistically very low (i.e., on the order of events per 1000,000 flights).

None of the reported events resulted in an accident.

See next paragraph "Safety implication" for FAA conclusion based on the content of these reports.

CAA Sweden

CAA Sweden provided by email a table of 20 events related to cabin air issue between 1998 and 2009, and many of them are related to the pressurisation system.

Only 3 events may be connected to a cabin air contamination issue, and 1 of them concerns a Small Aeroplane.

1 event does not report effect on occupants, 1 event reports discomfort, and 1 event reports crews discomfort and mild dizziness. These 3 events are described below:

- 1 event on a SA227 (Small Aeroplane) on 10/09/1998: During climb to cruise level, smoke entered the cabin and the crew decided to return to ESSB. The bleed air valve of the right engine was closed and the smoke disappeared while returning to ESSB. On final an "engine low oil pressure" warning came on for the right engine, which was shut down by the crew. The landing was uneventful. Trouble-shooting revealed that there was an old oil leak in the propeller hub, which had been subject to maintenance actions several times, but not completely cured. The basic fault was now identified.

- 1 event on BAE146 on 09/04/2008: During the approach into ESMS, two cabin crew members experienced a sudden sense of discomfort, with difficulties breathing, tingling sensations in the fingers and a light dizziness. A few passengers seated in the aft section felt a sense of change in pressure and discomfort. CA3 used oxygen for a few minutes, and felt shortly thereafter better. Landing uneventful. The remaining crew members and technician were briefed upon arrival. Suspected contaminated air.

- 1 event on BAE146 on 12/11/1999: During Cruise - The crew was to carry out three return flights between Stockholm and Malmo together. The flying time on the route is approximately one hour. During the first flight the purser experienced an unpleasant feeling of fainting. She told the other two cabin crew members about this and they stated that they had also experienced something similar. They did not recognise any special odour. The pilots had not noticed anything abnormal. During the subsequent flight one of the cabin attendants who was placed in the forward part of the cabin, experienced an odd pressure in the head, nasal itching and ear pain. The other two colleagues in the cabin also felt discomfort and the feeling of "moon walk" while working. The pilots, who did not notice anything abnormal during the second flight either, discussed whether the problem could possibly be due to some fault within the cabin pressure system. The third flight that same day was flown by the commander. During the flight, which took place at a cruising altitude of FL 280, all three members of the cabin crew experienced similar discomfort as during the preceding two flights, but more pronounced. During the first portion of the flight the pilots did not notice anything abnormal but shortly before they were to leave the cruising altitude the commander began to feel a mild dizziness. During the approach towards Malmö/Sturup airport when the aircraft was descending through FL 150 the co-pilot

suddenly became nauseous and donned his oxygen mask. Then, after an estimated period of ten seconds, the commander also became very nauseous and immediately donned his oxygen mask. After a few seconds of breathing in the oxygen mask the co-pilot felt better and thereafter had no difficulty in performing his duties. However, the captain felt markedly dizzy and groggy for a couple of minutes. He had difficulty with physiological motor response, simultaneity and in focusing. Finally he handed over the controls to the co-pilot. After having breathed oxygen a few minutes even the captain began to feel better and thereafter the pilots were able to accomplish a normal approach and landing on runway 17 without problems. Subsequent to the incident, the airline performed a trouble-shooting of the aircraft, which ascertained a minor external oil leak on engine # 2. An extensive technical investigation has been performed on the aircraft and on engine # 2. During engine test in test cell and flight test, air samples from the bleed air- and the air-conditioning system have been taken and analysed. The samples have not provided any indication of what/which chemical substances caused the symptoms, and no technical fault that can explain the incident has been found.

CAA UK

CAA UK provided a status update from their database of MORs (mandatory occurrences reports) for years 2007, 2008, 2009 (Jan-Jun). This complements the data already presented to the Agency in 2007 and presented in the A-NPA.

Overall, 355 occurrences were reported involving contaminated air on Large Aeroplanes between 1999 and June 2009. The yearly distribution is shown below:

Year	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009 (Jan-Jun)
Nr of events	8	9	26	10	8	9	8	26	116	97	38

Note: a peak of events (26) appears in 2001, then followed by a significant decrease in 2002 and 2003. This decrease in the number of events can be explained by the measures taken in 2001-2002 towards the two aeroplane types generating the majority of the events (BAE146 and B757); these measures consisted in inspections and corrective actions to limit the risk of oil leakage from APU and engines. Then, after a very calm period, an increase of the reported events can be seen, with a big step in 2007; this may be explained by a better reporting of the events. Years 2008 and 2009 seem to show another decrease trend.

Evaluation by the Committee on Toxicity of chemicals in food consumer products and the environment (COT).

The COT, an independent organisation in UK, was asked by the UK Department for Transport (DfT) to undertake an independent scientific review of data submitted by the British Airline Pilots Association (BALPA) due to concerns about the possible effects on aircrew health of oil/hydraulic fluid smoke/fume contamination incidents in commercial aircraft.

The COT published their report COT Statement 2007/06 in September 2007.

CAA UK also contributed to the study by providing statistical data after searching in their databases.

The following statement was made concerning smoke/fume contamination events:

An oil/hydraulic fluid smoke/fume air contamination incident is an event, in which a small quantity of oil/hydraulic fluid released into the compressor stage of the engine, due to an oil seal failure, is extracted into the bleed air supplying the aircraft air conditioning system resulting in the formation of an oil mist or odour in the aircraft. The leaked oil/hydraulic fluid is subject to a range of temperatures within the engine and aircraft air conditioning system that might cause thermal decomposition of the oil/hydraulic fluid. Not all odours detected within the aircraft cabin originate from oil contamination of the air supply, for

example, toilet and galley odours also occur, and it is not possible to define the cause of all smoke/fume air contamination incidents. It has been estimated from information provided by three airlines that overall, smoke/fume incidents associated with possible explanatory faults identified by engineers (engineering-confirmed smoke/fume incidents) occur in around 0.05% of flights (sectors) but that the incidence may be higher than this in some circumstances, depending on airframe, engine type and servicing.

c. Safety implication

Through the on-line questionnaire, NAAs were asked to assess the safety implication of cabin air contamination events.

In addition, other opinions have been provided by commenting the A-NPA document. These opinions and feedbacks are summarised below.

- CAA UK declared that the event rate has been estimated at 0.05% of all flights by the Committee on Toxicity and that there has been no significant safety effect to date. From their 2007 presentation to the Agency on reported events between 1999 and 2006, only 5 events involved some degrees of flight crew incapacitation.

- FAA analysed events from their database, see previous chapter.

While the latest survey (i.e., conducted in 2009) did not find any reports of pilots or flight attendants reporting that their performance was impaired, there were some events from earlier surveys (i.e. conducted in 1999 and 2000) where crew members did report impairment of their performance. There also have been a number of reports of foreign airline crew members having their performance impaired to the point that they had to be assisted in performing their flight duties or had to relinquish their flying duties during the flight.

Additional note: an observation from the latest survey results shows the "trial-and-error" nature of maintenance when applied to complex systems. For example, in several cases multiple events took place on the same airplane before a final "root cause" was determined and the problem fixed. The character of the air transportation system requires quick turn around times between flights and minimises the time allotted for maintenance actions. Maintenance difficulties are compounded when faced with subjective statements such as "electrical odor", "unusual smell", and "sweaty sock odor". It is believed that such occurrences may happen frequently. FAA will consider the need for additional guidance in this area to ensure that, when an air contaminant event is suspected, a diligent search is undertaken to locate all engine oil leaks, air cycle machine lubricant leaks, and hydraulic fluid leaks and repair them prior to further revenue service. However, these additional actions will require completion of the rulemaking action as reported in, "Report to the Administrator on the National Research Council Report, "The Airliner Cabin Environment and the Health of Passengers and Crew," prepared by The Airliner Cabin Environment Report Response Team (ACERRT), Feb 6, 2002.

- FOCA Switzerland believes there can be a safety hazard but with a low risk, due to procedures in place.

d. Health effects

By making reference to current AMC 25.1309 and systems safety analysis, FOCA Switzerland also recommended to improve the definition of failure conditions which may affect the health of the aircraft occupants and to provide additional guidance as it concerns their assessment during the initial design and the continued airworthiness.

e. Reporting systems

CAA UK, FAA, FOCA Switzerland, CAA Czech Republic consider that reporting systems are already adapted to cabin air contamination events.

However, FOCA Switzerland also recommended improving EASA AMC 20-8 "Occurrence Reporting" to provide guidance on events affecting the health of crew members and passengers and establishing the criteria based on which they need to be reported with particular emphasis to events where cabin air contamination or more generally degradation of the cabin air quality is or might be suspected.

Meanwhile, it has to be noted that AMC 20-8 already has provisions for reporting cabin air contamination events:

Paragraph B Systems "(11) Leakage of hydraulic fluids, fuel, oil or other fluids which resulted in a fire hazard or possible hazardous contamination of aircraft structure, systems or equipment, or risk to occupants."

Paragraph C Propulsion "(3) Failure or malfunction of any part of an engine or powerplant resulting in any one or more of the following:

[…] (h) Dense visible fumes or concentrations of toxic products sufficient to incapacitate crew or passengers;"

Note: Directive 2003/42/CE also applies and has the same provisions in its Annex 1.

CAA Sweden declared the reporting system should be improved in terms of "coding of details".

f. Certification Specifications

From the on-line questionnaire, only FAA considers that FAR Part-25 and CS-25 need being amended to better protect Large Aeroplanes from cabin air contamination by engine or APU. Rulemaking (i.e., either in support of EASA rulemaking or as a separate FAA rulemaking activity) could be initiated once industry research and FAA supported research (e.g., through their Center of Excellence) in this area is complete. FAA is open to consideration of increased monitoring and filtration of the cabin environment during normal and upset (i.e., failure) conditions. Their Center of Excellence (COE) on the cabin environment is performing research on instrumentation and air contamination. FAA believes that a thorough review of events and current regulations, in conjunction with research, should be conducted to ensure a balanced assessment is completed.

FOCA Switzerland recommended, in the AMC 25.1309, to improve the definition of failure conditions which may affect the health of the aircraft occupants and to provide additional guidance as it concerns their assessment during the initial design and the continued airworthiness.

Other items:

CAA-UK made a remark that, in addition to CS-25 provisions mentioned in the A-NPA, other provisions already exist for certification of engines and APU.

The Agency agrees: CS-E and CS-APU require determining the potential bleed air contaminants that can be generated by engines or APU defects and also require a safety analysis being done. The analysis considers a possible incapacitation of crew or passengers by contaminated bleed air. Characteristics of any possible contamination must be provided to the aeroplane manufacturer and the installer (refer to CS-E 690 and 510, CS-APU 320 and 210).

g. Measures on in-service aeroplanes

Concerning retroactive action on in-service aeroplanes, FAA explained that it should be considered and evaluated similarly as for CS-25/FAR Part-25 improvement through a rulemaking activity (based on a thorough review of events and current regulations, in conjunction with research).

CAA UK, CAA Sweden, FOCA Switzerland, CAA Czech Republic consider there is no need for retroactive measures.

h. Research

All NAAs (CAA UK, FAA, CAA Sweden, FOCA Switzerland, CAA Czech Republic) believe that further research should be first conducted.

CAA UK refers to the Cranfield university on-going study (in-flight measurements campaign) as the appropriate approach (the phase 2 report is now expected in 2011).

They also referred to the extensive work done by Committee on Toxicity which produced a report in 2007 concluding that:

"It was not possible on the basis of the available evidence in the BALPA submission or that sourced by the Secretariat and DH Toxicology Unit to conclude that there is a causal association between cabin air exposures (either general or following incidents) and ill-health in commercial aircraft crews. However, we noted a number of oil/hydraulic fluid smoke/fume contamination incidents where the temporal relationship between reports of exposure and acute health symptoms provided evidence that an association was plausible".

The Committee proposed research to ascertain whether substances in the aircraft cabin could potentially harm health. It stressed that the research should not focus on one substance, but include as wide a range as possible.

FAA is committed to support their COE (Center Of Excellence) research on the cabin environment (i.e. previously named ACER (Airliner Cabin Environment Research), now RITE (Research in the Intermodal Transport Environment)). Refer to the website: http://www.acer-coe.org.

The relevant research projects include "Aircraft air quality incidents", "In-flight measurements of cabin air quality", "Contaminant transport", "Real-time air quality sensing on aircraft".

FAA also provided a summary of 3 studies concluded between 1993 and 1999, which used in-flight measurements on cabin air quality of several airliners (Boeing B777, B737, B727, Mc Donnell Douglas MD-80). The conclusions of these studies were that the contaminants present in the air were at very low concentrations and should not pose a health hazard.

FAA also attached a list of 230 literature references (books, proceedings, reports, standards, journal articles, hearings, legal, websites) dealing with cabin air subjects.

CAA Sweden believes that research should be carried out to better understand "if there is a generic cause for these events". Then based on this research and the outcome from this questionnaire a rulemaking project could be launched (in case a widespread problem is identified).

FOCA Switzerland advised a risk assessment and technical possibilities versus cost.

17. Large Aeroplanes manufacturers

a. General highlights

Only 2 manufacturers responded to the on-line questionnaire: Dassault Aviation, Fokker Services.

Comments were also received through the CRT from: Airbus, ASD (Aerospace and Defence Industries Association of Europe), Boeing, Dassault Aviation, Fokker Services.

In addition, Embraer and BAE Systems sent their comments by email.

This makes a total of 6 manufacturers plus the ASD.

b. Statistical data

Fokker Service declared having statistical data on air contamination by engine or APU but cannot share it with the Agency. The reason is that these data are not considered reliable because their reporting depends on the Operators willingness and procedures of event reporting. However, a trend can be observed. The trends Fokker Service can distinguish are related to e.g. "wet sock smell", smoke and odours from e.g. ovens, occasional event of the smell of oils and crew complaints without any traceability to causes.

Airbus explained that they are not convinced that the EASA questionnaire is an appropriate scientific approach to acquire additional knowledge on frequency and severity of respective occurrences. Statistics provided on cabin air quality issues in general lack of appropriate categorisation and are often biased by public perception and individual perspective.

The ASD believes "that it is difficult to see how the general surveys contained within the A-NPA will help develop a better understanding of the subject. The responses cannot lead to the generation of meaningful data that will add to what is already well documented; they might simply result in a number of unsubstantiated claims of health being affected by cabin air events."

Boeing reminded that air quality studies have been conducted over the years by government agencies, independent researchers, universities, and industry and that they have shown that contaminant levels are generally low and consistently comply with applicable health and safety standards. However, Boeing continues to work with scientists to improve their understanding of cabin environmental factors.

Boeing mentioned that the FAA's review of the Accident/Incident Data System (AIDS) and the Service Difficulty Reporting System (SDRS) databases shows that the frequency of bleed air contamination incidents is very low. Using the AIDS database, the FAA has indicated that approximately 416 incidents involving cabin air contamination have occurred over a 20-year period (January 1978 – December 1999). The sources of contamination in these 416 incidents can be broken down as follows:

- in 33% of the events, the source was an electrical anomaly,
- in 23% the source was the ECS (Environmental Control Systems),
- in 17% the source was engine oil, hydraulic fluid, or jet fuel,
- in 4% the source was the MSC (miscellaneous)
- in 2% the source was Hazmat (hazardous material), and
- in 11% there was some "other" source.

For the 10-year period of 1987-1996, the FAA reported that approximately 222 "air quality" events occurred. This equates to approximately 2.2 "air quality" events per 1,000,000 flight hours. Only a small percentage of these events was attributable to bleed air contamination. Using the SDRS database over a 10-year period, the FAA estimates that 1,013 events occurred, 252 were in the category of bleed air contamination. The SDRS results indicate a likelihood of an event occurring at 2.7 events per 1,000,000 airplane

departures. Incidents reported in the SDRS were dispositioned and found to be connected to faulty equipment and/or maintenance practices. With proper airplane maintenance, the frequency of such incidents is minimised.

c. Safety implication

Fokker Services commented that they consider the fourth category in the trends (crew complaints) the most elusive. They added that especially in this category the most unsubstantiated health and safety claims are made. In the cases where they have traced back the events to clear causes, where airworthiness was related, Fokker Services has, as part of the continuous airworthiness obligations, taken appropriate actions.

Airbus also believes that, as shown by ICAO and UK databases, there is no evidence of a serious safety risk by degradation of air quality by defects in engines or APU; when a specific problem is identified on a given aeroplanes, relevant measures should be taken.

The ASD stated that the existing continuing airworthiness process has not identified any cabin air concern that would be a threat for safety.

d. Health effects

Manufacturers were asked if they are aware of any proven serious health concern linked to an occurrence of cabin air contamination by engine or APU.

Only Fokker Services answered positively but they did not provide any explanation or information and they reminded that they cannot control the reliability of the reports received.

Airbus referred to the UK COT research which showed that based on the available evidence no conclusive relation between cabin air contamination and long-term health effects can be drawn.

Boeing indicated that there are no data indicating that bleed air contamination is adversely affecting the health of aircraft crew or passengers.

Embraer explained that most of the reports they receive do not address health effects on occupants.

e. Technical solutions

The manufacturers were asked if they had investigated technical solutions to better protect the aeroplane from bleed air contamination, for existing aeroplane types and for future aeroplane types.

Dassault replied negatively.

Fokker Services only mentioned the actions previously taken in the frame of the continuous airworthiness obligations following events with clear causes identified.

Airbus cannot recommend "requiring additional technical solutions, which might implicate additional risks, without appropriate justification."

f. Regulation impovement

The question was asked to manufacturers if they consider it would be beneficial to amend the current CS-25 certification specifications to better protect Large Aeroplanes from cabin air contamination by engine or APU.

Dassault does not believe it is required without further comments.

Fokker Services suggested investigating the standards that were/are used in the current airworthiness specifications and the history of those airworthiness specifications. They added that these standards are based on certain postulations and it has to be researched whether or not these postulations still stand in view of the current research.

Airbus reminded of the existing specifications in CS-25, CS-E and CS-APU which already ensure an appropriate bleed air quality and asked for a safety analysis of any possible scenario which could lead to crew or passengers incapacitation.

Airbus also referred to existing harmonised air quality standard in the USA and in Europe (SAE ARP4418 Rev A and EN4618 for bleed and cabin air quality respectively). They invite the Agency to support the continuing work on European standards.

In absence of any evidence for a serious safety risk or ill-health effects caused by cabin air, Airbus does not support a further prescriptive amendment. "Current certification specifications are conclusive on cabin and bleed air quality and large passenger aircraft have proven the technical ability to provide unobjectionable air to passengers and crew".

Embraer provided a similar comment.

For the ASD, "the absence of any unresolved in-service cabin air event that is a threat to safety and the lack of data from any study linking cabin air to safety suggests that it is inappropriate to be using the EASA rulemaking process to prompt a debate on the subject."

g. Measures on in-service aeroplanes

Manufacturers were asked if they envisage proposing a modification of in-service aeroplanes to better protect from engine and APU bleed air contamination.

Dassault has no intent to take any action.

Fokker Services re-explained that they would take ad-hoc action if any airworthiness issue is identified with causes, in the frame of their continuous airworthiness obligations.

Airbus also advised using the same approach (specific action when a problem is identified on given type).

Boeing pointed to the improvements done on the B757 and the BAE 146, as mentioned in the A-NPA.

BAE Systems raised the issue that, in addition to the measures mentioned in the A-NPA for the BAE 146, the following improvements were also made: Service Bulletins which introduced:

a) Bearing seals with improved reliability for the engine and APU,

b) Modified dip stick to ensure the APU oil is replenished to the correct level, and

c) System changes to ensure the APU is 'de-oiled' on shutdown.

Embraer stated that they have been improving their fleet through the modification and improvement of engine oil seals' reliability. The current rate of events does not justify further modifications.

h. Research

Dassault advised a statistical record of chemical molecules on new aircraft and old aircraft including business jets.

Fokker Services believes that the extent and severity of the health and safety issue must be established by scientific research before taking any regulatory action.

Airbus made reference to the Cranfield University in-flight measurements (commissioned by the UK Department for Transport) which should evaluate the actual nature of contamination, if any, and the concentration of respective contaminants.

The ASD supports further research with a strong scientific basis.

Boeing supports the studies being conducted in the U.S.A by the FAA Center of Excellence for Research in the Intermodal Transport Environment (RITE), and by ASHRAE in their in-flight 1262 RP project designed to characterise the cabin environment and relate to comfort and health symptoms. They also support the Cranfield University in-flight measurements.

Embraer considers that the health effects due to exposition to engine/APU oil have not yet been determined (although studies indicate the substances that are dangerous for health). They believe research should be conducted by the international community to determine, for each substance generated from oil degradation, what concentrations are allowed for passenger exposure, for how long.

i. Reporting system

Boeing believes that today there is no standard or consistent terminology for reporting air contamination events, and there is no generally accepted definition of the term "cabin air quality event". Airlines do not follow consistent practices in reporting such events. Boeing believes it is important that standard terminology be developed for use in reporting cabin air quality events.

j. Other comments

Fokker Services also provided the following general comments on the A-NPA:

"At Fokker Services we are of the opinion that the set-up of this A-NPA is not an adequate means to improve the view of EASA on the understanding of the situation or to come to an amendment of a rulemaking document. As the reports will be rather of an incidental nature and in most cases do not contain hard facts on causes, particularly in the fourth category as mentioned above, Fokker Services would like to urge the Agency to first conduct (scientific) research and only thereafter start the discussion with (local) Authorities, Operators, Type Certificate Holders and Maintenance Organizations as well as oil manufacturers.

The research of Cranfield University was until now primarily focused on air quality on the flight deck. The researchers indicate that doing (scientific) research in the main cabin is a far greater challenge because of the vast size and influences of passengers. This questionnaire however does not make any segregation between the flight deck and the cabin. The segregation between these two is of importance because of the huge difference in impact of safety implications."

The ASD declared that the Agency's rulemaking resources would be better used on other subjects that have been identified as a priority by the SSCC.

18. Other comments received

The Agency received other comments in the form of emails or letters from individuals including passengers, scientists and from associations. The main outcome of these comments is summarised below.

a. Passengers

We received 6 submissions from passengers.

One passenger from UK, who seems to be very familiar with the occurrence reporting system, reported an event of bad oil smell during descent, but no effect on his health.

Five passengers reported health concerns appearing during or after a flight, but they did not provide evidence of their experience:

- One person (from USA) reported having symptoms one day after a flight: "teeth started chattering", "I was shaking all over my body and started having seizures". This person was interviewed by a television along with a scientist doing research on aerotoxic syndrome, and they filmed the seizure. There is no mention of unusual cabin air smell or fumes.
- One person (from USA) started to be ill during a flight and the following three days. She described the symptoms as follows: "extreme fatigue, nausea, significant edema of the face, constipation and a dull pressure and pain all over my body, like a painful sense of fullness in my muscles and internal organs", "brain fog", "decreased memory", "loss of concentration". She experienced the same reaction few years later when she was driving by a major airport. She did not mention fume or smell in the cabin.
- One person (assumed from Australia) contacted us to explain that she believes that the paranoid schizophrenia disease of her son, who was a pilot, is linked to cabin air quality. The son does not agree.
- One person (from UK) explained she had troubles during a return flight. Symptoms were illness, fever, trembling, high blood pressure. The doctors concluded to a probable virus infection before the flight. The person is not convinced. There is no report of unusual smell in the cabin.
- One person (from Canada) reported that her husband fell ill after a flight during which engine oil fumes contaminated cabin air. She was also travelling with her husband but did not fall ill. The symptoms developed by the husband were first of all sore throat and occasional headaches. Then few days later when they flew back, he got major headaches, tightness across his chest, stabbing pains in the left temple, memory loss, difficulty with speech, dizziness, nausea, insomnia, fatigue, grey and pale tone face.

b. Associations of consumers

Three associations provided their opinions and experiences.

- CO-Gas Safety is a charity in UK, mainly acting on the prevention of people dying or being poisoned by carbon monoxide and other fuel emission toxins in indoor air. They consider aircraft bleed air systems as dangerous, and they recommend bleed air cleaning to prevent fume events and bleed air monitoring to inform pilot and maintenance. They believe that events are underreported and recommend a mandatory reporting system for fume events.
- Holiday Travel Watch (HTW) is a British based consumers organisation founded in 1995; it collaborates with the Aerotoxic Association and the GCAQE (Global Cabin Air Quality Executive). They provide information, advice and when necessary legal assistance to travel consumers to solve their complaints. HTW have been aware of the issue of fumes on board aircraft in 2006. They published a press article in April 2008 to advice consumers on how to deal with a fume/smoke event.

Their recommendation to the Agency is:

- Install filters on all bleed aircraft immediately,

- Create an "obligatory" aircrew/passenger reporting system which is subject to public scrutiny,

- For all stakeholders to create a "no-fault" protocol to deal with the substantial issues arising from the aerotoxic issue, to assist aircrew, passengers and possibly those living close to airports.

This is based on the following elements:

- The testimony of one UK family who faced a fume event in 2007 and became ill; other passengers of the same flight would also have become ill (no description of the illness).

- A Facebook Survey in 2007 ran for 24 hours and which captured 100 opinions. The outcome was that 15% of respondents had experienced a smoke or fume event on board an aircraft and 5% suffered with illness as a result of that exposure.

- An on-line survey between March and November 2009, advertised through Google advertising. The goal was to collect experiences and views of aircrews and passengers. Some 99 contributions were retained from the survey. The outcome from the 11 questions is that 63% of respondents had experienced a smoke or fume event on board an aircraft and 38% suffered with illness/symptoms as a result of that exposure.

- Toxic Free Airlines is a UK association to inform, through a public website, about cases of chemical exposure injuries amongst airline pilots, cabin crews and passengers. They provided the result of Crew Health Survey (Pilots and Cabin crews) they have been conducting since March 2009; the survey is not focused on fume events but on crews' health problems.

On their website, one can read the outcome of the survey dated March 2010. 910 surveys have been received from 21 pilots and 889 cabin crews (from Australia, Ireland, France, Germany, Netherlands, Spain, UK & USA).

The average age of the participants was 40.

The main outcome is as follows:

Out of 910 surveys received the number of crew with no symptoms or sick leave in the previous 12 months was 16,

- 231 (25%) had no time off sick
- 679 (74%) had some time off sick
- 208 (22%) had long term sickness of 3 weeks+

Many crews who had not reported sick declared that they were ill on their days off/leave/ part time weeks. Others said they went to work when they weren't 100% fit because they were afraid of the consequences of taking time off.

These are some of the conditions crew declared they had been diagnosed with:

- Depression 181 - 19.9%
- Irritable bowel syndrome 123 - 13.5%
- High blood pressure 110 - 12.1%
- Asthma 65 - 7.1%
- Pneumonia/bronchitis 59 - 6.5%
- Chronic fatigue 46 - 5.1%
- Cancer 41 - 4.5%
- Thyroid disorder 39 - 4.3%

The association also concludes that the cancer rate is approx. 10 times the UK national average as for this age group (34-44) the incidence of cancer is usually 1 in 200.

Based on this survey, the Toxic Free Airlines believes that there is a serious crew and passenger health problem. They also consider that flight safety is affected.

c. Various statements

- Australian Licensed Aircraft Engineers Association:

The ALAEA represents approximately 4000 licensed and unlicensed aircraft maintenance engineers maintaining Australian aircraft.

They ask that maintenance engineers and technicians be included in the relevant stakeholders because they are exposed when repeatedly doing troubleshooting tasks, and also in the frame of the normal maintenance of engines on ground.

From their point of view, "the Agency also needs to use the current process to assist in prevention of long term health effects caused by multiple exposures over a longer period of time".

Their recommendation is the implementation of measures to prevent oil contamination from entering the passenger cabin and flight deck conditioned air when mechanical malfunctions occur; no particular technical solutions is recommended, they say that this can be done "by filtering, redesigning existing systems and setting new design standards for future aircraft".

Finally, a sample of 51 fumes events involving engine oil or fluids is provided; these events were reported via the Australian Civil Aviation Safety Authority (CASA) Service Difficulty Reporting system between 2008 and 2009.

- An Australian respiratory physician: This person provided a paper explaining that "the toxic effects of inadvertent inhalation of aviation fuels and lubricants are not well described but are thought to include both respiratory and neurocognitive features". "The purpose of this paper is to describe respiratory and other symptoms and detected physiological and pathological abnormalities in a group of fourteen BAe 146 flight crew who presented complaining of symptoms following exposure to fine aerosols or fumes during and/or after aircraft flights".

The paper was presented at the "Contaminated air protection conference" at the Imperial College, London, in April 2005.

- A UK scientist from the university of Sunderland: This person is an advisor of the Aerotoxic Association and the GCAQE. He was involved with UK veterans from the first Gulf War (suffering from the Gulf War syndrome) and groups of persons suffering from aerotoxic syndrome (pilots and cabin crews). He explains that these symptoms are overlapping and that there is a large amount of biomedical research showing that these symptoms are caused by routine and regular exposure to toxic chemicals, particularly TCPs, from engine oil. He says that this evidence has been compiled by Captain Susan Michaelis.

- A Guest researcher of the Free University of Amsterdam (MD, ex ATPL):

This person explains the following in an email: "My early measurements in 2007/2008 gave me the impression that leakage of pyrolized oil compounds, including TCP's, did enter the cabine unfiltered. I started to look for the effects in people exposed to these substances and found the neurological damage in individuals described on the oil can's (Mobil Jet II etc,) and literature."

However there is no explanation of what is meant by "my early measurements" and "look for the effects in people exposed".

Attached to the email was a 4 pages draft document entitled "Serum test for neuronal and glial autoantibodies". A table provides the percentage change in autoantibodies of some subjects (no explanation on the profile and number of these persons) compared to healthy subjects. The conclusion in the end states that "The patient's serum profile of autoantibodies against brain-specific proteins shows that the autoantibodies against the axonal proteins, MAP-2 was severely higher than controls, in agreement with the great increase of autoantibodies against GFAP and the slight to moderate of autoantibodies against all other proteins. The moderate increase in the level of autoantibodies of S100

protein in the serum suggests moderate acute traumatic brain injury in the subject. These results are consistent with the presence of severe nervous system injury."

Given the lack of explanations about the scope of this report (in particular the profile of the subjects, description of how the conclusions were obtained,…) this information is difficult to understand and it seems not possible to draw a conclusion.

- A student from the University of Wollongong, Australia:

This student provided a thesis report entitled "Interests and the shaping of an occupational health and safety controversy: the BAe 146 case", submitted in view of being awarded the degree of doctor in philosophy (school of social sciences, media and communication). It consists of a review and analysis of existing documents and information concerning aircraft cabin air fumes and it focuses on the BAE 146 aircraft in Australia. The student has been supported by Susan Michaelis. The thesis provides similar conclusions and recommendations as the ones in the "Aviation Contaminated Air Reference Manual," from Captain Susan Michaelis, dated 2007.

- A clinical neuropsychologist at University College London (specialised in neuropsychological toxicology):

A report of 27 pilots examination was submitted. This report was also published in a scientific journal in 2008.

Purpose of the examination: "The general aim of the assessment was to determine whether pilots show evidence of cognitive impairment and whether this relates to exposure history. Pilots reported alarming cognitive failures at work such as being unable to retain or confusing numerical information from Air Traffic Control. Nine pilots were excluded from further analysis because they had a medical or psychiatric condition which might otherwise explain these difficulties. In the remaining 18 pilots, language, perceptual skills and general intellectual ability were preserved, but performance on tests of psychomotor speed, attention and executive functioning was below expected levels."

The conclusion from this assessment is following: "The cognitive deficits identified in this cohort of pilots cannot be attributed to factors such as mood disorder or malingering. However, the evidence available in this study does not enable firm conclusions to be drawn regarding a causal link with contaminated air; the cohort of pilots was self-selected and only crude indices of exposure were available. Further research is warranted given the scientific uncertainty regarding the health effects of inhalation of heated or pyrolized engine oil."

- Susan Michaelis, former Australian pilot:

Susan Michaelis, in addition to her participation in the on-line questionnaire, sent to the Agency her book "Aviation Contaminated Air Reference Manual", dated 2007; this manual is based on a review of the literature, personal experience and feedback from doctors and scientists dealing with aircraft air contamination events. She also has just completed a PhD on this subject.

In addition, she sent a copy of the manual entitled "Proceedings of the BALPA Contaminated Air Protection Air Safety and Cabin Air Quality International Aero Industry Conference. Held at Imperial College, London, 20-21 April 2005." and 2 DVDs: "Welcome aboard toxic airlines", documentary dated 2008; "Aircraft air contamination- An on-going health and safety issue", AOIPS/Australian Federation of Air Pilots, documentary dated 2003.

VI. CRD table of comments, responses and resulting text

(General Comments)	-

comment	*5* comment by: *Sue Pyles* I don't know if the Q400 planes used by Alaska Airlines are included in this document. My concern is the air quality or altitude experienced in the passenger compartment of the 62 or 72 passenger Q400. I have traveled from Seattle to/from Reno with my 13 year old. On each of these flights, she has suffered symptoms similar to altitude sickness, i.e. headache, nausea, and weakness. In each case, she recovered by the next day. Another health safety issue is the lack of a sink in the restroom on these planes. Although the restroom contains an antibacterial liquid, this isn't the same as a sink. If someone needs to change a diaper, lack of water with which to clean up is a great imposition and health risk. I am submitting these concerns because of the other safety issues of these planes.
response	Noted. The scope of this A-NPA is about abnormal events where cabin air may be contaminated. We note your concern on the cabin altitude and the sink.

comment	*13* comment by: *AEA* **General AEA comment in response to EASA Advanced Notice of Proposed Amendment (A-NPA) 2009-10 Cabin Air Quality** EASA in its A-NPA 2009-10 (Cabin Air Quality) acknowledges that cabin air quality in modern large aeroplanes is recognized as being excellent. EASA also acknowledges that various research studies, in different countries (i.e. the United Kingdom in Europe) have attempted to answer a number of questions in relation of some events related to cabin air contamination which as such were minor events and therefore did not pose any significant risk for safety or health. In particular, the AEA would like to draw attention to the report of the UK Government's Committee on Toxicity, a comprehensive review of the scientific and technical evidence, which concluded that the available evidence does not support claims of long term ill-health attributable to cabin air contamination. Where there were some minor issues in the past (which had no impact on health), they have been addressed through Airworthiness Directives for those specific type of aeroplanes. Despite any positive evidence of any safety risk related to cabin air quality and during ongoing research, EASA issued A-NPA 2009-10. This A-NPA requested individual pilots or cabin crew to answer simplified questions and / or forward reports of anecdotal events. The AEA is very concerned that this unscientific approach by Europe's aviation safety regulator will open the issue to certain interested parties seeking to promote their personal views. The AEA therefore urges EASA to withdraw this A-NPA which will add nothing to the scientific analysis of a complex issue. The AEA would encourage EASA to monitor ongoing research (such as the one taking place in the United Kingdom) and/or conduct further research. When the research has reached a conclusion then if that there is scientific evidence that actions are required either in

general or for specific aircraft types, EASA should act accordingly.

Finally, the AEA would respectfully ask which criteria EASA has applied to consider cabin air quality an EASA priority. The AEA believes that EASA's resources should be applied where they can contribute most to further improvements in (data driven) aviation safety based on European safety priorities. The AEA suggests that EASA should avoid using resources in launching any regulatory actions which have no safety justification but which are driven by social agenda's or public perception/media.

response

Not accepted.

As you mention, this appears to be a complex issue, and a controversial debate exists that the Agency cannot ignore. Although the Agency already had an opinion on this subject as presented in the A-NPA, we considered that it had to be consolidated or updated by including all stakeholders' contributions.

It is also worth mentioning that, although the prime responsibility of EASA is safety, the Agency would also take action should a health case be found in order to protect aircraft occupants (refer to Basic Regulation 216/2008 recital (20)).

comment

15 comment by: *Swiss International Airlines / Bruno Pfister*

SWISS International's General Comment in response to EASA Advanced Notice of Proposed Amendment (A-NPA) 2009-10 Cabin Air Quality

EASA in its A-NPA 2009-10 (Cabin Air Quality) acknowledges that cabin air quality in modern large aeroplanes is recognized as being excellent. EASA also acknowledges that various research studies, in different countries (i.e. the United Kingdom in Europe) have attempted to answer a number of questions in relation of some events related to cabin air contamination which as such were minor events and therefore did not pose any significant risk for safety or health. In particular, SWISS would like to draw attention to the report of the UK Government's Committee on Toxicity, a comprehensive review of the scientific and technical evidence, which concluded that the available evidence does not support claims of long term ill-health attributable to cabin air contamination. Where there were some minor issues in the past (which had no impact on health), they have been addressed through Airworthiness Directives for those specific type of aeroplanes. As an AVRO RJ Operator, SWISS addresses these minor issues additionally with the installation of the "Air Quest Manager" Cabin Air improvement kit during the HMV of the first aircraft in DEC09 and considers modyfying the whole AVRO RJ fleet.

Despite any positive evidence of any safety risk related to cabin air quality and during ongoing research, EASA issued A-NPA 2009-10. This A-NPA requested individual pilots or cabin crew to answer simplified questions and / or forward reports of anecdotal events. SWISS is very concerned that this unscientific approach by Europe's aviation safety regulator will open the issue to certain interested parties seeking to promote their personal views.

SWISS therefore urges EASA to withdraw this A-NPA which will add nothing to the scientific analysis of a complex issue. SWISS would encourage EASA to monitor ongoing research (such as the one taking place in the United Kingdom) and/or conduct further research. When the research has reached a conclusion then if that there is scientific evidence that actions are required either in general or for specific aircraft types, EASA should act accordingly.

Finally, SWISS would respectfully ask which criteria EASA has applied to

consider cabin air quality an EASA priority. SWISS believes that EASA's resources should be applied where they can contribute most to further improvements in (data driven) aviation safety based on European safety priorities. SWISS suggests that EASA should avoid using resources in launching any regulatory actions which have no safety justification but which are driven by social agenda's or public perception/media.

response

Not accepted.

As you mention, this appears to be a complex issue, and a controversial debate exists that the Agency cannot ignore. Although the Agency already had an opinion on this subject as presented in the A-NPA, we considered that it had to be consolidated or updated by including all stakeholders' contributions.

It is also worth mentioning that, although the prime responsibility of the Agency is safety, the Agency would also take action should a health case be found in order to protect aircraft occupants (refer to Basic Regulation 216/2008 recital (20)).

comment

16 comment by: *British Airways Flight Operations*

British Airways is pleased to note that EASA acknowledges cabin air quality in modern large aeroplanes is recognised as being excellent. EASA also acknowledges that various research studies, in different countries, particularly the UK, have attempted to answer a number of questions relating to specific, minor, events which did not pose any significant risk for safety or health. In particular, British Airways would like to draw the Agency's attention to the report of the UK Government's Committee on Toxicity, a comprehensive review of the scientific and technical evidence, which concluded that the available facts do not support claims of long term ill-health caused by cabin-air contamination. Where there were some minor issues in the past (which had no impact on health), they have been addressed through Airworthiness Directives for those specific type of aeroplanes. British Airways is also pleased to note, as does the Agency in Paragraph 9 of the A-NPA, that the number of fumes events appears to be decreasing, at least in the UK.

British Airways agrees wholeheartedly with the Agency's conclusions in Paragraph 12:

- Today, the events of cabin air contamination by engine or APU remain relatively rare, and among these events the proportion for which flight crew performance degradation has been reported is very low. Since the entry into service of the first jet airliners in the 1950's, there has never been any single catastrophic record caused by this kind of event.
- Concerning health, there is no known scientifically proven case of serious illness attributed to exposition to cabin air contamination by engine/APU.
- Among the reported events, a major part have been generated by two aeroplane types for which mandatory measures have been taken to mitigate the occurrence of ECS contamination by engine or APU oil.
- Thus, based on available evidence, the current overall risk of this kind of event could be considered acceptable.

Consequently, British Airways is very concerned that, in spite of there being no positive evidence of any safety risk related to cabin air quality, the Agency has issued this A-NPA. We note that it requested individual pilots or cabin crew to answer simplified questions and / or forward anecdotal reports of events. British Airways is concerned that this unscientific approach will open the issue to certain interested parties seeking to promote their personal views. We

	believe it will not contribute anything material to the discussions around the facts as they relate to safety. British Airways therefore urges EASA to withdraw A-NPA 2009-10 (Cabin Air Quality) which will add nothing to the scientific analysis of a complex issue. British Airways would encourage EASA to monitor ongoing research (such as that taking place in the United Kingdom) and/or conduct further research itself. If the research reaches a conclusion that there is scientific evidence supporting the case for regulatory action, that action is required either in general or for specific aircraft types, only then should EASA act accordingly.
response	Partially accepted. As you mention, this appears to be a complex issue, and a controversial debate exists that the Agency cannot ignore. Although the Agency already had an opinion on this subject as presented in the A-NPA, we considered that it had to be consolidated or updated by including all stakeholders' contributions. It is also worth mentioning that, although the prime responsibility of EASA is safety, the Agency would also take action should a health case be found in order to protect aircraft occupants (refer to Basic Regulation 216/2008 recital (20)). The Agency agrees to monitor and if possible contribute to research studies in view of improving or updating the knowledge available.

comment	*17* comment by: *Deputy Technical pilot* Norwegian Air Shuttle has no comments on this NPA. We have not had any reports regarding bad cabin air due to airleak from APU.
response	Noted.

comment	*19* comment by: *Boeing* Attachment #1 Please see attached letter representing comments to A-NPA 2009-10 from Boeing Commercial Airplanes
response	Noted. FAA also provided information from analysis of their database which is consistent with your letter, i.e. that the frequency of "air quality" events (where failures occurred in airplane, engine, or auxiliary power unit (APU) systems) is of the order of one event every 1000,000 flight hours.

comment	*50* comment by: *MOT Austria* Due to the debates and discussions that cabin air quality events still generate, and in order to improve the Agency`s view and understanding of the situation, the decision to start a pre-rulemaking phase is supported. The collection of detailed information on events and experiences involving cabin air contamination by engine or APU with the intention to enable a better assessment of the rate of occurrences and of the encountered symptoms is also supported.
response	Noted.

comment	*84* comment by: *Austro Control GmbH* The initative of this A-NPA is fully supported by Austro Control.
response	Noted.

comment	*123* comment by: *Luftfahrt-Bundesamt* The LBA has no comments on A-NPA 2009-10.
response	Noted.

comment	*125* comment by: *KLM* EASA in its A-NPA 2009-10 (Cabin Air Quality) acknowledges that cabin air quality in modern large aeroplanes is recognized as being excellent. EASA also acknowledges that various research studies, in different countries (i.e. the United Kingdom in Europe) have attempted to answer a number of questions in relation of some events related to cabin air contamination which as such were minor events and therefore did not pose any significant risk for safety or health. In particular, the KLM would like to draw attention to the report of the UK Government's Committee on Toxicity, a comprehensive review of the scientific and technical evidence, which concluded that the available evidence does not support claims of long term ill-health attributable to cabin air contamination. Where there were some minor issues in the past (which had no impact on health), they have been addressed through Airworthiness Directives for those specific type of aeroplanes. Despite any positive evidence of any safety risk related to cabin air quality and during ongoing research, EASA issued A-NPA 2009-10. This A-NPA requested individual pilots or cabin crew to answer simplified questions and / or forward reports of anecdotal events. KLM is very concerned that this unscientific approach by Europe's aviation safety regulator will open the issue to certain interested parties seeking to promote their personal views. KLM therefore urges EASA to withdraw this A-NPA which will add nothing to the scientific analysis of a complex issue. KLM would encourage EASA to monitor ongoing research (such as the one taking place in the United Kingdom) and/or conduct further research. When the research has reached a conclusion then if that there is scientific evidence that actions are required either in general or for specific aircraft types, EASA should act accordingly. Finally, KLM would respectfully ask which criteria EASA has applied to consider cabin air quality an EASA priority. KLM believes that EASA's resources should be applied where they can contribute most to further improvements in (data driven) aviation safety based on European safety priorities. KLM suggests that EASA should avoid using resources in launching any regulatory actions which have no safety justification but which are driven by social agenda's or public perception/media.
response	Not accepted. As you mention, this appears to be a complex issue, and a controversial debate exists that the Agency cannot ignore. Although the Agency already had an opinion on this subject as presented in the A-NPA, we considered that it had to be consolidated or updated by including all stakeholders' contributions. It is also worth mentioning that, although the prime responsibility of EASA is

safety, the Agency would also take action should a health case be found in order to protect aircraft occupants (refer to Basic Regulation 216/2008 recital (20)).

comment

126 comment by: *Federal Office of Civil Aviation (FOCA), Switzerland*

Comment No. 1

When it comes to system design and analysis the classification of failure conditions is based on the definitions and guidance contained in FAA AC No. 23.1309 and 25.1309. These documents already reflect the basic principle that failure conditions have to be assessed in terms of effects that they may have on either the airplane or its occupants, or both.

The classification of system malfunctions affecting the health of crew members and passengers takes into consideration conditions such as "discomfort" or "distress": A definition of these conditions or criteria to assess them are not given.

The evaluation of failure conditions which may result in undesirable health conditions is not limited to cabin air quality and concerns several aircraft systems: this is for example the case of the pressurization system. A pressurization system malfunction causing rapidly oscillating pressure changes (e.g. oscillating rate of climb and descent) would have also to be assessed based on the discomfort or distress it may cause to the occupants.

However no specific guidance is available to determine whether the consequences of failure conditions which may result in undesirable health conditions have to be considered as "discomfort" or "distress".

Since the definition of these terms is quite nebulous in the very first place and limited service experience is available in this respect (limited and highly variable occurrence reporting) it follows that the system analysis may fail to identify the severity of some failure conditions. This affects the initial design as well as the continued airworthiness (determination of an unsafe condition).

It is recommended to make use of the rulemaking task 25.035 "Cabin environment – Air quality" to improve the definition of failure conditions which may affect the health of the aircraft occupants and to provide additional guidance as it concerns their assessment during the initial design and the continued airworthiness.

Comment No. 2

Section AMC 20-8 "Occurrence Reporting" of Decision No. 2003/12/RM on general acceptable means of compliance for airworthiness of products, parts and appliances (« AMC-20 ») provides guidance on occurrences which should be reported to the Agency. "Crew incapacitation" qualifies as reportable event; however "incapacitation" does not apply to passengers. Furthermore AMC 20-8 "Occurrence Reporting" does not mention events where the health of crew members and passengers was affected in terms of "discomfort" or "distress".

It is recommended to make use of the rulemaking task 25.035 "Cabin environment – Air quality" to update Section AMC 20-8 "Occurrence Reporting" of Decision No. 2003/12/RM on general acceptable means of compliance for airworthiness of products, parts and appliances (« AMC-20 ») in order to

provide guidance on events affecting the health of crew members and passengers and establishing the criteria based on which they need to be reported with particular emphasis to events where cabin air contamination or more generally degradation of the cabin air quality is or might be suspected.

response

Not accepted.

1) The 1309 analysis is used to ensure that aircraft designs are safe. It indeed includes the terms "physical discomfort" and "physical distress" when defining the failure conditions. There is no detailed definition for those two terms, especially when it is related to exposure to chemical contaminants, and it is probably impossible to provide a universal definition that will satisfy anyone. These are subjective definitions because what is comfortable for one person may not be acceptable for another person, and vice versa. The same applies to distress.

Concerning the scope of our discussion, i.e. contamination of cabin air by toxic compounds from engine or APU, this case is classified Hazardous in the safety analysis when concentrations are sufficient to incapacitate crew or passengers. Refer to CS-E 510 and CS-E 690 (Certification Specifications for engines), CS-APU 210 and CS-APU 320 (Certification Specifications for auxiliary power unit).

2) AMC 20-8 identifies as "reportable occurrence" failures of engines or APU resulting in "Dense visible fumes or concentrations of toxic products sufficient to incapacitate crew or passengers". The same item is provided in Directive 2003/42/EC of 13 June 2003 on occurrence reporting in civil aviation.

comment

127 comment by: *Airbus*

In the Explanatory Note provided with A-NPA 2009-10, EASA compiled an excellent and comprehensive review of the technical and historical background on cabin air quality. It is stated that cabin air quality is excellent on modern large airplanes. Airbus can fully assent to this statement, which is supported by numerous scientific publications. Contaminants usually found in aircraft cabins at very low concentrations are thought to be mainly generated by passengers and related cabin services, as main organic contaminant is ethanol.

Airbus doubts however that the EASA questionnaire provided with A-NPA 2009-10 is an appropriate scientific approach to acquire additional knowledge on frequency and severity of respective occurrences. Statistics provided on cabin air quality issues in general lack of appropriate categorization and are often biased by public perception and individual perspective.

An appropriate bleed air quality is prerequisite for cabin air quality. Consequently respective regulations for Air Quality on European level can be found in CS 25, CS-E and CS-APU.

CS 25.831 and 25.832 besides the regulations for air exchange and smoke removal contain limitations for carbon monoxide, carbon dioxide and ozone. Furthermore a more general term requires the air to be free from harmful or even hazardous concentrations of gases and vapours.
For Engines and APU as predominant sources for the air supplied to the aircraft cabin, CS-E and CS-APU require determination of possible bleed air contaminants generated by engines or APU and require a safety analysis, which considers a possible incapacitation of crew or passengers by contaminated bleed air. Characteristics of any possible contamination must be

provided to the installer (refer to CS-E 690 and 510, CS-APU 320 and 210).

In order to define an appropriate air quality, harmonized standardization has been made in the United States and on European level for the aircraft environment specifically. Based on specific marker compounds guidelines to determine appropriate quality are provided for example by SAE ARP4418 (Rev. A) and EN4618 for bleed and cabin air respectively. Those standards are subject to regular revisions and hence allow an appropriate adaptation to scientific and technical evolution. It would be highly appreciated if EASA could support continuing work on European standards in this regard.

Based on the EASA interrogation of the UK and ICAO databases there seems to be no evidence for a serious safety risk by degradation of air quality by defects in engines or APU. Problems, which occurred on specific airplanes obviously could be appropriately identified and corrected by relevant measures.

Independent research by the UK Committee on Toxicity has also shown that based on the available evidence no conclusive relation between cabin air contamination and long term health effects can be drawn. Supportive research is ongoing and in-service measurements are conducted commissioned by the UK Department for Transport to evaluate the actual nature of contamination, if any, and the concentration of respective contaminants.

In absence of any evidence for a serious safety risk or ill-health effects caused by cabin air, Airbus cannot support a further prescriptive amendment. Current certification specifications are conclusive on cabin and bleed air quality and large passenger aircraft have proven the technical ability to provide unobjectionable air to passengers and crew. Airbus especially cannot recommend to EASA requiring additional technical solutions, which might implicate additional risks, without appropriate justification.

response

Noted.

The Agency supports the work being done by ASD-STAN. A collaboration between the Agency and ASD-STAN took place in the frame of prEN4666 dealing with cabin pressure, thermal and humidity conditions. ASD-STAN received comments similar to these A-NPA comments, although they were not relevant to prEN4666.

comment

130 comment by: *European Transport Worker's Federation*

Attachment #2

Please see the attach file.

response

Partially accepted.

Reported events: The Agency accepts the possibility that the minor events may be underreported by some organisations, probably because these events are considered as nuisance (e.g. temporary bad odours or smells), and therefore they are not considered as safety related occurrences which must be reported.

Concerning the serious events involving a degree of crew or passengers' impairment or incapacitation, we believe they are reported and their number remains very limited. A regulation is already in place for this category of events through Directive 2003/42/EC of 13 June 2003 on occurrence reporting in civil aviation: it clearly identifies failures of engines or APU resulting in "Dense visible fumes or concentrations of toxic products sufficient to

incapacitate crew or passengers".

Events involving crew incapacitation in the UK: based on the information we received from CAA UK, between 1999 and 2006, 5 events involved some degrees of flight crews incapacitation, among which 2 cases are classified as (single) incapacitation.

Among the huge amount of flight hours gathered since the introduction of bleed air systems in the 1960's, until now the Agency is not aware of any accident and there are only a very limited number of serious incidents; therefore, there is no evidence of a safety case and the safety analysis objective is met.

Concerning health, there is no evidence that a general health case exists, although it is not impossible. Further investigation is appropriate in this domain.

Use of filters and converters: The Agency agrees that the removal of odours by filters which may still release toxic compounds is an issue. Based on EASA knowledge, there is no filter available on the market which would be able to remove all the toxic compounds in case of bleed air contamination failure event. The use of air sensors may be a solution. However, the Agency has not found justification to mandate such devices.

Oil toxicity: The Agency agrees that aviation oils toxicity knowledge can be improved and we have recommended studies to be conducted in this domain. The special cabin environment should be taken into account in those studies.

Analysis of all engine oils base stock content: The Agency could not do that because the Agency does not regulate aviation fluids, and therefore we do not inspect oil manufacturers' productions. Nevertheless, the specified toxic compounds and their concentrations are provided to the engine manufacturers, which then conduct a safety analysis to verify that no hazardous quantities are released in the bleed air for identified failure scenarios. The Agency then reviews this analysis.

Safety and health effects: The Agency has conducted an analysis based on all information available to date. Please refer to our conclusions. As of today there is no scientific evidence of a safety or health case.

Comment on CS-25, CS-E, CS-APU: Even though these specifications are not binding as a stand-alone regulation, they become binding as soon as the Agency has received and accepted an application for a certificate by the industry. Then the applicant must comply with the rules provided in the Book 1 of the applicable CS. Book 2 provides acceptable means and guidance material to show compliance with the Book 1 rules. Please refer to regulation (EC) 1702/2003 for more explanations on applications.

Comments on prEN4666 and EN4618: In our opinion, prEN4618 provides the available cabin air contaminants limits based on the best existing scientific knowledge and norms. Concerning TCP, this compound is listed as part of oils, lubricants and hydraulics sources (table 1); however, it is true that no exposure limits are provided. Meanwhile, the Agency is aware that many countries use an average limit of 0.1mg/m3 (over an 8 hours workshift) based on the tri-ortho-isomer toxicity; however, we do not know on which basis this limit has been established. It is nevertheless provided by OSHA, NIOSH, ACGIH. Further study is probably needed to consolidate safety and health limits, especially in an aeroplane cabin pressure and ventilation environment.

PrEN4666 provides for pressure conditions, thermal conditions, humidity conditions, noise and vibration standards. Therefore, this document is

	complementary to EN4618 and it is not relevant when recommending contaminants standards.

comment	*135* comment by: *Dassault Aviation* Dassault Aviation will comment "Large aeroplanes (CS 25) manufacturers questionnaire
response	Noted.

comment	*137* comment by: *International Air Transport Association (IATA)* **IATA Position Paper on EASA A-NPA 2009-10 (Cabin Air Quality)** Cabin air quality has generated considerable concern and controversy over the last two to three decades and several studies have tackled one or more aspects of this issue. The research conducted so far by the US Federal Aviation Administration National Center of Excellence for Airliner Cabin Environment Research (ACER) and the last two recent and comprehensive studies in Europe, Cabinair and ICE (Ideal Cabin Environment), have all revealed that aircraft cabin air quality is generally very good. This is in fact acknowledged by EASA in its A-NPA. However, a lot of negative anecdotal evidence is still circulating and significant pressure for action is applied at different levels. As a result, the UK Government Committee on Toxicity of Chemical in Food, Consumer Products and the Environment (COT) was asked by the Department of Transport to undertake an independent scientific review of data submitted by the British Airline Pilots Association (BALPA) due to concerns about the possible effects on aircrew health of oil/hydraulic fluid smoke/fume contamination incidents in commercial aircraft. After a careful and detailed review of all available scientific and anecdotal evidence (over 400 references), the COT concluded that "It was not possible on the basis of the available evidence in the BALPA submission or that sourced by the Secretariat of DH Toxicology Unit to conclude that there is a causal association between cabin air exposures (either general or following incidents) and ill-health in commercial aircraft crews. However, we noted a number of oil/hydraulic fluid smoke/fume contamination incidents where the temporal relationship between reports of exposure and acute health symptoms provided evidence that an association was plausible."[1] Based on their conclusion, the COT made a number of recommendations, some of which include further research. The recommendations were accepted by the Department of Transport and the research project was contracted out and is already on the way. Considering all the research already carried out and the above mentioned independent extensive review of available evidence by the COT, it is likely that the EASA A-NPA will only bring in some more anecdotal evidence that will not add value to the decision making process concerning cabin air quality. IATA therefore recommends that EASA withdraw this A-NPA and wait for the outcome of the ongoing independent research. EASA can then reassess the situation in light of the new research outcome and decide if further action is required. 1. COT statement on the review of the cabin air environment, ill-health in aircraft crews and the possible relationship to smoke/fume events in aircraft,

http://cot.food.gov.uk/cotstatements/cotstatementsyrs/cotstatements2007/cotstatementbalpa0706 accessed December 15, 2009

response

Not accepted.
As you mention, this appears to be a complex issue, and a controversial debate exists that the EASA cannot ignore. Although the Agency had already issued an opinion on this subject as presented in the A-NPA, we considered that it had to be consolidated or updated by including all stakeholders' contributions.

comment

154 comment by: *ASD*

The Aerospace and Defence Industries Association of Europe (ASD) welcomes the opportunity to respond to A-NPA No. 2009-10 on Cabin Air Quality. ASD well recognises the need to ensure that flight safety is not compromised and that the health of both passengers and crew is not adversely affected by aircraft cabin air.

We note that the A-NPA acknowledges that modern aircraft have cabin air that is 'excellent in terms of the presence of contaminants' in normal conditions. This is a direct consequence of the certification standards applied to aircraft, engines and propellers and the determination of manufacturing industry to continually review the design of its products and react to reports and events that implicate the quality of cabin air.

As with any safety-related concern, an analysis based on credible data is the only way to assess what, if any, action is required to modify the design, operation or maintenance activities of an aircraft or engine type. Fundamental within the review process is the dialogue between aviation authorities and manufacturing industry - which is the accepted way of dealing with in-service safety. This dialogue has, as far as we know, not identified any cabin air concern that has not been properly addressed through the continuing airworthiness process.

The absence of any unresolved in-service cabin air event that is a threat to safety and the lack of data from any study linking cabin air to safety suggests that it is inappropriate to be using the EASA rulemaking process to prompt a debate on the subject. We are of the view that EASA's scarce rulemaking resources would be better used on other subjects that have been identified as a priority by the SSCC.

Further, it is difficult to see how the general surveys contained within the A-NPA will help develop a better understanding of the subject. The responses cannot lead to the generation of meaningful data that will add to what is already well documented; they might simply result in a number of unsubstantiated claims of health being affected by cabin air events.

We are aware of the studies carried out to date, the inconclusive nature of their findings and the lack of data they have provided. This is why we support further, well designed and thorough research that has a strong scientific basis.

Without such research, it is difficult to see on what basis proposed rulemaking on flight safety and the health of passengers and crew can be based.

We would, therefore, urge that no further rulemaking activity on the subject is taken by EASA unless the rigorous scientific studies

	conclude that actions are, in fact, necessary.
response	Partially accepted. This issue is complex, and a controversial debate exists that the the Agency cannot ignore. Although the Agency had already issued an opinion on this subject as presented in the A-NPA, we considered that it had to be consolidated or updated by including all stakeholders' contributions. Please refer to our conclusions which recommend studies to improve our knowledge.

A. Explanatory Note - I. General p. 3

comment	*12* comment by: *European Cockpit Association* ECA welcomes the opportunity to comment on the issue of cabin air quality. ECA fully supports the EASA action to identify if a problem with cabin air quality exists or not. As explained in the A-NPA 2009-10 questionnaire, issued on 28 September 2009, it is a challenge to find reliable data on cabin air quality. Indeed, ECA is concerned it will be very difficult to collect sufficient data that will provide EASA with a statistically relevant source of information. As explained in the A-NPA previous data has shown unexplained peaks in some years whilst in other years there were hardly any reports issued on problems experienced with cabin air quality. An open and uncontrolled questionnaire as launched by EASA may lead to the same 'polluted' data being re-issued as response to your questionnaire. In order to have a clearer and more reliable dataset to work with, ECA suggests EASA to run a dedicated study, with similar questions as in the A-NPA, based on a limited but statistically relevant sample of pilots. This would allow EASA to base its evaluation on a scientific and relevant set of data.
response	Partially accepted. The Agency recommends independent studies of pilots and flight attendants with the objective to better define the health impact of exposure to oil fumes on commercial aircraft. Refer to our conclusions. However, the Agency cannot run this kind of study which should be performed by a research organisation competent in the domain of health and toxicity.

comment	*21* comment by: *FSC - CCOO* "Today, based on European Aviation Safety Agency (EASA) knowledge, the cabin air contamination events by engine or Auxiliary Power Unit (APU) remain relatively rare, and among these events the proportion for which there was an impact on flight safety (e.g. flight crew performance degradation) is very low. However, as explained in the following chapter IV, there is an on-going debate among stakeholders about the reporting of these events and also about the associated possible health effects. In addition, the number of reports appears to be very variable from one country to another one, and it is not possible to determine a reliable rate of occurrence." Comment: It cannot be stated with certainty that Cabin air contamination events by engine or APU are "relatively rare" and the impact on flight safety "is very low"

as there is not enough research or reporting on these events. Reporting events is not done very often because of ignorance as to the signs of oil leakage and subsequent cabin air contamination (pervading smell like that of "old socks" or "smelly feet", blue mists in the cabin, etc…) or because of fear of reporting an incident.

Further explanation can be found in *ACARM (2007b) "Chapter 12: Frequency of Events and Underreporting" "Aviation Contaminated Air Reference Manual,"* Michaelis, S., ed. ISBN 9780955567209, London, England, pp. 211-248.

We support the intention of the EASA to collect detailed information on this issue in order to evaluate the threat for the health of aeroplane occupants & create new airworthiness standards.

response

Partially accepted.
The Agency accepts the possibility that the minor events may be underreported by some organisations, probably because these events are considered as nuisance (e.g. temporary bad odours or smells), and therefore they are not considered as safety related occurrences which must be reported.

Concerning the serious events involving a degree of crew or passengers' impairment or incapacitation, we believe they are reported and their number remains very limited. A regulation is already in place for this category of events through Directive 2003/42/EC of 13 June 2003 on occurrence reporting in civil aviation: it clearly identifies failures of engines or APU resulting in "Dense visible fumes or concentrations of toxic products sufficient to incapacitate crew or passengers".

comment

36 comment by: *Unionen/Sweden*

"Today, based on European Aviation Safety Agency (EASA) knowledge, the cabin air contamination events by engine or Auxiliary Power Unit (APU) remain relatively rare, and among these events the proportion for which there was an impact on flight safety (e.g. flight crew performance degradation) is very low. However, as explained in the following chapter IV, there is an on-going debate among stakeholders about the reporting of these events and also about the associated possible health effects. In addition, the number of reports appears to be very variable from one country to another one, and it is not possible to determine a reliable rate of occurrence."

Comment:
It cannot be stated with certainty that Cabin air contamination events by engine or APU are "relatively rare" and the impact on flight safety "is very low" as there is not enough research or reporting on these events. Reporting events is not done very often because of ignorance as to the signs of oil leakage and subsequent cabin air contamination (pervading smell like that of "old socks" or "smelly feet", blue mists in the cabin, etc…) or because of fear of reporting an incident.

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comment

51 comment by: *cfdt france*

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comment

67 comment by: *Fédération des transports CGT*

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comment

108 comment by: *CUD*

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comment

128 comment by: *IACA International Air Carrier Association*

As a Full SSCC member, I would like to provide the following comments:

Regarding the contents of the NPA

- In its A-NPA 2009-10, EASA acknowledges that cabin air quality in modern large aircraft is recognized as excellent. A report of the UK Government's Committee on Toxicity concluded that available scientific and technical evidence does not support claims of long term effects on health as being attributable to cabin air contamination.
- Various research studies attempted answering minor events related to cabin air contamination, events which however were not shown to pose any significant risk for safety or health. These incidents have been mitigated through Airworthiness Directives e.a. for the specific type of aircraft, e.g. BAe 146 and B757.
- Currently, there is no data to indicate that bleed air contamination is adversely affecting the health of aircraft crew or its passengers. Contaminant levels are generally low and consistently comply with applicable health and safety standards. Bleed air contamination incidents are very infrequent.
- More research is needed to increase the understanding of the potential for bleed air contamination incidents and any potential health effects that might be associated with such incidents. IACA would have expected EASA monitoring such on-going research, e.g. the on-going Cranfield study, prior issuing its questionnaires.

response

Partially accepted.
This issue is complex, and a controversial debate exists that the Agency cannot ignore. Although the Agency already had an opinion on this subject as presented in the A-NPA, we considered that it had to be consolidated or updated by including all stakeholders' contributions. Please refer to our conclusions which recommend studies to improve our knowledge.

comment

129 comment by: *IACA International Air Carrier Association*

Regarding the format of the NPA

- No Terms of Reference were published for Rulemaking Task 25.035.
- The public questionnaires for five different stakeholder categories on the internet is a new approach which was not consulted with AGNA/SSCC. This approach appears to address the application of political pressure and of media coverage rather than being a means of scientific data collection.
- IACA is very concerned with the quality of the replies on such open questions to the general public. Information is important, but there are differences between a European Agency and a tabloid. It is of utmost importance to collect data in a standardized way, e.g. using standard or consistent terminology.
- In times where EASA is under enormous pressure to perform in due time the tasks given by the Basic Regulation, it is regrettable that EASA resources will be lost on volumes of data of poor quality related to issues without any safety risk.

Yours sincerely

Erik Moyson/IACA

	Full SSCC member
response	Noted.

comment

131 comment by: *Susan Michaelis*

Attachment #3

1.
comment:It is incorrect to suggest that cabin air contamination events remain relatively rare

proposed Text:
the cabin air contamination events by engine or Auxiliary Power Unit (APU) are not rare

Justification: It is clearly acknowledged that oil seals allow oil to leak into the cabin air supply as a function of the design of the bleed air system in addition to maintenance issues. Additionally it is clearly accepted that the majority of fume events are related to oil leaking into the bleed air supply. Therefore contaminated air is occuring frequently at 'low level' and accepted as normal as a function of design, yet this is an abnormal condition and should not be viewed as acceptable. The more infrequent partial or full oil bearing seal failure or other component in the air supply system allowing higher levels of contamination should no longer be seen as the only issue of concern. The reporting system is not working & under-reporting is an ongoing major problem as the lower level fume events are seen as ongoing and normal by most and not worth reporting. See attached document for more detail & chapter 12, appx 2, 6,7 of Michaelis S. (2007) Aviation Contaminated Air Reference Manual. ISBN 9780955567209

2.
comment:It is incorrect to state: 'the proportion for which there was an impact on flight safety (e.g. flight crew performance degradation) is very low' '
proposed Text:the proportion for which there was an impact on flight safety (e.g. flight crew performance degradation) is not low.

Justification:Aircrew impairment related to contaminated air events is far higher than realized. Impairment clearly causes a degradation of crew performance and if suspected to be related to cabin air contamination, this is a breach of EASA 25.831 a/b. The UK contaminated air database (collated by S Michaelis) shows that 32% of contaminated air events involved some degree of crew impairment, while 20% involved impairment by at least 1 pilot and 9% of events involved both pilots. Recent research shows even higher rates of crew impairment due to contaminated air (mostly related to oil fumes) than this.- See attached document for more detail & chapter 2,12, 15 and appx 2, 6,7 of Michaelis S. (2007) Aviation Contaminated Air Reference Manual. ISBN 9780955567209

3. comment: 'the number of reports appears to be very variable from one country to another one, and it is not possible to determine a reliable rate of occurrence.'

proposed Text:
'the number of reports appears to be very variable from one country to another one, as the reporting systems are not working as intended and it is not

possible to determine a reliable rate of occurrence.'

Justification:
The reason the number of events is variable per country is due to the level of awareness of the contaminated air problem in various countries and the failure of the reporting systems. The UK and Australia have the highest level of reporting as there has been greater awareness of the problem in these countries by the airlines & crew. Much data within other countries such as the US remains concealed within the airlines and not available for review: Bleed air is used by all current large commercial transport aircraft and the design issue will be worldwide, while maintenance practices will vary a little, however the main problem is the failure of the reporting system and lack of collation internationally of the data indicating the degree of the problem- Michaelis S. (2007) Aviation Contaminated Air Reference Manual. ISBN 9780955567209 and See attached document

4.
comment: 'The goal is to expose EASA understanding of the subject and also to collect from stakeholders detailed information on events and experiences involving cabin air contamination by engine or APU.'

proposed Text:'The goal is to expose EASA understanding of the subject and also to collect from some stakeholders detailed information on events and experiences involving cabin air contamination by engine or APU.'

Justification: Most crews remain unaware of the EASA A-NPA on cabin air quality and as fumes have been going on for decades with industry actively working against addressing the problem in reality, few will be bothered to complete the EASA questionnaire & in any case most fume events are not related to 'the failure of the engine or APU seals' and crews that do complete the survey or may have completed it, would consider the fume events they were experiencing were not related to a complete engine/APU seal failure, rather partial failure or more likely seals not operating as intended by design. The reporting system is NOT working as has been evidenced over many decades and therefore you will hear from a small selection of stakeholders and very few aircrew. You should therefore be basing actions on the problem /evidence available and not the number of people who tell you there is a problem or otherwise. see also Michaelis S. (2007) Aviation Contaminated Air Reference Manual. ISBN 9780955567209, ch 12 and See attached document

For all the above also see:
C.Winder, S. Michaelis.(2005). 'Aircraft Air Quality Malfunction Incidents: Causation, Regulatory, Reporting and Rates'. Air Quality in airplane cabins and similar enclosed spaces -The Handbook of Environmental Chemistry - Publisher: Springer-Verlag GmbH. August 2005 and related published papers at: http://www.aopis.org/ScientificReports.html

response

Partially accepted.

The Agency accepts the possibility that the minor events may be underreported by some organisations, probably because these events are considered as nuisance (e.g. temporary bad odours or smells) and therefore they are not considered as safety related occurrences which must be reported.

Concerning the serious events involving a degree of crew or passengers' impairment or incapacitation, we believe they are reported and their number

remains very limited. A regulation is already in place for this category of events through Directive 2003/42/EC of 13 June 2003 on occurrence reporting in civil aviation: it clearly identifies failures of engines or APU resulting in "Dense visible fumes or concentrations of toxic products sufficient to incapacitate crew or passengers".

Finally we agree that decision shall be taken based on available evidences. Nevertheless, we considered that using questionnaires would provide an indication on the number of persons who may be concerned, although this will not reflect the real situation, because participants are self-selected.

comment

139 comment by: *kapers Cabin Crew Union*

It cannot be stated with certainty that Cabin air contamination events by engine or APU are "relatively rare" and the impact on flight safety "is very low" as there is not enough research or reporting on these events. Reporting events is not done very often because of ignorance as to the signs of oil leakage and subsequent cabin air contamination (pervading smell like that of "old socks" or "smelly feet", blue mists in the cabin, etc…) or because of fear of reporting an incident.

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A. Explanatory Note - II Consultation p. 3-4

comment

107 comment by: *Peter Marosszeky FRAeS*

This paper skirts around a core issue which is fundamental to the problem of contaminated air in aircraft cabins during flight. My research and experience of 47 years (maintenance & engineering as well as flight operations) and 10,800 hours of flying in very large aircraft (VLA) has proven beyond doubt that the prime cause of contamination from modern bypass engines are the following:

1. Ageing engines
2. airlines/operators failing to follow manufacturers recommended procedures, and replacing worn components
3. Due to financial constraints airlines are reluctant to remove engines

exhibiting high oil consumption, by masking it and not noting it in aircraft technical log books

4. In some cases poor engine design, althought this is confined to a small number of engines only.
5. Flight crew and maintenance crews not exercising there authority under respective legislation to insist the airline/operator remove or take appropriate maintenance action to correct engines/apu's that are consuming oil.

The lack of regulatory oversight to ensure aircraft operators comply with their own approved systems of maintenance and manufacturers approved procedures, is a major concern and requires immediate action.

Péter Marosszéky
ARN: 088321 *
*Aviation Reference Number (Australia)

response

Partially accepted.
It is possible that some airlines may not always follow the manufacturer's published maintenance instructions; however, this must not be taken as a general issue because the large majority of airlines comply with the required maintenance tasks.

A. Explanatory Note - IV. Content of the A-NPA - 8. Background and description of the issue p. 5

comment

6 comment by: *British Airways*

Comment:
New regulations should only be considered where there is evidence of a safety (or health) issue which could effectively be addressed by regulation. We do not believe that there is evidence to support new regulation in this area.

Justification:
We endorse the need for the questions at the end of this section to be answered. A indicated elsewhere in the document, there is as yet no evidence of a significant safety risk that is not already addressed through existing flight safety procedures. In addition, the UK Government's Committee on Toxicity (a group of independent and eminent scientific advisers) concluded in its recent comprehensive review of the evidence that there is no clear evidence of long-term ill-health caused by cabin air contamination. The Committee did recommend further research and, as noted elsewhere in the document, current research is intended to answer some of the questions given in the document.

response

Accepted.

comment

22 comment by: *FSC - CCOO*

"Most of the modern Large Aeroplanes use a fine High Efficiency Particulate Air (HEPA) filtration."

Comment:
We don't agree with this statement and ask the EASA to question European

	Airlines on their use of HEPA filters on aircraft in their fleet.
response	Not accepted. The Agency does not intend to make a survey on the utilisation of recirculation HEPA filters, as this would not help understanding the issue discussed in the A-NPA.

comment	*23* comment by: *FSC - CCOO* "The majority of cabin air recirculation filters take out particulate, bacteria and viruses contamination. Some recent filters also combine the HEPA filtration with an odour absorber which removes odours and Volatile Organic Compounds (VOC's)." Comment : Before such air conditioning system filters can be assessed for their performance, the nature and concentrations of all hazardous compounds to which they may be exposed, needs to be established in order that such filters are effective *and effective over long periods.* In considering this subject in response to a safety recommendation made during an investigation, Boeing concluded that the efficiency and life of such VOC converters precluded their introduction into service at this time. Another consideration with the use of filters or converters is that they could possibly mask the evidence of an oil leak by the removal of the odour normally associated with such events, but fail to remove any contamination which could affect flight crews. ETF feels that filtration should only ever be used in conjunction with good maintenance practices/design & less toxic oils in reducing the likelihood of the oil leakage in the first place, and not as a substitute.
response	Accepted. The Agency agrees that if filters would have to be mandated, this would require specifying limits for hazardous compounds based on recognised standards. It is also accepted that the removal of odours by filters which may still release toxic compounds is an issue. Based on EASA knowledge, there is no filter available on the market which would be able to remove all the toxic compounds in case of bleed air contamination failure event. The use of air sensors may be a solution. However, the Agency has not found justification to mandate such devices.

comment	*24* comment by: *FSC - CCOO* "Under certain fault conditions (e.g. engine or APU oil seal or bearing failure, engine or APU maintenance error/irregularities, or design deficiency), engine or APU oil, hydraulic fluid, fuel, de-icing fluid and the corresponding pyrolysis products may contaminate the bleed air, which then enters the cabin air supply and can be inhaled by the aeroplane occupants. In such a situation, the following questions therefore need to be answered: **What contaminants are released to the cabin and in which quantity?** **What is the effect on flight safety?**

Can it induce a health concern?

What is the frequency of this kind of event?"

Comment:
There has been and is still great difficulty in collecting and interpreting the mounting data and identifying toxic/irritant products in oil substances used in the airline industry. The physiological effects of gases and vapours in cabin air are now becoming clear and the defining of maximum acceptable quantities or concentrations must become a subject for legislation and standards.

response

Accepted.
The Agency recommends performing studies on chemical substances toxicities in aviation oils.

comment

25 comment by: *FSC - CCOO*

"What contaminants are released to the cabin and in which quantity?"

Comment:
We refer to statements published by Dr. Mackerer in 1999 and to the Henschler report published in 1958 "Engine oils contain a mixture of tricresylphosphates, of which TOCP in not the most toxic".
TOCP is NOT the only ortho isomer in TCP - the more toxic MOCP& DOCP are in the oil in far higher quantities.
Mobil advised the Australian Senate Inquiry that the ortho isomers were in the TCP in it's oil at >0.3%. The more toxic MOCP & DOCP were not mentioned.
ORTHO isomers divide into: **TOCP**, **DOCP** and **MOCP**.
Focus has been on TOCP with UK House of Lords and CAA reports of 2000 and 2004. These reports fail to ever mention DOCP or MOCP.

TOCP	**0.006 ppm**	**Toxicity factor x 1**
DOCP	**6 ppm**	**Toxicity factor x 5**
MOCP	**3070 ppm**	**Toxicity factor x 10**

In ignoring DOCP and MOCP the total ORTHO toxicity is underestimated by a factor of **6.14 million** which has been known since 1958 (Henschler).

It has been known for years that when aviation engine oils are heated, a potent neurotoxic chemical called TMPP (trimethylolpropane phosphate) can be formed. TMPP is even worse than TCPs and exposure is associated with epileptic type seizures, convulsion, tremors, and changes to social/emotional behaviors. To our knowledge, it has never been found on aircraft. But to our knowledge, nobody has ever looked into this..
A 1989 US Navy report stated that Exxon 2380 (now BP2380) generated high levels of TMPP when it was heated to temperatures at or above 350C. The TCPs in the oil then react with TMP chemicals in the "base stock" of the oil. **The levels of TMPP were so significant that the authors recommended that Exxon 2380 not be used on US naval vessels. But BP2380 is still widely used in commercial aviation**.

A 1996 US Air Force paper raised concerns about the potential for being exposed to highly toxic TMPP, and stated that TMPP could be formed when oils that contain TCPs and TMP are heated to temperatures as low as 250C. This is important because these temperatures are more likely to be reached in the engine/bleed air system. Wright also stated that TMPP can NOT be formed if the engine oil base stock contains PE chemicals instead of TMP. *WRIGHT R. L. Formation of the neurotoxin TMPP from TMPE-phosphate formulations -*

Tribiology transactions 1996, vol. 39, no4, pp. 827-834

Another US navy report in 1992 also expressed concern about the hazards

1) What engine oil(s) are used (e.g., Mobil Jet Oil II, BP2380, etc).
2) What APU and engine types are installed on what aircraft types (e.g. Pratt Whitney 4000, Honeywell Series 85, etc).

Oils and lubricants used on the aircraft and in the engines contain not only the neurotoxins (TCPs and triphenylphosphates) but **sensitizers (N-phenyl-L-naphthylamine, PAN),** and **asphyxiants (carbon monoxide)**.. Pyrolysis studies have confirmed the presence of these toxins when commercial oils are heated (van Netten, 2000; Marshman, 2001; Fox, 2001). A Material SafetyData Sheet for engine oils acknowledge only the TCP content and the fact that "toxicfumes may be evolved on burning or exposure to heat" (BP, 2001).

We ask that Studies include the potential impact of exposure to the mixture of these and other chemicals in **a reduced pressure environment**.
We suggest that the EASA review all data and see if a less toxic alternative oil can be recommended that would be compatible with given aircraft engines/APUs.
Ultimately, all of the engine oils should be analyzed for their base stock content (rather than relying on the analysis of the oil companies), as well as for the potential to form TMPP, and temperature range of TMPP formation.

response

Partially accepted.

The Agency agrees that aviation oils toxicity knowledge can be improved and we have recommended studies to be conducted in this domain. The special cabin environment should be taken into account in those studies.

Analysis of all engine oils base stock content: The Agency could not do that because the Agency does not regulate aviation fluids, and therefore we do not inspect oil manufacturers' productions. Nevertheless, the specified toxic compounds and their concentrations are provided to the engine manufacturers, which then conduct a safety analysis to verify that no hazardous quantities are released in the bleed air for identified failure scenarios. The Agency then reviews this analysis.

comment

26 comment by: *FSC - CCOO*

"What is the effect on flight safety?"

Comment:
We refer to the following statements and documents:

2001: "Incidents have been reported of impaired performance of flight crew…events could have been
caused by inhalation of agents… leaking from oil or APU and contaminating the Environmental control
system."
(CAA AD 002-03-2001)

2002: "oil leaks and cabin / flight deck odours must be regarded as a potential threat to flight safety, theyshould not be dismissed as a mere nuisance and

should be addressed as soon as possible."
(BAe ISB 21-150 2001 / ISB 21-156, 2002)

2003: "Any oil leaking from an engine, entering the aircraft customer bleed offtake, is classified as
HAZARDOUS"
(Rolls Royce, Germany 2003, BRE air quality Conference, London)

2004: "This amendment adopts a new airworthiness directive (AD), applicable to all BAE Systems
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medical examination of the copilot after the flight showed that during the flight toxic exposure took place."
(Swiss Federal Department of Environment, Transport Energy and Communications Investigation Report No u1884 by the Aircraft Accident Investigation Bureau, 2 March 2006)

We also refer the EASA to the manual written by Prof. S. Michaelis, (renowned expert on Cabin air contamination): *"Aviation Contaminated Air Reference Manual,"* Michaelis, S., ed. ISBN 9780955567209, London,

response

Noted.

comment

27 comment by: *FSC - CCOO*

Attachments #4 #5

"Can it induce a health concern?"

Comment:
We believe that there is now sufficient available material and literature on cabin air being contaminated by toxic substances used on the aircraft. Studies are now available giving indications that the health of aircraft occupants may be severely affected by the inhalation and contact with gases and vapours of lubricants, anti-freeze agents and others.

We refer the EASA to the following statements and studies :

"individuals exposed to a single large toxic dose, or to small subclinical doses, of ***organophosphorus compounds*** have developed a chronic neurotoxicity that persists for years after exposure and is distinct from both cholinergic and OPIDN"(AbouDonia, 2003; *Arch. Environ. Health* **58**:484-97).

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Journal of Occupational Health & Safety, Australia & New Zealand, Vol 21, Number 5 ,August 2005 - Special edition: New findings in aircrew exposed to airborne contaminants: Long-term health effects confirmed. - Organophosphate Ester Induced Chronic Neurotoxicity (OPICN)- Mohamed B Abou-Donia

1981: Engine Lube Oil: "At temperatures above 320C this oil breaks down into irritating and toxic compounds."
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(NYCO MSDS 2009 , TURBONYCOIL 600)
2009: "Product may decompose at elevated temperatures or under fire conditions and give off irritating and/or harmful (carbon monoxide) gases/vapours/fumes. Symptoms from acute exposure to these decomposition products in confined spaces may include headache, nausea, eye, nose, and throat irritation."
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dangerous?"
Professor D henschler (1958 TCP researcher): "I believe it to be dangerous."
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AAIB Bulletin 6/2009 G-BYAO B757, EW/C2006/10/08

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Winder, C. (2006) Hazardous chemicals on jet aircraft: Case study – Jet engine oils and aerotoxic syndrome. Current Topics in Toxicology. Vol 3, 2006

2008 -- Cognitive function following exposure to contaminated air on commercial aircraft: A case series of 27 pilots seen for clinical purposes -- S Mackenzie Ross -- Journal of Nutritional &Environmental Medicine -- June 2008; 17(2): 111–126 (see attachment 1: SMR_2008_27_pilots.pdf)
2006 -- Hazardous Chemicals on Jet Aircraft: Case Study-Jet Engine Oils and Aerotoxic Syndrome, -- C.Winder -- Current Topics in Toxicology. Vol 3 2006 (see attachment 2: Winder_Hazardous_Chemicals_on_Jet_Aircraft_2006.pdf)

The neuro-toxicity of products used in lubricants and other substances in the aircraft engines seem to provoke Long-term health problems including :

- Neurological effects: CNS,PNS: Jamal 1997, Jamal, Julu… 2002, 2005
- Autonomic nervous system effects: Jamal, Julu… 2002, 2005
- Working memory / cognitive problems. (neuropsychological), Coxon 2002 / Mackenzie Ross 2006
- Chronic neurotoxicity (OPICN): Abou-Donia 2004, 2005
- Neuronal brain cell death: Abou-Donia
- Respiratory disorders: Burdon, Glanville 2005
- Immune system effects, fatigue, chemical sensitivity etc..
- Blood pathology disorders
- Strong occupational link: Cone 1983,1999 / Harper 2005
- Individual susceptibility: Furlong
    - TCP Blood test: 6 of 10 TCP isomers are converted into the highly toxic metabolite – psp: that inhibits the activity of a number of important enzymes.
    - Gene expression: Gene expression effected by TCP at levels found in UK pilots' blood.

	The US Federal Aviation Administration (FAA) has acknowledged that "no present airplane design fulfils the intent of [federal aviation regulation] 25.831 because no airplane design incorporates an air contaminant monitoring system to ensure that the air provided to the occupants is free of hazardous contaminants" (FAA, 2002), **We point out that there is a sizable (and growing) body of literature on the association between exposure to oil fumes and acute and chronic symptoms reported globally by crews and passengers alike (ACARM, 2007). We believe there is ample justification for regulations that dictate bleed air cleaning and monitoring with flight deck indication to: (1) prevent exposure to oil fumes; (2) alert crew members if they are exposed in flight; and (3) enable maintenance workers to more effectively identify and remedy the contamination upon landing.**
response	Not accepted. Studies performed until today failed to demonstrate that cabin air can be contaminated in such a way that it could induce a safety or health issue. Cabin measurements found non-detectable or barely detectable levels of toxic contaminants. Concerning the symptoms reported by some crews or passengers: they are too generic to be directly linked to a toxic substance, although this is not rejected. Further investigation into this issue is recommended.

comment	*28* comment by: *FSC - CCOO* "What is the frequency of this kind of event?" Comment: As remarked earlier and in this EASA document (see IV. 9.), the frequency of events reported varies from country to country. Due to lack of information on the subject of contaminated air and risks, many incidents are simply not reported unless extremely serious or causing events that lead to full investigations. **Events are underreported. We ask that EASA initiate a mandatory reporting system for fume events.** **As Crews are not trained to recognize or respond to fume events, we ask EASA to legislate on the training of both pilots and cabin crew to recognize and respond to fume events.** Dr Rayman says fume events are very rare & cannot cause a problem.... but in 1983 & 2002 he said this: '***Smoke & fumes in the cockpit is not a rare event and a clear threat to flight safety due to acute toxic effects.***' *Rayman R.B., McNaughton G.B. (1983) Smoke/fumes in the cockpit. Aviation, Space and Environmental Medicine 1983; 67: 738-740.* AND exposure to VOCs used in aircraft operations can cause skin rashes, pulmonary and CNS symptoms ranging from mild to severe *RAYMAN Russell Cabin air quality: An overview . Aviation, space, and environmental medicine 2002, vol. 73, n°3, pp. 211-215*
response	Partially accepted. The Agency accepts the possibility that the minor events may be

	underreported by some organisations, probably because these events are considered as nuisance (e.g. temporary bad odours or smells), and therefore they are not considered as safety related occurrences which must be reported. Concerning the serious events involving a degree of crew or passengers' impairment or incapacitation, we believe they are reported and their number remains very limited. A regulation is already in place for this category of events through Directive 2003/42/EC of 13 June 2003 on occurrence reporting in civil aviation: it clearly identifies failures of engines or APU resulting in "Dense visible fumes or concentrations of toxic products sufficient to incapacitate crew or passengers". It is the responsibility of each Member State to ensure that stakeholders comply with this Directive. The Agency does not intend to create another mandatory reporting system.
comment	*37* comment by: *Unionen/Sweden* "Most of the modern Large Aeroplanes use a fine High Efficiency Particulate Air (HEPA) filtration." Comment: We don't agree with this statement and ask the EASA to question European Airlines on their use of HEPA filters on aircraft in their fleet
response	Not accepted. The Agency does not intend to make a survey on the utilisation of recirculation HEPA filters, as this would not help understanding the issue discussed in the A-NPA.
comment	*38* comment by: *Unionen/Sweden* "The majority of cabin air recirculation filters take out particulate, bacteria and viruses contamination. Some recent filters also combine the HEPA filtration with an odour absorber which removes odours and Volatile Organic Compounds (VOC's)." Comment : Before such air conditioning system filters can be assessed for their performance, the nature and concentrations of all hazardous compounds to which they may be exposed, needs to be established in order that such filters are effective *and effective over long periods.* In considering this subject in response to a safety recommendation made during an investigation, Boeing concluded that the efficiency and life of such VOC converters precluded their introduction into service at this time. Another consideration with the use of filters or converters is that they could possibly mask the evidence of an oil leak by the removal of the odour normally associated with such events, but fail to remove any contamination which could affect flight crews. ETF feels that filtration should only ever be used in conjunction with good maintenance practices/design & less toxic oils in reducing the likelihood of the oil leakage in the first place, and not as a substitute.
response	Accepted. The Agency agrees that if filters had to be mandated, this would require specifying limits for hazardous compounds based on recognised standards.

It is also accepted that the removal of odours by filters which may still release toxic compounds is an issue. Based on EASA knowledge, there is no filter available on the market which would be able to remove all the toxic compounds in case of bleed air contamination failure event. The use of air sensors may be a solution. However, the Agency has not found justification to mandate such devices.

comment

39 comment by: *Unionen/Sweden*

Under certain fault conditions (e.g. engine or APU oil seal or bearing failure, engine or APU maintenance error/irregularities, or design deficiency), engine or APU oil, hydraulic fluid, fuel, de-icing fluid and the corresponding pyrolysis products may contaminate the bleed air, which then enters the cabin air supply and can be inhaled by the aeroplane occupants.
In such a situation, the following questions therefore need to be answered:

What contaminants are released to the cabin and in which quantity?

What is the effect on flight safety?

Can it induce a health concern?

What is the frequency of this kind of event?"

Comment:
There has been and is still great difficulty in collecting and interpreting the mounting data and identifying toxic/irritant products in oil substances used in the airline industry. The physiological effects of gases and vapours in cabin air are now becoming clear and the defining of maximum acceptable quantities or concentrations must become a subject for legislation and standards.

response

Accepted.
The Agency recommends performing studies on chemical substances toxicities in aviation oils.

comment

40 comment by: *Unionen/Sweden*

"What contaminants are released to the cabin and in which quantity?"

Comment:
We refer to statements published by Dr. Mackerer in 1999 and to the Henschler report published in 1958 "Engine oils contain a mixture of tricresylphosphates, of which TOCP in not the most toxic".
TOCP is NOT the only ortho isomer in TCP - the more toxic MOCP& DOCP are in the oil in far higher quantities.
Mobil advised the Australian Senate Inquiry that the ortho isomers were in the TCP in it's oil at >0.3%. The more toxic MOCP & DOCP were not mentioned.
ORTHO isomers divide into: **TOCP**, **DOCP** and **MOCP**.
Focus has been on TOCP with UK House of Lords and CAA reports of 2000 and 2004. These reports fail to ever mention DOCP or MOCP.

TOCP	**0.006 ppm**	**Toxicity factor x 1**
DOCP	**6 ppm**	**Toxicity factor x 5**
MOCP	**3070 ppm**	**Toxicity factor x 10**

In ignoring DOCP and MOCP the total ORTHO toxicity is underestimated by a factor of **6.14 million** which has been known since 1958 (Henschler).

It has been known for years that when aviation engine oils are heated, a potent neurotoxic chemical called TMPP (trimethylolpropane phosphate) can be formed. TMPP is even worse than TCPs and exposure is associated with epileptic type seizures, convulsion, tremors, and changes to social/emotional behaviors. To our knowledge, it has never been found on aircraft. But to our knowledge, nobody has ever looked into this..
A 1989 US Navy report stated that Exxon 2380 (now BP2380) generated high levels of TMPP when it was heated to temperatures at or above 350C. The TCPs in the oil then react with TMP chemicals in the "base stock" of the oil. **The levels of TMPP were so significant that the authors recommended that Exxon 2380 not be used on US naval vessels. But BP2380 is still widely used in commercial aviation**.

A 1996 US Air Force paper raised concerns about the potential for being exposed to highly toxic TMPP, and stated that TMPP could be formed when oils that contain TCPs and TMP are heated to temperatures as low as 250C. This is important because these temperatures are more likely to be reached in the engine/bleed air system. Wright also stated that TMPP can NOT be formed if the engine oil base stock contains PE chemicals instead of TMP. *WRIGHT R. L. Formation of the neurotoxin TMPP from TMPE-phosphate formulations - Tribiology transactions 1996, vol. 39, no4, pp. 827-834*

Another US navy report in 1992 also expressed concern about the hazards

1) What engine oil(s) are used (e.g., Mobil Jet Oil II, BP2380, etc).
2) What APU and engine types are installed on what aircraft types (e.g. Pratt Whitney 4000, Honeywell Series 85, etc).

Oils and lubricants used on the aircraft and in the engines contain not only the neurotoxins (TCPs and triphenylphosphates) but **sensitizers (N-phenyl-L-naphthylamine, PAN),** and **asphyxiants (carbon monoxide)**.. Pyrolysis studies have confirmed the presence of these toxins when commercial oils are heated (van Netten, 2000; Marshman, 2001; Fox, 2001). A Material SafetyData Sheet for engine oils acknowledge only the TCP content and the fact that "toxicfumes may be evolved on burning or exposure to heat" (BP, 2001).

We ask that Studies include the potential impact of exposure to the mixture of these and other chemicals in **a reduced pressure environment**.
We suggest that the EASA review all data and see if a less toxic alternative oil can be recommended that would be compatible with given aircraft engines/APUs.
Ultimately, all of the engine oils should be analyzed for their base stock content (rather than relying on the analysis of the oil companies), as well as for the potential to form TMPP, and temperature range of TMPP formation.

response

Partially accepted.

The Agency agrees that aviation oils toxicity knowledge can be improved and we have recommended studies to be conducted in this domain. The special cabin environment should be taken into account in those studies.

Analysis of all engine oils base stock content: The Agency could not do that because the Agency does not regulate aviation fluids, and therefore we do not inspect oil manufacturers' productions. Nevertheless, the specified toxic compounds and their concentrations are provided to the engine manufacturers

	which then conduct a safety analysis to verify that no hazardous quantities are released in the bleed air for identified failure scenarios. The Agency then reviews this analysis.
comment	*41* comment by: *Unionen/Sweden* "What is the effect on flight safety?" Comment: We refer to the following statements and documents: **2001:** "Incidents have been reported of impaired performance of flight crew…events could have been caused by inhalation of agents… leaking from oil or APU and contaminating the Environmental control system." (CAA AD 002-03-2001) **2002:** "oil leaks and cabin / flight deck odours must be regarded as a potential threat to flight safety, theyshould not be dismissed as a mere nuisance and should be addressed as soon as possible." (BAe ISB 21-150 2001 / ISB 21-156, 2002) **2003:** "Any oil leaking from an engine, entering the aircraft customer bleed offtake, is classified as HAZARDOUS" (Rolls Royce, Germany 2003, BRE air quality Conference, London) **2004:** "This amendment adopts a new airworthiness directive (AD), applicable to all BAE Systems (Operations) Limited Model BAe 146 series airplanes, that requires repetitive detailed inspections of the inside of each air conditioning sound-attenuating duct, and corrective actions as necessary. This action is necessary to prevent impairment of the operational skills and abilities of the flightcrew caused by the inhalation of agents released from oil or oil breakdown products, which could result in reduced controllability of the airplane. This action is intended to address the identified unsafe condition." (FAA AD 2004-12-05) **2006:** "The serious incident is attributable to the fact that on approach to Zurich Airport the cockpit filled with fumes which caused a toxic effect, leading to a limited capability of acting of the copilot. These fumes were caused by an oil leak as a result of a bearing damage in engine No. 1" "The medical examination of the copilot after the flight showed that during the flight toxic exposure took place." (Swiss Federal Department of Environment, Transport Energy and Communications Investigation Report No u1884 by the Aircraft Accident Investigation Bureau, 2 March 2006) We also refer the EASA to the manual written by Prof. S. Michaelis, (renowned expert on Cabin air contamination): *"Aviation Contaminated Air Reference Manual,"* Michaelis, S., ed. ISBN 9780955567209, London,
response	Noted.
comment	*42* comment by: *Unionen/Sweden* "Can it induce a health concern?"

Comment:
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The neuro-toxicity of products used in lubricants and other substances in the aircraft engines seem to provoke Long-term health problems including :

– Neurological effects: CNS,PNS: Jamal 1997, Jamal, Julu… 2002, 2005
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"What is the frequency of this kind of event?"

Comment:
As remarked earlier and in this EASA document (see IV. 9.), the frequency of events reported varies from country to country. Due to lack of information on the subject of contaminated air and risks, many incidents are simply not reported unless extremely serious or causing events that lead to full investigations.
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AND exposure to VOCs used in aircraft operations can cause skin rashes, pulmonary and CNS symptoms ranging from mild to severe *RAYMAN Russell Cabin air quality: An overview . Aviation, space, and environmental medicine 2002, vol. 73, n°3, pp. 211-215*

"In the European Community, the majority of the reports are originated from the United Kingdom (UK), the other Member States reporting far less on this issue (refer to UK AAIB report 1/2004 published in February 2004). According to a presentation from the UK Civil Aviation Authority (CAA UK) to the Agency in March 2007, there were 104 flight deck occurrences on Large Aeroplanes between 1999 and 2006; a peak of events (26) appears in 2001, then followed by a significant decrease in 2002 and 2003. This decrease in the number of events can be explained by the measures taken in 2001-2002 towards the two aeroplane types generating the majority of the events (BAE146 and B757); these measures consisted in inspections and corrective actions to limit the risk of oil leakage from APU and engines. Then, after a very calm period, another peak of events appeared in 2006 (26 events). No official CAA UK events figures are available to EASA for 2007 and 2008, but according to them the tendency is a decrease in the number of reports."

Comment:
Despite claims that there is insufficient reporting **(please refer to ACARM (2007b) "Chapter 12: Frequency of Events and Underreporting" "*Aviation Contaminated Air Reference Manual,"* Michaelis, S., ed. ISBN 9780955567209, London, England, pp. 211-248)** and evidence to support casual relationship between exposure to oil contaminated air and pilot ill health the **UK COT report** concluded that it would be PRUDENT to PREVENT exposure to oil contaminated air. We fully support any study that the EASA undertakes to collect data regarding the number of events/incidents linked to oil contaminated air and request that preventative measures be taken and included in new standards.
The FAA says it has recorded 900 fume events in 10 years. But in 2006 they said this:
'There have been concerns raised about numerous reports of "smoke/fumes in the cockpit/cabin" events on commercial air carrier/operator aircraft. During the FAA's analysis of this data, it appears as though there are numerous air carriers/operators who may not have reported these events as required by regulation. **Flight Standards Information Bulletin for Airworthiness (FSAW)06-05A, Guidance for Smoke/Fumes in the Cockpit/Cabin_29 March 2006.29 March 2006 (see attachment: Smoke-Cockpit-Ballough.ppt)**

Concerning the detection & reporting of oil leakage and vapours inside the aircraft cabin Professor Windsor states that "***The only technically functional way to identify the presence of poorly volatile contaminants present in aircraft environments is to place a direct reading machine on the aircraft during flight."***
The US FAA has acknowledged that "no present airplane design fulfils the intent of [federal aviation regulation] 25.831 because no airplane design incorporates an air contaminant monitoring system to ensure that the air provided to the occupants is free of hazardous contaminants"

response

Not accepted.

Health effect: Studies performed until today failed to demonstrate that cabin air can be contaminated in such a way that it could induce a safety or health issue. Cabin measurements found non-detectable or barely detectable levels of toxic contaminants. Concerning the symptoms reported by some crews or passengers: they are too generic to be directly linked to a toxic substance, although this is not rejected. Further investigation into this issue is

recommended.

Reporting: The Agency accepts the possibility that the minor events may be underreported by some organisations, probably because these events are considered as nuisance (e.g. temporary bad odours or smells), and therefore they are not considered as safety related occurrences which must be reported.

Concerning the serious events involving a degree of crew or passengers' impairment or incapacitation, we believe they are reported and their number remains very limited. A regulation is already in place for this category of events through Directive 2003/42/EC of 13 June 2003 on occurrence reporting in civil aviation: it clearly identifies failures of engines or APU resulting in "Dense visible fumes or concentrations of toxic products sufficient to incapacitate crew or passengers". It is the responsibility of each Member State to ensure that stakeholders comply with this Directive. The Agency does not intend to create another mandatory reporting system.

comment

52 comment by: *cfdt france*

Most of the modern Large Aeroplanes use a fine High Efficiency Particulate Air (HEPA) filtration."

Comment:
We don't agree with this statement and ask the EASA to question European Airlines on their use of HEPA filters on aircraft in their fleet.

response

Not accepted.
The Agency does not intend to make a survey on the utilisation of recirculation HEPA filters, as this would not help understanding the issue discussed in the A-NPA.

comment

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"The majority of cabin air recirculation filters take out particulate, bacteria and viruses contamination. Some recent filters also combine the HEPA filtration with an odour absorber which removes odours and Volatile Organic Compounds (VOC's)."

Comment :
Before such air conditioning system filters can be assessed for their performance, the nature and concentrations of all hazardous compounds to which they may be exposed, needs to be established in order that such filters are effective *and effective over long periods.* In considering this subject in response to a safety recommendation made during an investigation, Boeing concluded that the efficiency and life of such VOC converters precluded their introduction into service at this time.

Another consideration with the use of filters or converters is that they could possibly mask the evidence of an oil leak by the removal of the odour normally associated with such events, but fail to remove any contamination which could affect flight crews. ETF feels that filtration should only ever be used in conjunction with good maintenance practices/design & less toxic oils in reducing the likelihood of the oil leakage in the first place, and not as a substitute.

response

Accepted.

The Agency agrees that if filters would have to be mandated, this would require specifying limits for hazardous compounds based on recognised standards.

It is also accepted that the removal of odours by filters which may still release toxic compounds is an issue. Based on the Agency's knowledge, there is no filter available on the market which would be able to remove all the toxic compounds in case of bleed air contamination failure event. The use of air sensors may be a solution. However, the Agency has not found justification to mandate such devices.

comment

54 comment by: *cfdt france*

Under certain fault conditions (e.g. engine or APU oil seal or bearing failure, engine or APU maintenance error/irregularities, or design deficiency), engine or APU oil, hydraulic fluid, fuel, de-icing fluid and the corresponding pyrolysis products may contaminate the bleed air, which then enters the cabin air supply and can be inhaled by the aeroplane occupants.
In such a situation, the following questions therefore need to be answered:

What contaminants are released to the cabin and in which quantity?

What is the effect on flight safety?

Can it induce a health concern?

What is the frequency of this kind of event?"

Comment:
There has been and is still great difficulty in collecting and interpreting the mounting data and identifying toxic/irritant products in oil substances used in the airline industry. The physiological effects of gases and vapours in cabin air are now becoming clear and the defining of maximum acceptable quantities or concentrations must become a subject for legislation and standards.

response

Accepted.
The Agency recommends performing studies on chemical substances toxicities in aviation oils.

comment

55 comment by: *cfdt france*

"**What contaminants are released to the cabin and in which quantity?"**

Comment:
We refer to statements published by Dr. Mackerer in 1999 and to the Henschler report published in 1958 "Engine oils contain a mixture of tricresylphosphates, of which TOCP in not the most toxic".
TOCP is NOT the only ortho isomer in TCP - the more toxic MOCP& DOCP are in the oil in far higher quantities.
Mobil advised the Australian Senate Inquiry that the ortho isomers were in the TCP in it's oil at >0.3%. The more toxic MOCP & DOCP were not mentioned.
ORTHO isomers divide into: **TOCP**, **DOCP** and **MOCP**.
Focus has been on TOCP with UK House of Lords and CAA reports of 2000 and 2004. These reports fail to ever mention DOCP or MOCP.

TOCP	**0.006 ppm**	**Toxicity factor x 1**
DOCP	**6 ppm**	**Toxicity factor x 5**

MOCP 3070 ppm Toxicity factor x 10
In ignoring DOCP and MOCP the total ORTHO toxicity is underestimated by a factor of **6.14 million** which has been known since 1958 (Henschler).

It has been known for years that when aviation engine oils are heated, a potent neurotoxic chemical called TMPP (trimethylolpropane phosphate) can be formed. TMPP is even worse than TCPs and exposure is associated with epileptic type seizures, convulsion, tremors, and changes to social/emotional behaviors. To our knowledge, it has never been found on aircraft. But to our knowledge, nobody has ever looked into this..
A 1989 US Navy report stated that Exxon 2380 (now BP2380) generated high levels of TMPP when it was heated to temperatures at or above 350C. The TCPs in the oil then react with TMP chemicals in the "base stock" of the oil. **The levels of TMPP were so significant that the authors recommended that Exxon 2380 not be used on US naval vessels. But BP2380 is still widely used in commercial aviation**.

A 1996 US Air Force paper raised concerns about the potential for being exposed to highly toxic TMPP, and stated that TMPP could be formed when oils that contain TCPs and TMP are heated to temperatures as low as 250C. This is important because these temperatures are more likely to be reached in the engine/bleed air system. Wright also stated that TMPP can NOT be formed if the engine oil base stock contains PE chemicals instead of TMP. *WRIGHT R. L. Formation of the neurotoxin TMPP from TMPE-phosphate formulations - Tribiology transactions 1996, vol. 39, no4, pp. 827-834*

Another US navy report in 1992 also expressed concern about the hazards
1) What engine oil(s) are used (e.g., Mobil Jet Oil II, BP2380, etc).
2) What APU and engine types are installed on what aircraft types (e.g. Pratt Whitney 4000, Honeywell Series 85, etc).

Oils and lubricants used on the aircraft and in the engines contain not only the neurotoxins (TCPs and triphenylphosphates) but **sensitizers (N-phenyl-L-naphthylamine, PAN),** and **asphyxiants (carbon monoxide)**.. Pyrolysis studies have confirmed the presence of these toxins when commercial oils are heated (van Netten, 2000; Marshman, 2001; Fox, 2001). A Material SafetyData Sheet for engine oils acknowledge only the TCP content and the fact that "toxicfumes may be evolved on burning or exposure to heat" (BP, 2001).

We ask that Studies include the potential impact of exposure to the mixture of these and other chemicals in **a reduced pressure environment**.
We suggest that the EASA review all data and see if a less toxic alternative oil can be recommended that would be compatible with given aircraft engines/APUs.
Ultimately, all of the engine oils should be analyzed for their base stock content (rather than relying on the analysis of the oil companies), as well as for the potential to form TMPP, and temperature range of TMPP formation.

response

Partially accepted.

The Agency agrees that aviation oils toxicity knowledge can be improved and we have recommended studies to be conducted in this domain. The special cabin environment should be taken into account in those studies.

Analysis of all engine oils base stock content: The Agency could not do that

	because the Agency does not regulate aviation fluids, and therefore we do not inspect oil manufacturers' productions. Nevertheless, the specified toxic compounds and their concentrations are provided to the engine manufacturers which then conduct a safety analysis to verify that no hazardous quantities are released in the bleed air for identified failure scenarios. The Agency then reviews this analysis.
comment	*56* comment by: *cfdt france* **"What is the effect on flight safety?"** Comment: We refer to the following statements and documents: **2001:** "Incidents have been reported of impaired performance of flight crew…events could have been caused by inhalation of agents… leaking from oil or APU and contaminating the Environmental control system." (CAA AD 002-03-2001) **2002:** "oil leaks and cabin / flight deck odours must be regarded as a potential threat to flight safety, theyshould not be dismissed as a mere nuisance and should be addressed as soon as possible." (BAe ISB 21-150 2001 / ISB 21-156, 2002) **2003:** "Any oil leaking from an engine, entering the aircraft customer bleed offtake, is classified as HAZARDOUS" (Rolls Royce, Germany 2003, BRE air quality Conference, London) **2004:** "This amendment adopts a new airworthiness directive (AD), applicable to all BAE Systems (Operations) Limited Model BAe 146 series airplanes, that requires repetitive detailed inspections of the inside of each air conditioning sound-attenuating duct, and corrective actions as necessary. This action is necessary to prevent impairment of the operational skills and abilities of the flightcrew caused by the inhalation of agents released from oil or oil breakdown products, which could result in reduced controllability of the airplane. This action is intended to address the identified unsafe condition." (FAA AD 2004-12-05) **2006:** "The serious incident is attributable to the fact that on approach to Zurich Airport the cockpit filled with fumes which caused a toxic effect, leading to a limited capability of acting of the copilot. These fumes were caused by an oil leak as a result of a bearing damage in engine No. 1" "The medical examination of the copilot after the flight showed that during the flight toxic exposure took place." (Swiss Federal Department of Environment, Transport Energy and Communications Investigation Report No u1884 by the Aircraft Accident Investigation Bureau, 2 March 2006) We also refer the EASA to the manual written by Prof. S. Michaelis, (renowned expert on Cabin air contamination): *"Aviation Contaminated Air Reference Manual,"* Michaelis, S., ed. ISBN 9780955567209, London,
response	Noted.

comment

57 comment by: *cfdt france*

"Can it induce a health concern?"

Comment:
We believe that there is now sufficient available material and literature on cabin air being contaminated by toxic substances used on the aircraft. Studies are now available giving indications that the health of aircraft occupants may be severely affected by the inhalation and contact with gases and vapours of lubricants, anti-freeze agents and others.

We refer the EASA to the following statements and studies :

"individuals exposed to a single large toxic dose, or to small subclinical doses, of ***organophosphorus compounds*** have developed a chronic neurotoxicity that persists for years after exposure and is distinct from both cholinergic and OPIDN"(AbouDonia, 2003; *Arch. Environ. Health* **58**:484-97).

- Abou-Donia MB(2004) Organophosphorus ester-induced chronic neurotoxicity. Archives of Environmental Health 58:484–497
- Organophosphate Ester Induced Chronic Neurotoxicity (OPICN)- Mohamed B Abou-Donia : Proceedings of the BALPA 'Contaminated Air Protection Air Safety and Cabin Air Quality International Aero Industry Conference'. Held at Imperial College, London, 20-21 April 2005: ISBN 0-7334-2282-9
- Journal of Occupational Health & Safety, Australia & New Zealand, Vol 21, Number 5 ,August 2005 - Special edition: New findings in aircrew exposed to airborne contaminants: Long-term health effects confirmed. - Organophosphate Ester Induced Chronic Neurotoxicity (OPICN)- Mohamed B Abou-Donia

1981: Engine Lube Oil: "At temperatures above 320C this oil breaks down into irritating and toxic
compounds."
(SAE Aviation Information Report: 1539, issued 1-30-81)
1983: "All of these toxic substances (includes engine oil) have acute and long-term effects"
(Rayman R.B., McNaughton G.B. Smoke/fumes in the cockpit. Aviation, Space and Environmental
Medicine, August 1983, pp 738-740. Current Director of the Aerospace Medical Association)
1998: "Repeated low level exposure leads to cumulative toxicity." (1981 ed)
"Acute and repeated exposure can produce harmful effects in man, and it has been suggested that chronic exposure at lower doses may cause long-term ill health." (1998 ed)
(UKHSE: Organophosphates: HSE: MS17: Medical aspects of occupational exposures to organophosphates. Draft revision 23, November, 1998.)
1999: "Neuropsychological outcomes - Neuropsychological abnormalities can occur as a long-term complication of acute OP poisoning"
(UK COT report. Long term sequelae of acute poisoning: 1999. Committee on Toxicity of Chemicals in Food, Consumer Products and the Environment: Organophosphates: Executive Summary. Published by the Department of Health, 1999, London)
1999: "The inhalation of mist (containing tricresylphosphate) which can be produced by high pressure systems, or direct contact with the skin, would be hazardous."
(UK Government Hansard 66599, 4 February 1999, column 737)
1999: "TCP is toxic"
(UK Government: Hansard 82322 6 May 1999 : Column: 428)

2000: "With the weight of human evidence and suffering, which is quite clear, there must be something there" "There is absolutely no doubt in our mind that there is a general health issue here"
(BAe Systems verbal evidence to Australian senate Inquiry 2000)
2001: "Incidents have been reported of impaired performance of flight crew…events could have been caused by inhalation of agents… leaking from oil or APU and contaminating the Environmental control system."
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2002: "FAA rule-making has not kept pace with public expectation and concern about air quality and does not afford explicit protection from particulate matter and other chemical and biological hazards." "No present airplane design fulfills the intent of 25.831 because no airplane design incorporates an air
Contaminant monitoring system to ensure that the air provided to the occupants is free of hazardous contaminants"
2003: "Any oil leaking from an engine, entering the aircraft customer bleed off-take, is classified as HAZARDOUS"
(Rolls Royce, Germany2003, BRE air quality Conference, London)
2003: "It is found that the sound attenuating material used in the air-conditioning ducts can absorb oil and can become a source of persistent air contamination."
(CASA AD /BAe 146/102, 23 January 2003)
2004: "In the event of oil leakage there is the opportunity, therefore, for the pyrolysis products of engine lubricant/fuel to enter the cabin air supply and exert toxic effects on both passengers and crew."
(CAA Air Quality report 2004)
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(FAA AD 2004-12-05)
2005: "Both Flight Crew Affected By Sore Throats And Other Symptoms After Flight." "Smells and irritants from burning organic compounds from within the engines are known to produce harmful volatile organic contaminants."
(UKAirline Air Safety Report, ASR G-CFAH, 4 July 2005)
2007: "Mobil Jet Oil II- Known to be harmful"
(CASA: AIR SAFETY & CABIN AIR QUALITY - Jim Coyne – A/g General Manager Manufacturing,
Certification & New Technologies Office: 2007 presentation)
2007: "A35-12: Protection of the health of passengers and crews and prevention of the spread of communicable disease through international travel
-Declares that the protection of the health of passengers and crews on international flights is an integral element of safe air travel and that conditions should be in place to ensure its preservation in a timely and cost-effective manner;
-Requests the Council to support further research on the consequences of air transport on the health of passengers and crews"
(ICAO- Aviation Medicine (Med) Section Related ICAO Resolutions, 5 July 2007)

http://www.icao.int/icao/en/assembl/a36/wp/wp022_en.pdf
2007: "I call on the government to reveal whether information about defects has been withheld from the regulator, the courts or the parliament"
"I am gravely concerned that crew and passengers of BAe146 aircraft have been exposed to dangerous fumes produced by engine defects"
(Senate Hansard: Monday, 13 August 2007, Senator O'Brien
2009: "Product may decompose at elevated temperatures or under fire conditions and produce harmful gases or vapours. Vapours or mist of heated product may be harmful by inhalation."
R 63.G3 Possible risk of harm to the unborn child.
R 62.F3 Possible risk of impaired fertility.
(NYCO MSDS 2009 , TURBONYCOIL 600)
2009: "Product may decompose at elevated temperatures or under fire conditions and give off irritating and/or harmful (carbon monoxide) gases/vapours/fumes. Symptoms from acute exposure to these decomposition products in confined spaces may include headache, nausea, eye, nose, and throat irritation."
(Mobil MJO2 MSDS EU 2009)
2009: Plus Minus: "Is inhaling of tricresyl phosphate (TCP) safe or dangerous?"
Professor D henschler (1958 TCP researcher): "I believe it to be dangerous."
(German TV: Plus Minus, March 2009)
2009: "Does the German Government believe that inhaling of heated engine oil fumes is harmless for the health of crew and passengers?". Answer "No"
German Ministry of Transport, Secretary of State Ulrich Kasparick.
(Question to MP Winfried Hermann of Bundnis90/Greenparty in regards to contaminated cabin air on board of civil airliners, printed matter 16/12023, 3 March 2009)
2009 "Smoke from pyrolysed oil can be hazardous to the eyes, mucous membranes and lungs"
(Turner V Eastwest Airlines [2009] NSWDDT 5 May 2009 , Australian Court)

2009: "Smoke or fumes in the flight deck or passenger cabin present the crew with a potentially hazardous situation"
AAIB Bulletin 6/2009 G-BYAO B757, EW/C2006/10/08

Bobb, A.J. and Still, K.R. (2003) "Known Harmful Effects of Constituents of Jet Oil Smoke," TOXDET-03-04, Naval Health Research Center Detachment (Toxicology), Wright-Patterson AFB, OH

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comment

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comment

70 comment by: *Fédération des transports CGT*

"Under certain fault conditions (e.g. engine or APU oil seal or bearing failure, engine or APU maintenance error/irregularities, or design deficiency), engine or APU oil, hydraulic fluid, fuel, de-icing fluid and the corresponding pyrolysis products may contaminate the bleed air, which then enters the cabin air supply and can be inhaled by the aeroplane occupants.
In such a situation, the following questions therefore need to be answered:

What contaminants are released to the cabin and in which quantity?

What is the effect on flight safety?

Can it induce a health concern?

What is the frequency of this kind of event?"

Comment:
There has been and is still great difficulty in collecting and interpreting the mounting data and identifying toxic/irritant products in oil substances used in the airline industry. The physiological effects of gases and vapours in cabin air are now becoming clear and the defining of maximum acceptable quantities or concentrations must become a subject for legislation and standards.

response

Accepted.
The Agency recommends performing studies on chemical substances toxicities in aviation oils.

comment

71 comment by: *Fédération des transports CGT*

"What contaminants are released to the cabin and in which quantity?"

Comment:
We refer to statements published by Dr. Mackerer in 1999 and to the Henschler report published in 1958 "Engine oils contain a mixture of tricresylphosphates, of which TOCP in not the most toxic".
TOCP is NOT the only ortho isomer in TCP - the more toxic MOCP& DOCP are in the oil in far higher quantities.
Mobil advised the Australian Senate Inquiry that the ortho isomers were in the TCP in it's oil at >0.3%. The more toxic MOCP & DOCP were not mentioned.
ORTHO isomers divide into: **TOCP**, **DOCP** and **MOCP**.
Focus has been on TOCP with UK House of Lords and CAA reports of 2000 and 2004. These reports fail to ever mention DOCP or MOCP.

TOCP	**0.006 ppm**	**Toxicity factor x 1**
DOCP	**6 ppm**	**Toxicity factor x 5**
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In ignoring DOCP and MOCP the total ORTHO toxicity is underestimated by a factor of **6.14 million** which has been known since 1958 (Henschler).

It has been known for years that when aviation engine oils are heated, a potent neurotoxic chemical called TMPP (trimethylolpropane phosphate) can be formed. TMPP is even worse than TCPs and exposure is associated with epileptic type seizures, convulsion, tremors, and changes to social/emotional behaviors. To our knowledge, it has never been found on aircraft. But to our knowledge, nobody has ever looked into this..

A 1989 US Navy report stated that Exxon 2380 (now BP2380) generated high levels of TMPP when it was heated to temperatures at or above 350C. The TCPs in the oil then react with TMP chemicals in the "base stock" of the oil. **The levels of TMPP were so significant that the authors recommended that Exxon 2380 not be used on US naval vessels. But BP2380 is still widely used in commercial aviation**.

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Another US navy report in 1992 also expressed concern about the hazards

1) What engine oil(s) are used (e.g., Mobil Jet Oil II, BP2380, etc).
2) What APU and engine types are installed on what aircraft types (e.g. Pratt Whitney 4000, Honeywell Series 85, etc).

Oils and lubricants used on the aircraft and in the engines contain not only the neurotoxins (TCPs and triphenylphosphates) but **sensitizers (N-phenyl-L-naphthylamine, PAN),** and **asphyxiants (carbon monoxide)**.. Pyrolysis studies have confirmed the presence of these toxins when commercial oils are heated (van Netten, 2000; Marshman, 2001; Fox, 2001). A Material SafetyData Sheet for engine oils acknowledge only the TCP content and the fact that "toxicfumes may be evolved on burning or exposure to heat" (BP, 2001).

We ask that Studies include the potential impact of exposure to the mixture of these and other chemicals in **a reduced pressure environment**.
We suggest that the EASA review all data and see if a less toxic alternative oil can be recommended that would be compatible with given aircraft engines/APUs.
Ultimately, all of the engine oils should be analyzed for their base stock content (rather than relying on the analysis of the oil companies), as well as for the potential to form TMPP, and temperature range of TMPP formation.

response

Partially accepted.

The Agency agrees that aviation oils toxicity knowledge can be improved and we have recommended studies to be conducted in this domain. The special cabin environment should be taken into account in those studies.

Analysis of all engine oils base stock content: The Agency could not do that because the Agency does not regulate aviation fluids, and therefore we do not inspect oil manufacturers' productions. Nevertheless, the specified toxic compounds and their concentrations are provided to the engine manufacturers which then conduct a safety analysis to verify that no hazardous quantities are released in the bleed air for identified failure scenarios. The Agency then reviews this analysis.

comment

72 comment by: *Fédération des transports CGT*

"What is the effect on flight safety?"

Comment:
We refer to the following statements and documents:

2001: "Incidents have been reported of impaired performance of flight crew…events could have been
caused by inhalation of agents… leaking from oil or APU and contaminating the Environmental control
system."
(CAA AD 002-03-2001)

2002: "oil leaks and cabin / flight deck odours must be regarded as a potential threat to flight safety, theyshould not be dismissed as a mere nuisance and should be addressed as soon as possible."
(BAe ISB 21-150 2001 / ISB 21-156, 2002)

2003: "Any oil leaking from an engine, entering the aircraft customer bleed offtake, is classified as HAZARDOUS"
(Rolls Royce, Germany 2003, BRE air quality Conference, London)

2004: "This amendment adopts a new airworthiness directive (AD), applicable to all BAE Systems (Operations) Limited Model BAe 146 series airplanes, that requires repetitive detailed inspections of the inside of each air conditioning sound-attenuating duct, and corrective actions as necessary. This action is necessary to prevent impairment of the operational skills and abilities of the flightcrew caused by the inhalation of agents released from oil or oil breakdown products, which could result in reduced controllability of the airplane. This action is intended to address the identified unsafe condition."
(FAA AD 2004-12-05)

2006: "The serious incident is attributable to the fact that on approach to Zurich Airport the cockpit filled with fumes which caused a toxic effect, leading to a limited capability of acting of the copilot. These fumes were caused by an oil leak as a result of a bearing damage in engine No. 1" "The medical examination of the copilot after the flight showed that during the flight toxic exposure took place."
(Swiss Federal Department of Environment, Transport Energy and Communications Investigation Report No u1884 by the Aircraft Accident Investigation Bureau, 2 March 2006)

We also refer the EASA to the manual written by Prof. S. Michaelis, (renowned expert on Cabin air contamination): *"Aviation Contaminated Air Reference Manual,"* Michaelis, S., ed. ISBN 9780955567209, London,

response

Noted.

comment

73 comment by: *Fédération des transports CGT*

"Can it induce a health concern?"

Comment:
We believe that there is now sufficient available material and literature on cabin air being contaminated by toxic substances used on the aircraft. Studies are now available giving indications that the health of aircraft occupants may be severely affected by the inhalation and contact with gases and vapours of lubricants, anti-freeze agents and others.

We refer the EASA to the following statements and studies :

"individuals exposed to a single large toxic dose, or to small subclinical doses, of ***organophosphorus compounds*** have developed a chronic neurotoxicity that persists for years after exposure and is distinct from both cholinergic and OPIDN"(AbouDonia, 2003; *Arch. Environ. Health* **58**:484-97).

- Abou-Donia MB(2004) Organophosphorus ester-induced chronic neurotoxicity. Archives of Environmental Health 58:484–497
- Organophosphate Ester Induced Chronic Neurotoxicity (OPICN)- Mohamed B Abou-Donia : Proceedings of the BALPA 'Contaminated Air Protection Air Safety and Cabin Air Quality International Aero Industry Conference'. Held at Imperial College, London, 20-21 April 2005: ISBN 0-7334-2282-9
- Journal of Occupational Health & Safety, Australia & New Zealand, Vol 21, Number 5 ,August 2005 - Special edition: New findings in aircrew exposed to airborne contaminants: Long-term health effects confirmed. - Organophosphate Ester Induced Chronic Neurotoxicity (OPICN)- Mohamed B Abou-Donia

1981: Engine Lube Oil: "At temperatures above 320C this oil breaks down into irritating and toxic compounds."
(SAE Aviation Information Report: 1539, issued 1-30-81)
1983: "All of these toxic substances (includes engine oil) have acute and long-term effects"
(Rayman R.B., McNaughton G.B. Smoke/fumes in the cockpit. Aviation, Space and Environmental
Medicine, August 1983, pp 738-740. Current Director of the Aerospace Medical Association)
1998: "Repeated low level exposure leads to cumulative toxicity." (1981 ed)
"Acute and repeated exposure can produce harmful effects in man, and it has been suggested that chronic exposure at lower doses may cause long-term ill

health." (1998 ed)
(UKHSE: Organophosphates: HSE: MS17: Medical aspects of occupational exposures to organophosphates. Draft revision 23, November, 1998.)
1999: "Neuropsychological outcomes - Neuropsychological abnormalities can occur as a long-term complication of acute OP poisoning"
(UK COT report. Long term sequelae of acute poisoning: 1999. Committee on Toxicity of Chemicals in Food, Consumer Products and the Environment: Organophosphates: Executive Summary. Published by the Department of Health, 1999, London)
1999: "The inhalation of mist (containing tricresylphosphate) which can be produced by high pressure systems, or direct contact with the skin, would be hazardous."
(UK Government Hansard 66599, 4 February 1999, column 737)
1999: "TCP is toxic"
(UK Government: Hansard 82322 6 May 1999 : Column: 428)
2000: "With the weight of human evidence and suffering, which is quite clear, there must be something there" "There is absolutely no doubt in our mind that there is a general health issue here"
(BAe Systems verbal evidence to Australian senate Inquiry 2000)
2001: "Incidents have been reported of impaired performance of flight crew…events could have been caused by inhalation of agents… leaking from oil or APU and contaminating the Environmental control system."
(CAA AD 002-03-2001)
2002: "oil leaks and cabin / flight deck odours must be regarded as a potential threat to flight safety, they should not be dismissed as a mere nuisance and should be addressed as soon as possible."
(BAe ISB 21-150 2001 / ISB 21-156, 2002)
2002: "FAA rule-making has not kept pace with public expectation and concern about air quality and does not afford explicit protection from particulate matter and other chemical and biological hazards." "No present airplane design fulfills the intent of 25.831 because no airplane design incorporates an air Contaminant monitoring system to ensure that the air provided to the occupants is free of hazardous contaminants"
2003: "Any oil leaking from an engine, entering the aircraft customer bleed off-take, is classified as HAZARDOUS"
(Rolls Royce, Germany2003, BRE air quality Conference, London)
2003: "It is found that the sound attenuating material used in the air-conditioning ducts can absorb oil and can become a source of persistent air contamination."
(CASA AD /BAe 146/102, 23 January 2003)
2004: "In the event of oil leakage there is the opportunity, therefore, for the pyrolysis products of engine lubricant/fuel to enter the cabin air supply and exert toxic effects on both passengers and crew."
(CAA Air Quality report 2004)
2004: "This amendment adopts a new airworthiness directive (AD), applicable to all BAE Systems (Operations) Limited Model BAe 146 series airplanes, that requires repetitive detailed inspections of the inside of each air conditioning sound-attenuating duct, and corrective actions as necessary. This action is necessary to prevent impairment of the operational skills and abilities of the flight crew caused by the inhalation of agents released from oil or oil breakdown products, which could result in reduced controllability of the airplane. This action is intended to address the identified unsafe condition."
(FAA AD 2004-12-05)
2005: "Both Flight Crew Affected By Sore Throats And Other Symptoms After Flight." "Smells and irritants from burning organic compounds from within the engines are known to produce harmful volatile organic contaminants."

(UKAirline Air Safety Report, ASR G-CFAH, 4 July 2005)
2007: "Mobil Jet Oil II- Known to be harmful"
(CASA: AIR SAFETY & CABIN AIR QUALITY - Jim Coyne – A/g General Manager Manufacturing, Certification & New Technologies Office: 2007 presentation)
2007: "A35-12: Protection of the health of passengers and crews and prevention of the spread of communicable disease through international travel
-*Declares* that the protection of the health of passengers and crews on international flights is an integral element of safe air travel and that conditions should be in place to ensure its preservation in a timely and cost-effective manner;
-*Requests* the Council to support further research on the consequences of air transport on the health of passengers and crews"
(ICAO- Aviation Medicine (Med) Section Related ICAO Resolutions, 5 July 2007) http://www.icao.int/icao/en/assembl/a36/wp/wp022_en.pdf
2007: "I call on the government to reveal whether information about defects has been withheld from the regulator, the courts or the parliament"
"I am gravely concerned that crew and passengers of BAe146 aircraft have been exposed to dangerous fumes produced by engine defects"
(Senate Hansard: Monday, 13 August 2007, Senator O'Brien
2009: "Product may decompose at elevated temperatures or under fire conditions and produce harmful gases or vapours. Vapours or mist of heated product may be harmful by inhalation."
R 63.G3 Possible risk of harm to the unborn child.
R 62.F3 Possible risk of impaired fertility.
(NYCO MSDS 2009 , TURBONYCOIL 600)
2009: "Product may decompose at elevated temperatures or under fire conditions and give off irritating and/or harmful (carbon monoxide) gases/vapours/fumes. Symptoms from acute exposure to these decomposition products in confined spaces may include headache, nausea, eye, nose, and throat irritation."
(Mobil MJO2 MSDS EU 2009)
2009: Plus Minus: "Is inhaling of tricresyl phosphate (TCP) safe or dangerous?"
Professor D henschler (1958 TCP researcher): "I believe it to be dangerous."
(German TV: Plus Minus, March 2009)
2009: "Does the German Government believe that inhaling of heated engine oil fumes is harmless for the health of crew and passengers?". Answer "No"
German Ministry of Transport, Secretary of State Ulrich Kasparick.
(Question to MP Winfried Hermann of Bundnis90/Greenparty in regards to contaminated cabin air on board of civil airliners, printed matter 16/12023, 3 March 2009)
2009 "Smoke from pyrolysed oil can be hazardous to the eyes, mucous membranes and lungs"
(Turner V Eastwest Airlines [2009] NSWDDT 5 May 2009 , Australian Court)

2009: "Smoke or fumes in the flight deck or passenger cabin present the crew with a potentially hazardous situation"
AAIB Bulletin 6/2009 G-BYAO B757, EW/C2006/10/08

Bobb, A.J. and Still, K.R. (2003) "Known Harmful Effects of Constituents of Jet Oil Smoke," TOXDET-03-04, Naval Health Research Center Detachment (Toxicology), Wright-Patterson AFB, OH

Winder, C; Fonteyn, P; Balouet, JC. (2002) "Aerotoxic syndrome: a descriptive epidemiological survey of aircrew exposed to in-cabin airborne contaminants" J Occup Health Safety – Austr New Zealand, 18(4): 321-328

Winder, C. (2006) Hazardous chemicals on jet aircraft: Case study – Jet engine oils and aerotoxic syndrome. Current Topics in Toxicology. Vol 3, 2006

2008 -- Cognitive function following exposure to contaminated air on commercial aircraft: A case series of 27 pilots seen for clinical purposes -- S Mackenzie Ross -- Journal of Nutritional &Environmental Medicine -- June 2008; 17(2): 111–126 (see attachment 1: SMR_2008_27_pilots.pdf)
2006 -- Hazardous Chemicals on Jet Aircraft: Case Study-Jet Engine Oils and Aerotoxic Syndrome, -- C.Winder -- Current Topics in Toxicology. Vol 3 2006 (see attachment 2: Winder_Hazardous_Chemicals_on_Jet_Aircraft_2006.pdf)

The neuro-toxicity of products used in lubricants and other substances in the aircraft engines seem to provoke Long-term health problems including :

- Neurological effects: CNS,PNS: Jamal 1997, Jamal, Julu… 2002, 2005
- Autonomic nervous system effects: Jamal, Julu… 2002, 2005
- Working memory / cognitive problems. (neuropsychological), Coxon 2002 / Mackenzie Ross 2006
- Chronic neurotoxicity (OPICN): Abou-Donia 2004, 2005
- Neuronal brain cell death: Abou-Donia
- Respiratory disorders: Burdon, Glanville 2005
- Immune system effects, fatigue, chemical sensitivity etc..
- Blood pathology disorders
- Strong occupational link: Cone 1983,1999 / Harper 2005
- Individual susceptibility: Furlong
  - TCP Blood test: 6 of 10 TCP isomers are converted into the highly toxic metabolite – psp: that inhibits the activity of a number of important enzymes.
  - Gene expression: Gene expression effected by TCP at levels found in UK pilots' blood.

The US Federal Aviation Administration (FAA) has acknowledged that "no present airplane design fulfils the intent of [federal aviation regulation] 25.831 because no airplane design incorporates an air contaminant monitoring system to ensure that the air provided to the occupants is free of hazardous contaminants" (FAA, 2002),

We point out that there is a sizable (and growing) body of literature on the association between exposure to oil fumes and acute and chronic symptoms reported globally by crews and passengers alike (ACARM, 2007). We believe there is ample justification for regulations that dictate bleed air cleaning and monitoring with flight deck indication to: (1) prevent exposure to oil fumes; (2) alert crew members if they are exposed in flight; and (3) enable maintenance workers to more effectively identify and remedy the contamination upon landing.

response

Not accepted.

Studies performed until today failed to demonstrate that cabin air can be contaminated in such a way that it could induce a safety or health issue. Cabin measurements found non-detectable or barely detectable levels of toxic contaminants. Concerning the symptoms reported by some crews or passengers: they are too generic to be directly linked to a toxic substance, although this is not rejected. Further investigation into this issue is

recommended.

comment

74 comment by: *Fédération des transports CGT*

"What is the frequency of this kind of event?"

Comment:
As remarked earlier and in this EASA document (see IV. 9.), the frequency of events reported varies from country to country. Due to lack of information on the subject of contaminated air and risks, many incidents are simply not reported unless extremely serious or causing events that lead to full investigations.
Events are underreported. We ask that EASA initiate a mandatory reporting system for fume events.
As Crews are not trained to recognize or respond to fume events, we ask EASA to legislate on the training of both pilots and cabin crew to recognize and respond to fume events.

Dr Rayman says fume events are very rare & cannot cause a problem.... but in 1983 & 2002 he said this:
'***Smoke & fumes in the cockpit is not a rare event and a clear threat to flight safety due to acute toxic effects.***'
Rayman R.B., McNaughton G.B. (1983) Smoke/fumes in the cockpit. Aviation, Space and Environmental Medicine 1983; 67: 738-740.
AND exposure to VOCs used in aircraft operations can cause skin rashes, pulmonary and CNS symptoms ranging from mild to severe
RAYMAN Russell Cabin air quality: An overview . Aviation, space, and environmental medicine 2002, vol. 73, n°3, pp. 211-215

response

Partially accepted.

The Agency accepts the possibility that the minor events may be underreported by some organisations, probably because these events are considered as nuisance (e.g. temporary bad odours or smells), and therefore they are not considered as safety related occurrences which must be reported.

Concerning the serious events involving a degree of crew or passengers' impairment or incapacitation, we believe they are reported and their number remains very limited. A regulation is already in place for this category of events through Directive 2003/42/EC of 13 June 2003 on occurrence reporting in civil aviation: it clearly identifies failures of engines or APU resulting in "Dense visible fumes or concentrations of toxic products sufficient to incapacitate crew or passengers". It is the responsibility of each Member State to ensure that stakeholders comply with this Directive. The Agency does not intend to create another mandatory reporting system.

comment

82 comment by: *Fédération des transports CGT*

"What contaminants are released to the cabin and in which quantity?"

Comment:
We refer to statements published by Dr. Mackerer in 1999 and to the Henschler report published in 1958 "Engine oils contain a mixture of tricresylphosphates, of which TOCP in not the most toxic".
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In ignoring DOCP and MOCP the total ORTHO toxicity is underestimated by a factor of **6.14 million** which has been known since 1958 (Henschler).

It has been known for years that when aviation engine oils are heated, a potent neurotoxic chemical called TMPP (trimethylolpropane phosphate) can be formed. TMPP is even worse than TCPs and exposure is associated with epileptic type seizures, convulsion, tremors, and changes to social/emotional behaviors. To our knowledge, it has never been found on aircraft. But to our knowledge, nobody has ever looked into this..

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We ask that Studies include the potential impact of exposure to the mixture of these and other chemicals in **a reduced pressure environment**.
We suggest that the EASA review all data and see if a less toxic alternative oil can be recommended that would be compatible with given aircraft engines/APUs.
Ultimately, all of the engine oils should be analyzed for their base stock content (rather than relying on the analysis of the oil companies), as well as for the potential to form TMPP, and temperature range of TMPP formation.

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comment

92 comment by: *cfdt france*

"Most of the modern Large Aeroplanes use a fine High Efficiency Particulate Air (HEPA) filtration."

Comment:
We don't agree with this statement and ask the EASA to question European Airlines on their use of HEPA filters on aircraft in their fleet.

response

Not accepted.
The Agency does not intend to make a survey on the utilisation of recirculation HEPA filters, as this would not help understanding the issue discussed in the A-NPA.

comment

93 comment by: *cfdt france*

"The majority of cabin air recirculation filters take out particulate, bacteria and

viruses contamination. Some recent filters also combine the HEPA filtration with an odour absorber which removes odours and Volatile Organic Compounds (VOC's)."

Comment :
Before such air conditioning system filters can be assessed for their performance, the nature and concentrations of all hazardous compounds to which they may be exposed, needs to be established in order that such filters are effective *and effective over long periods.* In considering this subject in response to a safety recommendation made during an investigation, Boeing concluded that the efficiency and life of such VOC converters precluded their introduction into service at this time.

Another consideration with the use of filters or converters is that they could possibly mask the evidence of an oil leak by the removal of the odour normally associated with such events, but fail to remove any contamination which could affect flight crews. ETF feels that filtration should only ever be used in conjunction with good maintenance practices/design & less toxic oils in reducing the likelihood of the oil leakage in the first place, and not as a substitute.

response

Accepted.
The Agency agrees that if filters had to be mandated, this would require specifying limits for hazardous compounds based on recognised standards.

It is also accepted that the removal of odours by filters which may still release toxic compounds is an issue. Based on EASA knowledge, there is no filter available on the market which would be able to remove all the toxic compounds in case of bleed air contamination failure event. The use of air sensors may be a solution. However, the Agency has not found justification to mandate such devices.

comment

95 comment by: *cfdt france*

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ETF Comment :
Before such air conditioning system filters can be assessed for their performance,the nature and concentrations of all hazardous compounds to which they may be exposed needs to be established in order that such filters are effective, *and effective over long periods.* In considering this subject in response to a safety recommendation made during an investigation, Boeing concluded that the efficiency and life of such VOC converters precluded their introduction into service at this time.
Another consideration with the use of filters or converters, is that they could possibly mask the evidence of an oil leak by the removal of the odour normally associated with such events, but fail to remove any contamination which could affect flight crews. ETF feels that filtration should only ever be used in conjunction with good maintenance practices/design & less toxic oils in reducing the likelihood of the oil leakage in the first place, and not as a substitute.

response

Accepted.

	The Agency agrees that if filters had to be mandated, this would require specifying limits for hazardous compounds based on recognised standards. It is also accepted that the removal of odours by filters which may still release toxic compounds is an issue. Based on EASA knowledge, there is no filter available on the market which would be able to remove all the toxic compounds in case of bleed air contamination failure event. The use of air sensors may be a solution. However, the Agency has not found justification to mandate such devices.
comment	*109* comment by: *CUD* "Most of the modern Large Aeroplanes use a fine High Efficiency Particulate Air (HEPA) filtration." Comment: We don't agree with this statement and ask the EASA to question European Airlines on their use of HEPA filters on aircraft in their fleet.
response	Not accepted. The Agency does not intend to make a survey on the utilisation of recirculation HEPA filters, as this would not help understanding the issue discussed in the A-NPA.
comment	*110* comment by: *CUD* "The majority of cabin air recirculation filters take out particulate, bacteria and viruses contamination. Some recent filters also combine the HEPA filtration with an odour absorber which removes odours and Volatile Organic Compounds (VOC's)." Comment : Before such air conditioning system filters can be assessed for their performance, the nature and concentrations of all hazardous compounds to which they may be exposed, needs to be established in order that such filters are effective *and effective over long periods.* In considering this subject in response to a safety recommendation made during an investigation, Boeing concluded that the efficiency and life of such VOC converters precluded their introduction into service at this time. Another consideration with the use of filters or converters is that they could possibly mask the evidence of an oil leak by the removal of the odour normally associated with such events, but fail to remove any contamination which could affect flight crews. ETF feels that filtration should only ever be used in conjunction with good maintenance practices/design & less toxic oils in reducing the likelihood of the oil leakage in the first place, and not as a substitute.
response	Accepted. The Agency agrees that if filters had to be mandated, this would require specifying limits for hazardous compounds based on recognised standards. It is also accepted that the removal of odours by filters which may still release toxic compounds is an issue. Based on EASA knowledge, there is no filter available on the market which would be able to remove all the toxic compounds in case of bleed air contamination failure event. The use of air

	sensors may be a solution. However, the Agency has not found justification to mandate such devices.
comment	*111* comment by: *CUD* "Under certain fault conditions (e.g. engine or APU oil seal or bearing failure, engine or APU maintenance error/irregularities, or design deficiency), engine or APU oil, hydraulic fluid, fuel, de-icing fluid and the corresponding pyrolysis products may contaminate the bleed air, which then enters the cabin air supply and can be inhaled by the aeroplane occupants. In such a situation, the following questions therefore need to be answered: **What contaminants are released to the cabin and in which quantity?** **What is the effect on flight safety?** **Can it induce a health concern?** **What is the frequency of this kind of event?"** Comment: There has been and is still great difficulty in collecting and interpreting the mounting data and identifying toxic/irritant products in oil substances used in the airline industry. The physiological effects of gases and vapours in cabin air are now becoming clear and the defining of maximum acceptable quantities or concentrations must become a subject for legislation and standards.
response	Accepted. The Agency recommends performing studies on chemical substances toxicities in aviation oils.
comment	*112* comment by: *CUD* "What contaminants are released to the cabin and in which quantity?" Comment: We refer to statements published by Dr. Mackerer in 1999 and to the Henschler report published in 1958 "Engine oils contain a mixture of tricresylphosphates, of which TOCP in not the most toxic". TOCP is NOT the only ortho isomer in TCP - the more toxic MOCP& DOCP are in the oil in far higher quantities. **Mobil** advised the Australian Senate Inquiry that the ortho isomers were in the TCP in it's oil at >0.3%. The more toxic MOCP & DOCP were not mentioned. **ORTHO** isomers divide into: **TOCP**, **DOCP** and **MOCP**. Focus has been on TOCP with UK House of Lords and CAA reports of 2000 and 2004. These reports fail to ever mention DOCP or MOCP. **TOCP 0.006 ppm Toxicity factor x 1** **DOCP 6 ppm Toxicity factor x 5** **MOCP 3070 ppm Toxicity factor x 10** In ignoring DOCP and MOCP the total ORTHO toxicity is underestimated by a factor of **6.14 million** which has been known since 1958 (Henschler). It has been known for years that when aviation engine oils are heated, a potent neurotoxic chemical called TMPP (trimethylolpropane phosphate) can be formed. TMPP is even worse than TCPs and exposure is associated with epileptic type seizures, convulsion, tremors, and changes to social/emotional

behaviors. To our knowledge, it has never been found on aircraft. But to our knowledge, nobody has ever looked into this..
A 1989 US Navy report stated that Exxon 2380 (now BP2380) generated high levels of TMPP when it was heated to temperatures at or above 350C. The TCPs in the oil then react with TMP chemicals in the "base stock" of the oil. **The levels of TMPP were so significant that the authors recommended that Exxon 2380 not be used on US naval vessels. But BP2380 is still widely used in commercial aviation**.

A 1996 US Air Force paper raised concerns about the potential for being exposed to highly toxic TMPP, and stated that TMPP could be formed when oils that contain TCPs and TMP are heated to temperatures as low as 250C. This is important because these temperatures are more likely to be reached in the engine/bleed air system. Wright also stated that TMPP can NOT be formed if the engine oil base stock contains PE chemicals instead of TMP. *WRIGHT R. L. Formation of the neurotoxin TMPP from TMPE-phosphate formulations - Tribiology transactions 1996, vol. 39, no4, pp. 827-834*

Another US navy report in 1992 also expressed concern about the hazards
1) What engine oil(s) are used (e.g., Mobil Jet Oil II, BP2380, etc).
2) What APU and engine types are installed on what aircraft types (e.g. Pratt Whitney 4000, Honeywell Series 85, etc).

Oils and lubricants used on the aircraft and in the engines contain not only the neurotoxins (TCPs and triphenylphosphates) but **sensitizers (N-phenyl-L-naphthylamine, PAN),** and **asphyxiants (carbon monoxide)**.. Pyrolysis studies have confirmed the presence of these toxins when commercial oils are heated (van Netten, 2000; Marshman, 2001; Fox, 2001). A Material SafetyData Sheet for engine oils acknowledge only the TCP content and the fact that "toxicfumes may be evolved on burning or exposure to heat" (BP, 2001).

We ask that Studies include the potential impact of exposure to the mixture of these and other chemicals in **a reduced pressure environment**.
We suggest that the EASA review all data and see if a less toxic alternative oil can be recommended that would be compatible with given aircraft engines/APUs.
Ultimately, all of the engine oils should be analyzed for their base stock content (rather than relying on the analysis of the oil companies), as well as for the potential to form TMPP, and temperature range of TMPP formation.

response

Partially accepted.

The Agency agrees that aviation oils toxicity knowledge can be improved and we have recommended studies to be conducted in this domain. The special cabin environment should be taken into account in those studies.

Analysis of all engine oils base stock content: The Agency could not do that because the Agency does not regulate aviation fluids, and therefore we do not inspect oil manufacturers' productions. Nevertheless, the specified toxic compounds and their concentrations are provided to the engine manufacturers which then conduct a safety analysis to verify that no hazardous quantities are released in the bleed air for identified failure scenarios. The Agency then reviews this analysis.

comment

113 comment by: *CUD*

"What is the effect on flight safety?"

Comment:
We refer to the following statements and documents:

2001: "Incidents have been reported of impaired performance of flight crew…events could have been caused by inhalation of agents… leaking from oil or APU and contaminating the Environmental control
system."
(CAA AD 002-03-2001)

2002: "oil leaks and cabin / flight deck odours must be regarded as a potential threat to flight safety, theyshould not be dismissed as a mere nuisance and should be addressed as soon as possible."
(BAe ISB 21-150 2001 / ISB 21-156, 2002)

2003: "Any oil leaking from an engine, entering the aircraft customer bleed offtake, is classified as HAZARDOUS"
(Rolls Royce, Germany 2003, BRE air quality Conference, London)

2004: "This amendment adopts a new airworthiness directive (AD), applicable to all BAE Systems (Operations) Limited Model BAe 146 series airplanes, that requires repetitive detailed inspections of the inside of each air conditioning sound-attenuating duct, and corrective actions as necessary. This action is necessary to prevent impairment of the operational skills and abilities of the flightcrew caused by the inhalation of agents released from oil or oil breakdown products, which could result in reduced controllability of the airplane. This action is intended to address the identified unsafe condition."
(FAA AD 2004-12-05)

2006: "The serious incident is attributable to the fact that on approach to Zurich Airport the cockpit filled with fumes which caused a toxic effect, leading to a limited capability of acting of the copilot. These fumes were caused by an oil leak as a result of a bearing damage in engine No. 1" "The medical examination of the copilot after the flight showed that during the flight toxic exposure took place."
(Swiss Federal Department of Environment, Transport Energy and Communications Investigation Report No u1884 by the Aircraft Accident Investigation Bureau, 2 March 2006)

We also refer the EASA to the manual written by Prof. S. Michaelis, (renowned expert on Cabin air contamination): *"Aviation Contaminated Air Reference Manual,"* Michaelis, S., ed. ISBN 9780955567209, London,

response Noted.

comment *114* comment by: *CUD*

"Can it induce a health concern?"

Comment:
We believe that there is now sufficient available material and literature on cabin air being contaminated by toxic substances used on the aircraft. Studies are now available giving indications that the health of aircraft occupants may be severely affected by the inhalation and contact with gases and vapours of lubricants, anti-freeze agents and others.

We refer the EASA to the following statements and studies :

"individuals exposed to a single large toxic dose, or to small subclinical doses, of ***organophosphorus compounds*** have developed a chronic neurotoxicity that persists for years after exposure and is distinct from both cholinergic and OPIDN"(AbouDonia, 2003; *Arch. Environ. Health* **58**:484-97).

- Abou-Donia MB(2004) Organophosphorus ester-induced chronic neurotoxicity. Archives of Environmental Health 58:484–497
- Organophosphate Ester Induced Chronic Neurotoxicity (OPICN)- Mohamed B Abou-Donia : Proceedings of the BALPA 'Contaminated Air Protection Air Safety and Cabin Air Quality International Aero Industry Conference'. Held at Imperial College, London, 20-21 April 2005: ISBN 0-7334-2282-9
- Journal of Occupational Health & Safety, Australia & New Zealand, Vol 21, Number 5 ,August 2005 - Special edition: New findings in aircrew exposed to airborne contaminants: Long-term health effects confirmed. - Organophosphate Ester Induced Chronic Neurotoxicity (OPICN)- Mohamed B Abou-Donia

1981: Engine Lube Oil: "At temperatures above 320C this oil breaks down into irritating and toxic compounds."
(SAE Aviation Information Report: 1539, issued 1-30-81)
1983: "All of these toxic substances (includes engine oil) have acute and long-term effects"
(Rayman R.B., McNaughton G.B. Smoke/fumes in the cockpit. Aviation, Space and Environmental Medicine, August 1983, pp 738-740. Current Director of the Aerospace Medical Association)
1998: "Repeated low level exposure leads to cumulative toxicity." (1981 ed)
"Acute and repeated exposure can produce harmful effects in man, and it has been suggested that chronic exposure at lower doses may cause long-term ill health." (1998 ed)
(UKHSE: Organophosphates: HSE: MS17: Medical aspects of occupational exposures to organophosphates. Draft revision 23, November, 1998.)
1999: "Neuropsychological outcomes - Neuropsychological abnormalities can occur as a long-term complication of acute OP poisoning"
(UK COT report. Long term sequelae of acute poisoning: 1999. Committee on Toxicity of Chemicals in Food, Consumer Products and the Environment: Organophosphates: Executive Summary. Published by the Department of Health, 1999, London)
1999: "The inhalation of mist (containing tricresylphosphate) which can be produced by high pressure systems, or direct contact with the skin, would be hazardous."
(UK Government Hansard 66599, 4 February 1999, column 737)
1999: "TCP is toxic"
(UK Government: Hansard 82322 6 May 1999 : Column: 428)
2000: "With the weight of human evidence and suffering, which is quite clear, there must be something there" "There is absolutely no doubt in our mind that there is a general health issue here"
(BAe Systems verbal evidence to Australian senate Inquiry 2000)
2001: "Incidents have been reported of impaired performance of flight crew…events could have been caused by inhalation of agents… leaking from oil or APU and contaminating the Environmental control system."
(CAA AD 002-03-2001)
2002: "oil leaks and cabin / flight deck odours must be regarded as a potential threat to flight safety, they

should not be dismissed as a mere nuisance and should be addressed as soon as possible."
(BAe ISB 21-150 2001 / ISB 21-156, 2002)
2002: "FAA rule-making has not kept pace with public expectation and concern about air quality and does not afford explicit protection from particulate matter and other chemical and biological hazards." "No present airplane design fulfills the intent of 25.831 because no airplane design incorporates an air Contaminant monitoring system to ensure that the air provided to the occupants is free of hazardous contaminants"
2003: "Any oil leaking from an engine, entering the aircraft customer bleed off-take, is classified as HAZARDOUS"
(Rolls Royce, Germany2003, BRE air quality Conference, London)
2003: "It is found that the sound attenuating material used in the air-conditioning ducts can absorb oil and can become a source of persistent air contamination."
(CASA AD /BAe 146/102, 23 January 2003)
2004: "In the event of oil leakage there is the opportunity, therefore, for the pyrolysis products of engine lubricant/fuel to enter the cabin air supply and exert toxic effects on both passengers and crew."
(CAA Air Quality report 2004)
2004: "This amendment adopts a new airworthiness directive (AD), applicable to all BAE Systems (Operations) Limited Model BAe 146 series airplanes, that requires repetitive detailed inspections of the inside of each air conditioning sound-attenuating duct, and corrective actions as necessary. This action is necessary to prevent impairment of the operational skills and abilities of the flight crew caused by the inhalation of agents released from oil or oil breakdown products, which could result in reduced controllability of the airplane. This action is intended to address the identified unsafe condition."
(FAA AD 2004-12-05)
2005: "Both Flight Crew Affected By Sore Throats And Other Symptoms After Flight." "Smells and irritants from burning organic compounds from within the engines are known to produce harmful volatile organic contaminants."
(UKAirline Air Safety Report, ASR G-CFAH, 4 July 2005)
2007: "Mobil Jet Oil II- Known to be harmful"
(CASA: AIR SAFETY & CABIN AIR QUALITY - Jim Coyne – A/g General Manager Manufacturing,
Certification & New Technologies Office: 2007 presentation)
2007: "A35-12: Protection of the health of passengers and crews and prevention of the spread of communicable disease through international travel
-Declares that the protection of the health of passengers and crews on international flights is an integral element of safe air travel and that conditions should be in place to ensure its preservation in a timely and cost-effective manner;
-Requests the Council to support further research on the consequences of air transport on the health of passengers and crews"
(ICAO- Aviation Medicine (Med) Section Related ICAO Resolutions, 5 July 2007)
http://www.icao.int/icao/en/assembl/a36/wp/wp022_en.pdf
2007: "I call on the government to reveal whether information about defects has been withheld from the regulator, the courts or the parliament"
"I am gravely concerned that crew and passengers of BAe146 aircraft have been exposed to dangerous fumes produced by engine defects"
(Senate Hansard: Monday, 13 August 2007, Senator O'Brien
2009: "Product may decompose at elevated temperatures or under fire conditions and produce harmful gases or vapours. Vapours or mist of heated product may be harmful by inhalation."
R 63.G3 Possible risk of harm to the unborn child.

R 62.F3 Possible risk of impaired fertility.
(NYCO MSDS 2009 , TURBONYCOIL 600)
2009: "Product may decompose at elevated temperatures or under fire conditions and give off irritating
and/or harmful (carbon monoxide) gases/vapours/fumes. Symptoms from acute exposure to these decomposition products in confined spaces may include headache, nausea, eye, nose, and throat irritation."
(Mobil MJO2 MSDS EU 2009)
2009: Plus Minus: "Is inhaling of tricresyl phosphate (TCP) safe or dangerous?"
Professor D henschler (1958 TCP researcher): "I believe it to be dangerous."
(German TV: Plus Minus, March 2009)
2009: "Does the German Government believe that inhaling of heated engine oil fumes is harmless for the health of crew and passengers?". Answer "No"
German Ministry of Transport, Secretary of State Ulrich Kasparick.
(Question to MP Winfried Hermann of Bundnis90/Greenparty in regards to contaminated cabin air on board of civil airliners, printed matter 16/12023, 3 March 2009)
2009 "Smoke from pyrolysed oil can be hazardous to the eyes, mucous membranes and lungs"
(Turner V Eastwest Airlines [2009] NSWDDT 5 May 2009 , Australian Court)

2009: "Smoke or fumes in the flight deck or passenger cabin present the crew with a potentially hazardous situation"
AAIB Bulletin 6/2009 G-BYAO B757, EW/C2006/10/08

Bobb, A.J. and Still, K.R. (2003) "Known Harmful Effects of Constituents of Jet Oil Smoke," TOXDET-03-04, Naval Health Research Center Detachment (Toxicology), Wright-Patterson AFB, OH

Winder, C; Fonteyn, P; Balouet, JC. (2002) "Aerotoxic syndrome: a descriptive epidemiological survey of aircrew exposed to in-cabin airborne contaminants" J Occup Health Safety – Austr New Zealand, 18(4): 321-328

Winder, C. (2006) Hazardous chemicals on jet aircraft: Case study – Jet engine oils and aerotoxic syndrome. Current Topics in Toxicology. Vol 3, 2006

2008 -- Cognitive function following exposure to contaminated air on commercial aircraft: A case series of 27 pilots seen for clinical purposes -- S Mackenzie Ross -- Journal of Nutritional &Environmental Medicine -- June 2008; 17(2): 111–126 (see attachment 1: SMR_2008_27_pilots.pdf)
2006 -- Hazardous Chemicals on Jet Aircraft: Case Study-Jet Engine Oils and Aerotoxic Syndrome, -- C.Winder -- Current Topics in Toxicology. Vol 3 2006 (see attachment 2: Winder_Hazardous_Chemicals_on_Jet_Aircraft_2006.pdf)

The neuro-toxicity of products used in lubricants and other substances in the aircraft engines seem to provoke Long-term health problems including :

- Neurological effects: CNS,PNS: Jamal 1997, Jamal, Julu… 2002, 2005
- Autonomic nervous system effects: Jamal, Julu… 2002, 2005
- Working memory / cognitive problems. (neuropsychological), Coxon 2002 / Mackenzie Ross 2006
- Chronic neurotoxicity (OPICN): Abou-Donia 2004, 2005
- Neuronal brain cell death: Abou-Donia
- Respiratory disorders: Burdon, Glanville 2005

- Immune system effects, fatigue, chemical sensitivity etc..
- Blood pathology disorders
- Strong occupational link: Cone 1983,1999 / Harper 2005
- Individual susceptibility: Furlong
  - TCP Blood test: 6 of 10 TCP isomers are converted into the highly toxic metabolite – psp: that inhibits the activity of a number of important enzymes.
  - Gene expression: Gene expression effected by TCP at levels found in UK pilots' blood.

The US Federal Aviation Administration (FAA) has acknowledged that "no present airplane design fulfils the intent of [federal aviation regulation] 25.831 because no airplane design incorporates an air contaminant monitoring system to ensure that the air provided to the occupants is free of hazardous contaminants" (FAA, 2002),

We point out that there is a sizable (and growing) body of literature on the association between exposure to oil fumes and acute and chronic symptoms reported globally by crews and passengers alike (ACARM, 2007). We believe there is ample justification for regulations that dictate bleed air cleaning and monitoring with flight deck indication to: (1) prevent exposure to oil fumes; (2) alert crew members if they are exposed in flight; and (3) enable maintenance workers to more effectively identify and remedy the contamination upon landing.

response

Not accepted.

Studies performed until today failed to demonstrate that cabin air can be contaminated in such a way that it could induce a safety or health issue. Cabin measurements found non-detectable or barely detectable levels of toxic contaminants. Concerning the symptoms reported by some crews or passengers: they are too generic to be directly linked to a toxic substance, although this is not rejected. Further investigation into this issue is recommended.

comment

115 comment by: *CUD*

"What is the frequency of this kind of event?"

Comment:
As remarked earlier and in this EASA document (see IV. 9.), the frequency of events reported varies from country to country. Due to lack of information on the subject of contaminated air and risks, many incidents are simply not reported unless extremely serious or causing events that lead to full investigations.
Events are underreported. We ask that EASA initiate a mandatory reporting system for fume events.
As Crews are not trained to recognize or respond to fume events, we ask EASA to legislate on the training of both pilots and cabin crew to recognize and respond to fume events.

Dr Rayman says fume events are very rare & cannot cause a problem.... but in 1983 & 2002 he said this:
'***Smoke & fumes in the cockpit is not a rare event and a clear threat to flight safety due to acute toxic effects.***'
Rayman R.B., McNaughton G.B. (1983) Smoke/fumes in the cockpit. Aviation,

	Space and Environmental Medicine 1983; 67: 738-740. AND exposure to VOCs used in aircraft operations can cause skin rashes, pulmonary and CNS symptoms ranging from mild to severe *RAYMAN Russell Cabin air quality: An overview . Aviation, space, and environmental medicine 2002, vol. 73, n°3, pp. 211-215*
response	Partially accepted. The Agency accepts the possibility that the minor events may be underreported by some organisations, probably because these events are considered as nuisance (e.g. temporary bad odours or smells), and therefore they are not considered as safety related occurrences which must be reported. Concerning the serious events involving a degree of crew or passengers' impairment or incapacitation, we believe they are reported and their number remains very limited. A regulation is already in place for this category of events through Directive 2003/42/EC of 13 June 2003 on occurrence reporting in civil aviation: it clearly identifies failures of engines or APU resulting in "Dense visible fumes or concentrations of toxic products sufficient to incapacitate crew or passengers". It is the responsibility of each Member State to ensure that stakeholders comply with this Directive. The Agency does not intend to create another mandatory reporting system.

comment	*132* comment by: *Susan Michaelis* Attachment #6 1. Comment: Modern Large Aeroplanes cabin air quality is clearly recognised as excellent in term of presence of contaminants, in normal condition. However, the quality of this air can be degraded after some abnormal and unusual events. Proposed Text:Many suggest that modern Large Aeroplanes cabin air quality is clearly recognised as excellent in term of presence of contaminants, in normal condition. However, the quality of this air can be degraded after some abnormal and unusual events. Any leakage of engine oil , hydraulic fluids or deicing fluids into the cabin air supply is considered an abnormal condition. Justification:Mobil has stated: 'We do not believe Mobil jet turbine oils pose any significant toxicological risk to individuals accidently exposed to aerosols or vapors in aircraft cabins. Such exposures are not what we would refer to as "normal use".(Principal toxicologist Mobil -Mackerer, C.R., Ladov, E.N. Mobil USA Submission to the Australian Senate Inquiry into Air Safety & cabin air quality. See also: Michaelis S. (2007) Aviation Contaminated Air Reference Manual. ISBN 9780955567209 2. Comment: Questions: What contaminants are released to the cabin and in which quantity? - What is the effect on flight safety? - Can it induce a health concern? - What is the frequency of this kind of event?- see attached document and Michaelis S. (2007) Aviation Contaminated Air Reference Manual. ISBN 9780955567209: chapters 2,3,4,6,7,8,9,12,15,16,17, appx 2,3,5,6,7,9, 10
response	1) Not accepted.

We do not agree that any oil or hydraulic fluid leakage will lead to an abnormal event (smoke or fume event). Significant leakage is necessary to contaminate bleed air and cabin air. For instance, this may happen in case of engine bearing or seal failures, oil tank substantial over filling. Meanwhile, the occurrence of such failure and leakage is not necessarily sufficient to induce a fume/smoke event. Such failures have occurred without any effect in the cabin air; other mechanism can explain the occurrence of fume event. For instance, if the air conditioning system is not cleaned regularly, oil vapours may accumulate over time in the packs and then be released in some particular operating conditions.

2) Noted.
The Agency thanks you for your extensive submission, including for providing us with your Aviation Contaminated Air Reference Manual. We have taken into account your recommendations and some of them can be found in our recommendations for studies. Please refer to the Agency conclusions.

comment

140 comment by: *kapers Cabin Crew Union*

"Most of the modern Large Aeroplanes use a fine High Efficiency Particulate Air (HEPA) filtration."
Comment:
We don't agree with this statement and ask the EASA to question European Airlines on their use of HEPA filters on aircraft in their fleet.

response

Not accepted.
The Agency does not intend to make a survey on the utilisation of recirculation HEPA filters, as this would not help understanding the issue discussed in the A-NPA.

comment

141 comment by: *kapers Cabin Crew Union*

"The majority of cabin air recirculation filters take out particulate, bacteria and viruses contamination. Some recent filters also combine the HEPA filtration with an odour absorber which removes odours and Volatile Organic Compounds (VOC's)."
Comment :
Before such air conditioning system filters can be assessed for their performance, the nature and concentrations of all hazardous compounds to which they may be exposed, needs to be established in order that such filters are effective and effective over long periods.
In considering this

response

Accepted.
The Agency agrees that if filters had to be mandated, this would require specifying limits for hazardous compounds based on recognized standards.

It is also accepted that the removal of odours by filters which may still release toxic compounds is an issue. Based on EASA knowledge, there is no filter available on the market which would be able to remove all the toxic compounds in case of bleed air contamination failure event. The use of air sensors may be a solution. However, the Agency has not found justification to mandate such devices.

comment

142 comment by: *kapers Cabin Crew Union*

"Under certain fault conditions (e.g. engine or APU oil seal or bearing failure, engine or APU maintenance error/irregularities, or design deficiency), engine or APU oil, hydraulic fluid, fuel, de-icing fluid and the corresponding pyrolysis products may contaminate the bleed air, which then enters the cabin air supply and can be inhaled by the aeroplane occupants.

In such a situation, the following questions therefore need to be answered:
What contaminants are released to the cabin and in which quantity?
What is the effect on flight safety?
Can it induce a health concern?
What is the frequency of this kind of event?"

Comment:
There has been and is still great difficulty in collecting and interpreting the mounting data and identifying toxic/irritant products in oil substances used in the airline industry. The physiological effects of gases and vapours in cabin air are now becoming clear and the defining of maximum acceptable quantities or concentrations must become a subject for legislation and standards.

response

Accepted.
The Agency recommends performing studies on chemical substances toxicities in aviation oils.

comment

143 comment by: *kapers Cabin Crew Union*

"What contaminants are released to the cabin and in which quantity?"
Comment:
We refer to statements published by Dr. Mackerer in 1999 and to the Henschler report published in 1958 "Engine oils contain a mixture of tricresylphosphates, of which TOCP in not the most toxic".
TOCP is NOT the only ortho isomer in TCP - the more toxic MOCP& DOCP are in the oil in far higher quantities.
Mobil advised the Australian Senate Inquiry that the ortho isomers were in the TCP in it's oil at >0.3%. The more toxic MOCP & DOCP were not mentioned.
ORTHO isomers divide into: **TOCP**, **DOCP** and **MOCP**.
Focus has been on TOCP with UK House of Lords and CAA reports of 2000 and 2004. These reports fail to ever mention DOCP or MOCP.
TOCP 0.006 ppm Toxicity factor x1
DOCP 6 ppm Toxicity factor x5
MOCP 3070 ppm Toxicity factor x10
In ignoring DOCP and MOCP the total ORTHO toxicity is underestimated by a factor of **6.14 million** which has been known since 1958 (Henschler).

It has been known for years that when aviation engine oils are heated, a potent neurotoxic chemical called TMPP (trimethylolpropane phosphate) can be formed. TMPP is even worse than TCPs and exposure is associated with epileptic type seizures, convulsion, tremors, and changes to social/emotional behaviors. To our knowledge, it has never been found on aircraft. But to our knowledge, nobody has ever looked into this.

A 1989 US Navy report
stated that Exxon 2380 (nowBP2380) generated high levels of TMPP when it was heated to temperatures at or above 350C. The TCPs in the oil then react with TMP chemicals in the "base stock" of the oil.
The levels of TMPP were so significant that the authors recommended that Exxon 2380 not be used on US naval vessels. But BP2380 is still

widely used in commercial aviation.

A 1996 US Air Force paper
raised concerns about the potential for being exposed to highly toxic TMPP, and stated that TMPP could be formed when oils that contain TCPs and TMP are heated to temperatures as low as 250C. This is important because these temperatures are more likely to be reached in the engine/bleed air system. Wright also stated that TMPP can NOT be formed if the engine oil base stock contains PE chemicals instead of TMP.
WRIGHT R. L.
Formation of the neurotoxin TMPP from TMPE-phosphate formulations - Tribiology transactions 1996, vol. 39, no4, pp. 827-834

Another US navy report in 1992
also expressed concern about the hazards
1) What engine oil(s) are used (e.g., Mobil Jet Oil II, BP2380, etc).
2) What APU and engine types are installed on what aircraft types (e.g. Pratt Whitney 4000, Honeywell Series 85, etc).
Oils and lubricants used on the aircraft and in the engines contain not only the neurotoxins (TCPs and triphenylphosphates) but **sensitizers (N-phenyl-Lnaphthylamine,PAN),** and **asphyxiants (carbon monoxide)**.
Pyrolysis studies have confirmed the presence of these toxins when commercial oils are heated (van Netten, 2000; Marshman, 2001; Fox, 2001). A Material SafetyData Sheet for engine oils acknowledge only the TCP content and the fact that "toxicfumes may be evolved on burning or exposure to heat" (BP, 2001).

We ask that Studies include the potential impact of exposure to the mixture of these and other chemicals in **a reduced pressure environment**. We suggest that the EASA review all data and see if a less toxic alternative oil can be recommended that would be compatible with given aircraft engines/APUs. Ultimately, all of the engine oils should be analyzed for their base stock content (rather than relying on the analysis of the oil companies), as well as for the potential to form TMPP, and temperature range of TMPP formation.

response

Partially accepted.

The Agency agrees that aviation oils toxicity knowledge can be improved and we have recommended studies to be conducted in this domain. The special cabin environment should be taken into account in those studies.

Analysis of all engine oils base stock content: The Agency could not do that because the Agency does not regulate aviation fluids, and therefore we do not inspect oil manufacturers' productions. Nevertheless, the specified toxic compounds and their concentrations are provided to the engine manufacturers which then conduct a safety analysis to verify that no hazardous quantities are released in the bleed air for identified failure scenarios. The Agency then reviews this analysis.

comment

144 comment by: *kapers Cabin Crew Union*

"What is the effect on flight safety?"
Comment:
We refer to the following statements and documents:
2001:
"Incidents have been reported of impaired performance of flight crew…events

could have been caused by inhalation of agents… leaking from oil or APU and contaminating the Environmental control system."
(CAA AD 002-03-2001)
2002:
"oil leaks and cabin / flight deck odours must be regarded as a potential threat to flight safety, theyshould not be dismissed as a mere nuisance and should be addressed as soon as possible."
(BAe ISB 21-150 2001 / ISB 21-156, 2002)
2003:
"Any oil leaking from an engine, entering the aircraft customer bleed offtake, is classified as HAZARDOUS"
(Rolls Royce, Germany 2003, BRE air quality Conference,London)
2004:
"This amendment adopts a new airworthiness directive (AD), applicable to all BAE Systems (Operations) Limited Model BAe 146 series airplanes, that requires repetitive detailed inspections of the inside of each air conditioning sound-attenuating duct, and corrective actions as necessary. This action is necessary to prevent impairment of the operational skills and abilities of the flightcrew caused by the inhalation of agents released from oil or oil breakdown products, which could result in reduced controllability of the airplane. This action is intended to address the identified unsafe condition."
(FAA AD 2004-12-05)
2006:
"The serious incident is attributable to the fact that on approach to Zurich Airport the cockpit filled with fumes which caused a toxic effect, leading to a limited capability of acting of the copilot. These fumes were caused by an oil leak as a result of a bearing damage in engine No. 1" "The medical examination of the copilot after the flight showed that during the flight toxic exposure took place."
(Swiss Federal Department of Environment, Transport Energy and Communications Investigation Report No u1884 by the Aircraft Accident Investigation Bureau, 2 March2006)

We also refer the EASA to the manual written by Prof. S. Michaelis, (renowned expert on Cabin air contamination):"*Aviation Contaminated Air Reference Manual,"* Michaelis, S., ed. ISBN 9780955567209, London

response Noted.

comment *145* comment by: *kapers Cabin Crew Union*

"Can it induce a health concern?"

Comment:
We believe that there is now sufficient available material and literature on cabin air being contaminated by toxic substances used on the aircraft. Studies are now available giving indications that the health of aircraft occupants may be severely affected by the inhalation and contact with gases and vapours of lubricants, anti-freeze agents and others.

We refer the EASA to the following statements and studies :

"individuals exposed to a single large toxic dose, or to small subclinical doses, of ***organophosphorus compounds*** have developed a chronic neurotoxicity that persists for years after exposure and is distinct from both cholinergic and OPIDN"(AbouDonia, 2003; *Arch. Environ. Health* **58**:484-97).

- Abou-Donia MB(2004) Organophosphorus ester-induced chronic neurotoxicity. Archives of Environmental Health 58:484–497
- Organophosphate Ester Induced Chronic Neurotoxicity (OPICN)- Mohamed B Abou-Donia : Proceedings of the BALPA 'Contaminated Air Protection Air Safety and Cabin Air Quality International Aero Industry Conference'. Held at Imperial College, London, 20-21 April 2005: ISBN 0-7334-2282-9
- Journal of Occupational Health & Safety, Australia & New Zealand, Vol 21, Number 5 ,August 2005 - Special edition: New findings in aircrew exposed to airborne contaminants: Long-term health effects confirmed. - Organophosphate Ester Induced Chronic Neurotoxicity (OPICN)- Mohamed B Abou-Donia

1981: Engine Lube Oil: "At temperatures above 320C this oil breaks down into irritating and toxic compounds."
(SAE Aviation Information Report: 1539, issued 1-30-81)
1983: "All of these toxic substances (includes engine oil) have acute and long-term effects"
(Rayman R.B., McNaughton G.B. Smoke/fumes in the cockpit. Aviation, Space and Environmental
Medicine, August 1983, pp 738-740. Current Director of the Aerospace Medical Association)
1998: "Repeated low level exposure leads to cumulative toxicity." (1981 ed)
"Acute and repeated exposure can produce harmful effects in man, and it has been suggested that chronic exposure at lower doses may cause long-term ill health." (1998 ed)
(UKHSE: Organophosphates: HSE: MS17: Medical aspects of occupational exposures to organophosphates. Draft revision 23, November, 1998.)
1999: "Neuropsychological outcomes - Neuropsychological abnormalities can occur as a long-term complication of acute OP poisoning"
(UK COT report. Long term sequelae of acute poisoning: 1999. Committee on Toxicity of Chemicals in Food, Consumer Products and the Environment: Organophosphates: Executive Summary. Published by the Department of Health, 1999, London)
1999: "The inhalation of mist (containing tricresylphosphate) which can be produced by high pressure systems, or direct contact with the skin, would be hazardous."
(UK Government Hansard 66599, 4 February 1999, column 737)
1999: "TCP is toxic"
(UK Government: Hansard 82322 6 May 1999 : Column: 428)
2000: "With the weight of human evidence and suffering, which is quite clear, there must be something there" "There is absolutely no doubt in our mind that there is a general health issue here"
(BAe Systems verbal evidence to Australian senate Inquiry 2000)
2001: "Incidents have been reported of impaired performance of flight crew…events could have been caused by inhalation of agents… leaking from oil or APU and contaminating the Environmental control system."
(CAA AD 002-03-2001)
2002: "oil leaks and cabin / flight deck odours must be regarded as a potential threat to flight safety, they should not be dismissed as a mere nuisance and should be addressed as soon as possible."
(BAe ISB 21-150 2001 / ISB 21-156, 2002)
2002: "FAA rule-making has not kept pace with public expectation and concern about air quality and does not afford explicit protection from particulate matter and other chemical and biological hazards." "No present airplane design fulfills the intent of 25.831 because no airplane design incorporates an air

Contaminant monitoring system to ensure that the air provided to the occupants is free of hazardous contaminants"
2003: "Any oil leaking from an engine, entering the aircraft customer bleed off-take, is classified as HAZARDOUS"
(Rolls Royce, Germany2003, BRE air quality Conference, London)
2003: "It is found that the sound attenuating material used in the air-conditioning ducts can absorb oil and can become a source of persistent air contamination."
(CASA AD /BAe 146/102, 23 January 2003)
2004: "In the event of oil leakage there is the opportunity, therefore, for the pyrolysis products of engine lubricant/fuel to enter the cabin air supply and exert toxic effects on both passengers and crew."
(CAA Air Quality report 2004)
2004: "This amendment adopts a new airworthiness directive (AD), applicable to all BAE Systems
(Operations) Limited Model BAe 146 series airplanes, that requires repetitive detailed inspections of the inside of each air conditioning sound-attenuating duct, and corrective actions as necessary. This action is necessary to prevent impairment of the operational skills and abilities of the flight crew caused by the inhalation of agents released from oil or oil breakdown products, which could result in reduced controllability of the airplane. This action is intended to address the identified unsafe condition."
(FAA AD 2004-12-05)
2005: "Both Flight Crew Affected By Sore Throats And Other Symptoms After Flight." "Smells and irritants from burning organic compounds from within the engines are known to produce harmful volatile organic contaminants."
(UKAirline Air Safety Report, ASR G-CFAH, 4 July 2005)
2007: "Mobil Jet Oil II- Known to be harmful"
(CASA: AIR SAFETY & CABIN AIR QUALITY - Jim Coyne – A/g General Manager Manufacturing, Certification & New Technologies Office: 2007 presentation)
2007: "A35-12: Protection of the health of passengers and crews and prevention of the spread of communicable disease through international travel
-*Declares* that the protection of the health of passengers and crews on international flights is an integral element of safe air travel and that conditions should be in place to ensure its preservation in a timely and cost-effective manner;
-*Requests* the Council to support further research on the consequences of air transport on the health of passengers and crews"
(ICAO- Aviation Medicine (Med) Section Related ICAO Resolutions, 5 July 2007)
http://www.icao.int/icao/en/assembl/a36/wp/wp022_en.pdf
2007: "I call on the government to reveal whether information about defects has been withheld from the regulator, the courts or the parliament"
"I am gravely concerned that crew and passengers of BAe146 aircraft have been exposed to dangerous fumes produced by engine defects"
(Senate Hansard: Monday, 13 August 2007, Senator O'Brien
2009: "Product may decompose at elevated temperatures or under fire conditions and produce harmful gases or vapours. Vapours or mist of heated product may be harmful by inhalation."
R 63.G3 Possible risk of harm to the unborn child.
R 62.F3 Possible risk of impaired fertility.
(NYCO MSDS 2009 , TURBONYCOIL 600)
2009: "Product may decompose at elevated temperatures or under fire conditions and give off irritating and/or harmful (carbon monoxide) gases/vapours/fumes. Symptoms from acute exposure to these decomposition products in confined spaces may include headache, nausea, eye, nose, and throat irritation."

(Mobil MJO2 MSDS EU 2009)
2009: Plus Minus: "Is inhaling of tricresyl phosphate (TCP) safe or dangerous?"
Professor D henschler (1958 TCP researcher): "I believe it to be dangerous."
(German TV: Plus Minus, March 2009)
2009: "Does the German Government believe that inhaling of heated engine oil fumes is harmless for the health of crew and passengers?". Answer "No"
German Ministry of Transport, Secretary of State Ulrich Kasparick.
(Question to MP Winfried Hermann of Bundnis90/Greenparty in regards to contaminated cabin air on board of civil airliners, printed matter 16/12023, 3 March 2009)
2009 "Smoke from pyrolysed oil can be hazardous to the eyes, mucous membranes and lungs"
(Turner V Eastwest Airlines [2009] NSWDDT 5 May 2009 , Australian Court)

2009: "Smoke or fumes in the flight deck or passenger cabin present the crew with a potentially hazardous situation"
AAIB Bulletin 6/2009 G-BYAO B757, EW/C2006/10/08

Bobb, A.J. and Still, K.R. (2003) "Known Harmful Effects of Constituents of Jet Oil Smoke," TOXDET-03-04, Naval Health Research Center Detachment (Toxicology), Wright-Patterson AFB, OH

Winder, C; Fonteyn, P; Balouet, JC. (2002) "Aerotoxic syndrome: a descriptive epidemiological survey of aircrew exposed to in-cabin airborne contaminants" J Occup Health Safety – Austr New Zealand, 18(4): 321-328

Winder, C. (2006) Hazardous chemicals on jet aircraft: Case study – Jet engine oils and aerotoxic syndrome. Current Topics in Toxicology. Vol 3, 2006

2008 -- Cognitive function following exposure to contaminated air on commercial aircraft: A case series of 27 pilots seen for clinical purposes -- S Mackenzie Ross -- Journal of Nutritional &Environmental Medicine -- June 2008; 17(2): 111–126 (see attachment 1: SMR_2008_27_pilots.pdf)
2006 -- Hazardous Chemicals on Jet Aircraft: Case Study-Jet Engine Oils and Aerotoxic Syndrome, -- C.Winder -- Current Topics in Toxicology. Vol 3 2006 (see attachment 2: Winder_Hazardous_Chemicals_on_Jet_Aircraft_2006.pdf)

The neuro-toxicity of products used in lubricants and other substances in the aircraft engines seem to provoke Long-term health problems including :

- Neurological effects: CNS,PNS: Jamal 1997, Jamal, Julu… 2002, 2005
- Autonomic nervous system effects: Jamal, Julu… 2002, 2005
- Working memory / cognitive problems. (neuropsychological), Coxon 2002 / Mackenzie Ross 2006
- Chronic neurotoxicity (OPICN): Abou-Donia 2004, 2005
- Neuronal brain cell death: Abou-Donia
- Respiratory disorders: Burdon, Glanville 2005
- Immune system effects, fatigue, chemical sensitivity etc..
- Blood pathology disorders
- Strong occupational link: Cone 1983,1999 / Harper 2005
- Individual susceptibility: Furlong
  - TCP Blood test: 6 of 10 TCP isomers are converted into the highly toxic metabolite – psp: that inhibits the activity of a number of important enzymes.

- Gene expression: Gene expression effected by TCP at levels found in UK pilots' blood.

The US Federal Aviation Administration (FAA) has acknowledged that "no present airplane design fulfils the intent of [federal aviation regulation] 25.831 because no airplane design incorporates an air contaminant monitoring system to ensure that the air provided to the occupants is free of hazardous contaminants" (FAA, 2002),

We point out that there is a sizable (and growing) body of literature on the association between exposure to oil fumes and acute and chronic symptoms reported globally by crews and passengers alike (ACARM, 2007). We believe there is ample justification for regulations that dictate bleed air cleaning and monitoring with flight deck indication to: (1) prevent exposure to oil fumes; (2) alert crew members if they are exposed in flight; and (3) enable maintenance workers to more effectively identify and remedy the contamination upon landing.

response

Not accepted.

Studies performed until today failed to demonstrate that cabin air can be contaminated in such a way that it could induce a safety or health issue. Cabin measurements found non-detectable or barely detectable levels of toxic contaminants. Concerning the symptoms reported by some crews or passengers: they are too generic to be directly linked to a toxic substance, although this is not rejected. Further investigation into this issue is recommended.

comment

146 comment by: *kapers Cabin Crew Union*

"What is the frequency of this kind of event?"

Comment:
As remarked earlier and in this EASA document (see IV. 9.), the frequency of events reported varies from country to country. Due to lack of information on the subject of contaminated air and risks, many incidents are simply not reported unless extremely serious or causing events that lead to full investigations.
Events are underreported. We ask that EASA initiate a mandatory reporting system for fume events.
As Crews are not trained to recognize or respond to fume events, we ask EASA to legislate on the training of both pilots and cabin crew to recognize and respond to fume events.

Dr Rayman says fume events are very rare & cannot cause a problem.... but in 1983 & 2002 he said this:

'***Smoke & fumes in the cockpit is not a rare event and a clear threat to flight safety due to acute toxic effects.***'
Rayman R.B., McNaughton G.B. (1983) Smoke/fumes in the cockpit. Aviation, Space and Environmental Medicine 1983; 67: 738-740.
AND exposure to VOCs used in aircraft operations can cause skin rashes, pulmonary and CNS symptoms ranging from mild to severe *RAYMAN Russell Cabin air quality: An overview . Aviation, space, and environmental medicine 2002, vol. 73, n°3, pp. 211-215*

response	Partially accepted. The Agency accepts the possibility that the minor events may be underreported by some organisations, probably because these events are considered as nuisance (e.g. temporary bad odours or smells), and therefore they are not considered as safety related occurrences which must be reported. Concerning the serious events involving a degree of crew or passengers' impairment or incapacitation, we believe they are reported and their number remains very limited. A regulation is already in place for this category of events through Directive 2003/42/EC of 13 June 2003 on occurrence reporting in civil aviation: it clearly identifies failures of engines or APU resulting in "Dense visible fumes or concentrations of toxic products sufficient to incapacitate crew or passengers". It is the responsibility of each Member State to ensure that stakeholders comply with this Directive. The Agency does not intend to create another mandatory reporting system.

A. Explanatory Note - IV. Content of the A-NPA - 9. Events caused by engine / APU air contamination p. 5-6

comment	*2* comment by: *Francis Fagegaltier Services* oil leak and oil degradation are not the only suspects. During engine certification, for example, it is required to consider the products resulting from contact of rotating blades with the abradable materials in the compressor. EASA should not limit the scope to oil.
response	Not accepted. The Agency agrees that the release of abradable materials shall be taken into account by engine manufacturers when performing their safety analysis, like it is done for engine oil. To our knowledge there has not been complaints or issues in service caused by engine abradable materials, therefore the design precautions are apparently efficient and reliable. Consequently, the Agency will not launch further investigation dedicated to abradable materials.

comment	*7* comment by: *British Airways* Comment: The evidence in this section does not support the need for additional regulation. Justification: This section confirms that existing reporting requirements have enabled the identification and rectification of specific problems on certain aircraft types. It also confirms that these events have not resulted in any catastrophic accidents or fatalities and that the reported symptoms are variable in nature and usually minor in nature.
response	Accepted. Meanwhile, the Agency needed to consolidate or update our knowledge because of the controversial opinions among the stakeholders. At this stage, the Agency did not find a justification for launching a rulemaking task.

comment	*18* comment by: *Christian Mueller, Eurowings Luftverkehrs AG* **De-Icing Fluid Residues as a cause for smell complaints** After modification of all of our Engines and APUs (advanced seals) on our whole BAe Systems 146 Fleet we made further investigations on possible Air Contamination sources. We found out that the "Typical BAe Smell" is very similary to the odour of heated de-icing fluid. After de-icing the A/C the de-icing fluid can enter the APU via the Compressor inlet housing and then gets into the Air Conditioning Packs through the APU Bleed Air Valve. The de-icing fluid gets dried and is stored in the heat exchanger and the condenser. We made several experiments using different types of deicing fluids. It has been discovered that after heating "new" deicing fluid an odour similar to the "Typical BAe Smell" was recognized. We cleaned airconditioning packs using the manufacturer cleaning procedure and analyzed the residues. After drying out the residues a white powder was found. This powder smelt exactly like "old socks". After sending it to the lab it was identified as deicing fluid residue and therefore identified as a possible source of cabin/cockpit air complaints. As a result from our studies we developed several Engineeering Orders. We asked BAe Systems for an alternate cleaning agent for the whole ECS and they recommended the use of "Frionett 360 Cleaning Agent". Next step was the development of a Cabin/Cockpit Duct Cleaning procedure to remove possible residues from the air conditioning ducting. As a second step we applied a special Cleaning Procedure to the Heat Exchanger and the Condensor of all Air Conditioning Packs. After these two steps where performed our Smell Complaint rate dropped significantly down. (Please refer also to the BAe Systems Regional A/C Annual Operators Technical Conference / September 2009)
response	Noted. The Agency encourages all operators to regularly clean the air conditioning system as prescribed by manufufacturers as it is indeed the best preventive measure to avoid fume/smoke/bad odour events caused by fluids accumulation inside the packs. In the case of de-icing fluids, the operator shall adapt the frequency of cleaning to their operation (e.g. operating in Sweden has not the same effect as operating in Greece).

comment	*20* comment by: *Christian Mueller, Eurowings Luftverkehrs AG* **TCP measurement methods** We did two different types of TCP measurements on our BAe Systems 146 aircraft. Wipe checks where performed on nine different places in the aircraft cabin. Additionally while a simulated flight was carried out on the ground, air measurements took place to determine the actual TCP concentraion in the cockpit and cabin air. The thresolds for TCP concentraion in the cockpit/cabin air were not exceeded. Unfortunately there are no real limits for concentration of TCP on parts (wipe checks) but we were able to recognize regions in the cabin with high or low

amounts of TCP per square cm.

response

Noted.
We agree that determining the concentration of TCP in the cabin air based on wipe checks is impossible. This can only be used to detect the presence of TCP.

comment

29 comment by: *FSC - CCOO*

"In the European Community, the majority of the reports are originated from the United Kingdom (UK), the other Member States reporting far less on this issue (refer to UK AAIB report 1/2004 published in February 2004). According to a presentation from the UK Civil Aviation Authority (CAA UK) to the Agency in March 2007, there were 104 flight deck occurrences on Large Aeroplanes between 1999 and 2006; a peak of events (26) appears in 2001, then followed by a significant decrease in 2002 and 2003. This decrease in the number of events can be explained by the measures taken in 2001-2002 towards the two aeroplane types generating the majority of the events (BAE146 and B757); these measures consisted in inspections and corrective actions to limit the risk of oil leakage from APU and engines. Then, after a very calm period, another peak of events appeared in 2006 (26 events). No official CAA UK events figures are available to EASA for 2007 and 2008, but according to them the tendency is a decrease in the number of reports."

Comment:
Despite claims that there is insufficient reporting **(please refer to ACARM (2007b) "Chapter 12: Frequency of Events and Underreporting" "*Aviation Contaminated Air Reference Manual,*" Michaelis, S., ed. ISBN 9780955567209, London, England, pp. 211-248)** and evidence to support casual relationship between exposure to oil contaminated air and pilot ill health the **UK COT report** concluded that it would be PRUDENT to PREVENT exposure to oil contaminated air. We fully support any study that the EASA undertakes to collect data regarding the number of events/incidents linked to oil contaminated air and request that preventative measures be taken and included in new standards.
The FAA says it has recorded 900 fume events in 10 years. But in 2006 they said this:

'There have been concerns raised about numerous reports of "smoke/fumes in the cockpit/cabin" events on commercial air carrier/operator aircraft. During the FAA's analysis of this data, it appears as though there are numerous air carriers/operators who may not have reported these events as required by regulation. **Flight Standards Information Bulletin for Airworthiness (FSAW)06-05A, Guidance for Smoke/Fumes in the Cockpit/Cabin_29 March 2006.29 March 2006 (see attachment: Smoke-Cockpit-Ballough.ppt)**

Concerning the detection & reporting of oil leakage and vapours inside the aircraft cabin Professor Windsor states that "***The only technically functional way to identify the presence of poorly volatile contaminants present in aircraft environments is to place a direct reading machine on the aircraft during flight."***
The US FAA has acknowledged that "no present airplane design fulfils the intent of [federal aviation regulation] 25.831 because no airplane design incorporates an air contaminant monitoring system to ensure that the air provided to the occupants is free of hazardous contaminants"

response	Partially accepted. The Agency accepts the possibility that the minor events may be underreported by some organisations, probably because these events are considered as nuisance (e.g. temporary bad odours or smells), and therefore they are not considered as safety related occurrences which must be reported. Concerning the serious events involving a degree of crew or passengers' impairment or incapacitation, we believe they are reported and their number remains very limited. A regulation is already in place for this category of events through Directive 2003/42/EC of 13 June 2003 on occurrence reporting in civil aviation: it clearly identifies failures of engines or APU resulting in "Dense visible fumes or concentrations of toxic products sufficient to incapacitate crew or passengers". It is the responsibility of each Member State to ensure that stakeholders comply with this Directive. The Agency does not intend to create another mandatory reporting system.
comment	*30* comment by: *FSC - CCOO* "The measures taken towards BAE146 and B757 types are summarised hereafter: In the case of the European type BAE 146, two Inspection Service Bulletins (ISB) have been mandated through Airworthiness Directives (ADs) by the UK CAA in March 2001 and November 2002. The first ISB requires the inspection for contaminants in the Environmental Control Systems (ECS), and should any be found, requires inspection of the engines and APU for any signs of oil leakage; inspection accomplishment is required every A-check or when a cabin air quality problem is reported. The second ISB, supplementing the first one, requires inspection of sound attenuating ducts within the ECS for signs of oil contamination; it also provides appropriate trouble shooting and rectification procedures, including replacement of contaminated ducts. In addition, in December 2002, CAA UK mandated the replacement of the inlet air connection to the APU by an improved design to prevent the induction of potentially contaminated air. Concerning the B757, the engine manufacturer Rolls Royce identified overhaul improvements for the engine and Boeing updated the engine oil servicing procedure in the B757 Aircraft Maintenance Manual to avoid oil tank over-servicing." Comment: It seems that there is still a UK preoccupation with continued "leaking" of oil into the cabin as there is a new device that sterilizes aircraft cabin air to eradicate contaminants and pathogens such as swine flu which has been developed by BAE Systems and UK firm Quest International. BAE Systems plans to fit 2,600 aircraft with the devices – that is about 10% of the global total of commercial aircraft. Larger commercial jets require more than one. Five airlines are trialing the device, and one has recently placed an order for it's BAE Avro RJ fleet of regional jets. The device is also installed on BAE System's own corporate jets. It has been certified for use on the BAE 146 and Avro RJ aircraft and has a supplemental certificate for Boeing 757s. **There still seems to be some concern over the effectiveness of this device to eliminate all toxic substances from heated oils and contaminants**.
response	Noted.

comment	*31* comment by: *FSC - CCOO* "According to available reports, there is a variety of symptoms, and there is not a single symptom or type of symptoms which can be characteristic of cabin air quality event. This ranges from benign symptoms like unpleasant odour, light eye or nose irritation, light headache up to more serious symptoms like severe headache, difficulty to concentrate, nausea or muscle cramp. The most serious symptoms can substantially degrade flight crew awareness and performance of their duties. Then, the main associated safety threat would be a dual and simultaneous pilot incapacitation occurring during a critical phase of flight such as take-off or landing, which would be potentially catastrophic. However, a majority of events involves low severity symptoms (irritation, feeling unwell), and the cases where incapacitation was reached are very rare (e.g. 2 reports of single incapacitation in UK as of 2006)." Comment: We believe that there are more than 2 reports of single incapacitation in the UK – this can be checked by contacting the UK CAA.
response	Noted. UK CAA provided to EASA data including the level of severity of events between 1999 and 2006, showing 2 cases of incapacitation. As a comment to this A-NPA, UK CAA provided data in terms of number of MORS for 2007, 2008 and 2009 (Jan-Jun). But there is no classification in terms of severity for those last events.
comment	*43* comment by: *Unionen/Sweden* "In the European Community, the majority of the reports are originated from the United Kingdom (UK), the other Member States reporting far less on this issue (refer to UK AAIB report 1/2004 published in February 2004). According to a presentation from the UK Civil Aviation Authority (CAA UK) to the Agency in March 2007, there were 104 flight deck occurrences on Large Aeroplanes between 1999 and 2006; a peak of events (26) appears in 2001, then followed by a significant decrease in 2002 and 2003. This decrease in the number of events can be explained by the measures taken in 2001-2002 towards the two aeroplane types generating the majority of the events (BAE146 and B757); these measures consisted in inspections and corrective actions to limit the risk of oil leakage from APU and engines. Then, after a very calm period, another peak of events appeared in 2006 (26 events). No official CAA UK events figures are available to EASA for 2007 and 2008, but according to them the tendency is a decrease in the number of reports." Comment: Despite claims that there is insufficient reporting **(please refer to ACARM (2007b) "Chapter 12: Frequency of Events and Underreporting" "*Aviation Contaminated Air Reference Manual,*" Michaelis, S., ed. ISBN 9780955567209, London, England, pp. 211-248)** and evidence to support casual relationship between exposure to oil contaminated air and pilot ill health the **UK COT report** concluded that it would be PRUDENT to PREVENT exposure to oil contaminated air. We fully support any study that the EASA undertakes to collect data regarding the number of events/incidents linked to oil contaminated air and request that preventative measures be taken and included in new standards. **The FAA says it has recorded 900 fume events in 10 years.** But in 2006

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Concerning the detection & reporting of oil leakage and vapours inside the aircraft cabin Professor Windsor states that "***The only technically functional way to identify the presence of poorly volatile contaminants present in aircraft environments is to place a direct reading machine on the aircraft during flight."***
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response

Partially accepted.

The Agency accepts the possibility that the minor events may be underreported by some organisations, probably because these events are considered as nuisance (e.g. temporary bad odours or smells), and therefore they are not considered as safety related occurrences which must be reported.

Concerning the serious events involving a degree of crew or passengers' impairment or incapacitation, we believe they are reported and their number remains very limited. A regulation is already in place for this category of events through Directive 2003/42/EC of 13 June 2003 on occurrence reporting in civil aviation: it clearly identifies failures of engines or APU resulting in "Dense visible fumes or concentrations of toxic products sufficient to incapacitate crew or passengers". It is the responsibility of each Member State to ensure that stakeholders comply with this Directive. The Agency does not intend to create another mandatory reporting system.

comment

44 comment by: *Unionen/Sweden*

"The measures taken towards BAE146 and B757 types are summarised hereafter:
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	Concerning the B757, the engine manufacturer Rolls Royce identified overhaul improvements for the engine and Boeing updated the engine oil servicing procedure in the B757 Aircraft Maintenance Manual to avoid oil tank over-servicing." Comment: It seems that there is still a UK preoccupation with continued "leaking" of oil into the cabin as there is a new device that sterilizes aircraft cabin air to eradicate contaminants and pathogens such as swine flu which has been developed by BAE Systems and UK firm Quest International. BAE Systems plans to fit 2,600 aircraft with the devices – that is about 10% of the global total of commercial aircraft. Larger commercial jets require more than one. Five airlines are trialing the device, and one has recently placed an order for it's BAE Avro RJ fleet of regional jets. The device is also installed on BAE System's own corporate jets. It has been certified for use on the BAE 146 and Avro RJ aircraft and has a supplemental certificate for Boeing 757s. **There still seems to be some concern over the effectiveness of this device to eliminate all toxic substances from heated oils and contaminants**.
response	Noted.

comment	*45* comment by: *Unionen/Sweden* "According to available reports, there is a variety of symptoms, and there is not a single symptom or type of symptoms which can be characteristic of cabin air quality event. This ranges from benign symptoms like unpleasant odour, light eye or nose irritation, light headache up to more serious symptoms like severe headache, difficulty to concentrate, nausea or muscle cramp. The most serious symptoms can substantially degrade flight crew awareness and performance of their duties. Then, the main associated safety threat would be a dual and simultaneous pilot incapacitation occurring during a critical phase of flight such as take-off or landing, which would be potentially catastrophic. However, a majority of events involves low severity symptoms (irritation, feeling unwell), and the cases where incapacitation was reached are very rare (e.g. 2 reports of single incapacitation in UK as of 2006)." Comment: We believe that there are more than 2 reports of single incapacitation in the UK – this can be checked by contacting the UK CAA.
response	Noted. UK CAA provided to EASA data including the level of severity of events between 1999 and 2006, showing 2 cases of incapacitation. As a comment to this A-NPA, UK CAA provided data in terms of number of MORS for 2007, 2008 and 2009 (Jan-Jun). But there is no classification in terms of severity for those last events.

comment	*59* comment by: *cfdt france* "In the European Community, the majority of the reports are originated from the United Kingdom (UK), the other Member States reporting far less on this issue (refer to UK AAIB report 1/2004 published in February 2004). According to a presentation from the UK Civil Aviation Authority (CAA UK) to the Agency in March 2007, there were 104 flight deck occurrences on Large Aeroplanes between 1999 and 2006; a peak of events (26) appears in 2001, then followed

	by a significant decrease in 2002 and 2003. This decrease in the number of events can be explained by the measures taken in 2001-2002 towards the two aeroplane types generating the majority of the events (BAE146 and B757); these measures consisted in inspections and corrective actions to limit the risk of oil leakage from APU and engines. Then, after a very calm period, another peak of events appeared in 2006 (26 events). No official CAA UK events figures are available to EASA for 2007 and 2008, but according to them the tendency is a decrease in the number of reports." Comment: Despite claims that there is insufficient reporting **(please refer to ACARM (2007b) "Chapter 12: Frequency of Events and Underreporting" "*Aviation Contaminated Air Reference Manual,"* Michaelis, S., ed. ISBN 9780955567209, London, England, pp. 211-248)** and evidence to support casual relationship between exposure to oil contaminated air and pilot ill health the **UK COT report** concluded that it would be PRUDENT to PREVENT exposure to oil contaminated air. We fully support any study that the EASA undertakes to collect data regarding the number of events/incidents linked to oil contaminated air and request that preventative measures be taken and included in new standards. **The FAA says it has recorded 900 fume events in 10 years.** But in 2006 they said this: ***'There have been concerns raised about numerous reports of "smoke/fumes in the cockpit/cabin" events on commercial air carrier/operator aircraft. During the FAA's analysis of this data, it appears as though there are numerous air carriers/operators who may not have reported these events as required by regulation.*** **Flight Standards Information Bulletin for Airworthiness (FSAW)06-05A, Guidance for Smoke/Fumes in the Cockpit/Cabin_29 March 2006.29 March 2006 (see attachment: Smoke-Cockpit-Ballough.ppt)** Concerning the detection & reporting of oil leakage and vapours inside the aircraft cabin Professor Windsor states that "***The only technically functional way to identify the presence of poorly volatile contaminants present in aircraft environments is to place a direct reading machine on the aircraft during flight."*** The US FAA has acknowledged that "no present airplane design fulfils the intent of [federal aviation regulation] 25.831 because no airplane design incorporates an air contaminant monitoring system to ensure that the air provided to the occupants is free of hazardous contaminants"
response	Partially accepted. The Agency accepts the possibility that the minor events may be underreported by some organisations, probably because these events are considered as nuisance (e.g. temporary bad odours or smells), and therefore they are not considered as safety related occurrences which must be reported. Concerning the serious events involving a degree of crew or passengers' impairment or incapacitation, we believe they are reported and their number remains very limited. A regulation is already in place for this category of events through Directive 2003/42/EC of 13 June 2003 on occurrence reporting in civil aviation: it clearly identifies failures of engines or APU resulting in "Dense visible fumes or concentrations of toxic products sufficient to incapacitate crew or passengers". It is the responsibility of each Member State to ensure that stakeholders comply with this Directive. The Agency does not

	intend to create another mandatory reporting system.
comment	*60* comment by: *cfdt france* "The measures taken towards BAE146 and B757 types are summarised hereafter: In the case of the European type BAE 146, two Inspection Service Bulletins (ISB) have been mandated through Airworthiness Directives (ADs) by the UK CAA in March 2001 and November 2002. The first ISB requires the inspection for contaminants in the Environmental Control Systems (ECS), and should any be found, requires inspection of the engines and APU for any signs of oil leakage; inspection accomplishment is required every A-check or when a cabin air quality problem is reported. The second ISB, supplementing the first one, requires inspection of sound attenuating ducts within the ECS for signs of oil contamination; it also provides appropriate trouble shooting and rectification procedures, including replacement of contaminated ducts. In addition, in December 2002, CAA UK mandated the replacement of the inlet air connection to the APU by an improved design to prevent the induction of potentially contaminated air. Concerning the B757, the engine manufacturer Rolls Royce identified overhaul improvements for the engine and Boeing updated the engine oil servicing procedure in the B757 Aircraft Maintenance Manual to avoid oil tank over-servicing." Comment: It seems that there is still a UK preoccupation with continued "leaking" of oil into the cabin as there is a new device that sterilizes aircraft cabin air to eradicate contaminants and pathogens such as swine flu which has been developed by BAE Systems and UK firm Quest International. BAE Systems plans to fit 2,600 aircraft with the devices – that is about 10% of the global total of commercial aircraft. Larger commercial jets require more than one. Five airlines are trialing the device, and one has recently placed an order for it's BAE Avro RJ fleet of regional jets. The device is also installed on BAE System's own corporate jets. It has been certified for use on the BAE 146 and Avro RJ aircraft and has a supplemental certificate for Boeing 757s. **There still seems to be some concern over the effectiveness of this device to eliminate all toxic substances from heated oils and contaminants**.
response	Noted.
comment	*61* comment by: *cfdt france* "According to available reports, there is a variety of symptoms, and there is not a single symptom or type of symptoms which can be characteristic of cabin air quality event. This ranges from benign symptoms like unpleasant odour, light eye or nose irritation, light headache up to more serious symptoms like severe headache, difficulty to concentrate, nausea or muscle cramp. The most serious symptoms can substantially degrade flight crew awareness and performance of their duties. Then, the main associated safety threat would be a dual and simultaneous pilot incapacitation occurring during a critical phase of flight such as take-off or landing, which would be potentially catastrophic. However, a majority of events involves low severity symptoms (irritation, feeling unwell), and the cases where incapacitation was reached are very rare

(e.g. 2 reports of single incapacitation in UK as of 2006)."

Comment:
We believe that there are more than 2 reports of single incapacitation in the UK – this can be checked by contacting the UK CAA.

response

Noted.
UK CAA provided to EASA data including the level of severity of events between 1999 and 2006, showing 2 cases of incapacitation. As a comment to this A-NPA, UK CAA provided data in terms of number of MORS for 2007, 2008 and 2009 (Jan-Jun). But there is no classification in terms of severity for those last events.

comment

75 comment by: *Fédération des transports CGT*

"In the European Community, the majority of the reports are originated from the United Kingdom (UK), the other Member States reporting far less on this issue (refer to UK AAIB report 1/2004 published in February 2004). According to a presentation from the UK Civil Aviation Authority (CAA UK) to the Agency in March 2007, there were 104 flight deck occurrences on Large Aeroplanes between 1999 and 2006; a peak of events (26) appears in 2001, then followed by a significant decrease in 2002 and 2003. This decrease in the number of events can be explained by the measures taken in 2001-2002 towards the two aeroplane types generating the majority of the events (BAE146 and B757); these measures consisted in inspections and corrective actions to limit the risk of oil leakage from APU and engines. Then, after a very calm period, another peak of events appeared in 2006 (26 events). No official CAA UK events figures are available to EASA for 2007 and 2008, but according to them the tendency is a decrease in the number of reports."

Comment:
Despite claims that there is insufficient reporting **(please refer to ACARM (2007b) "Chapter 12: Frequency of Events and Underreporting" "*Aviation Contaminated Air Reference Manual,*" Michaelis, S., ed. ISBN 9780955567209, London, England, pp. 211-248)** and evidence to support casual relationship between exposure to oil contaminated air and pilot ill health the **UK COT report** concluded that it would be PRUDENT to PREVENT exposure to oil contaminated air. We fully support any study that the EASA undertakes to collect data regarding the number of events/incidents linked to oil contaminated air and request that preventative measures be taken and included in new standards.
The FAA says it has recorded 900 fume events in 10 years. But in 2006 they said this:
***'There have been concerns raised about numerous reports of "smoke/fumes in the cockpit/cabin" events on commercial air carrier/operator aircraft. During the FAA's analysis of this data, it appears as though there are numerous air carriers/operators who may not have reported these events as required by regulation.* Flight Standards Information Bulletin for Airworthiness (FSAW)06-05A, Guidance for Smoke/Fumes in the Cockpit/Cabin_29 March 2006.29 March 2006 (see attachment: Smoke-Cockpit-Ballough.ppt)**

Concerning the detection & reporting of oil leakage and vapours inside the aircraft cabin Professor Windsor states that "***The only technically functional way to identify the presence of poorly volatile contaminants present in aircraft environments is to place a direct reading machine on the***

aircraft during flight."
The US FAA has acknowledged that "no present airplane design fulfils the intent of [federal aviation regulation] 25.831 because no airplane design incorporates an air contaminant monitoring system to ensure that the air provided to the occupants is free of hazardous contaminants"

response

Partially accepted.

The Agency accepts the possibility that the minor events may be underreported by some organisations, probably because these events are considered as nuisance (e.g. temporary bad odours or smells), and therefore they are not considered as safety related occurrences which must be reported.

Concerning the serious events involving a degree of crew or passengers' impairment or incapacitation, we believe they are reported and their number remains very limited. A regulation is already in place for this category of events through Directive 2003/42/EC of 13 June 2003 on occurrence reporting in civil aviation: it clearly identifies failures of engines or APU resulting in "Dense visible fumes or concentrations of toxic products sufficient to incapacitate crew or passengers". It is the responsibility of each Member State to ensure that stakeholders comply with this Directive. The Agency does not intend to create another mandatory reporting system.

comment

76 comment by: *Fédération des transports CGT*

"The measures taken towards BAE146 and B757 types are summarised hereafter:
In the case of the European type BAE 146, two Inspection Service Bulletins (ISB) have been mandated through Airworthiness Directives (ADs) by the UK CAA in March 2001 and November 2002. The first ISB requires the inspection for contaminants in the Environmental Control Systems (ECS), and should any be found, requires inspection of the engines and APU for any signs of oil leakage; inspection accomplishment is required every A-check or when a cabin air quality problem is reported. The second ISB, supplementing the first one, requires inspection of sound attenuating ducts within the ECS for signs of oil contamination; it also provides appropriate trouble shooting and rectification procedures, including replacement of contaminated ducts. In addition, in December 2002, CAA UK mandated the replacement of the inlet air connection to the APU by an improved design to prevent the induction of potentially contaminated air.

Concerning the B757, the engine manufacturer Rolls Royce identified overhaul improvements for the engine and Boeing updated the engine oil servicing procedure in the B757 Aircraft Maintenance Manual to avoid oil tank over-servicing."

Comment:
It seems that there is still a UK preoccupation with continued "leaking" of oil into the cabin as there is a new device that sterilizes aircraft cabin air to eradicate contaminants and pathogens such as swine flu which has been developed by BAE Systems and UK firm Quest International. BAE Systems plans to fit 2,600 aircraft with the devices – that is about 10% of the global total of commercial aircraft. Larger commercial jets require more than one. Five airlines are trialing the device, and one has recently placed an order for it's BAE Avro RJ fleet of regional jets.
The device is also installed on BAE System's own corporate jets. It has been

certified for use on the BAE 146 and Avro RJ aircraft and has a supplemental certificate for Boeing 757s. **There still seems to be some concern over the effectiveness of this device to eliminate all toxic substances from heated oils and contaminants**.

response: Noted.

comment: *77* comment by: *Fédération des transports CGT*

"According to available reports, there is a variety of symptoms, and there is not a single symptom or type of symptoms which can be characteristic of cabin air quality event. This ranges from benign symptoms like unpleasant odour, light eye or nose irritation, light headache up to more serious symptoms like severe headache, difficulty to concentrate, nausea or muscle cramp. The most serious symptoms can substantially degrade flight crew awareness and performance of their duties. Then, the main associated safety threat would be a dual and simultaneous pilot incapacitation occurring during a critical phase of flight such as take-off or landing, which would be potentially catastrophic.
However, a majority of events involves low severity symptoms (irritation, feeling unwell), and the cases where incapacitation was reached are very rare (e.g. 2 reports of single incapacitation in UK as of 2006)."

Comment:
We believe that there are more than 2 reports of single incapacitation in the UK – this can be checked by contacting the UK CAA.

response: Noted.
UK CAA provided to EASA data including the level of severity of events between 1999 and 2006, showing 2 cases of incapacitation. As a comment to this A-NPA, UK CAA provided data in terms of number of MORS for 2007, 2008 and 2009 (Jan-Jun). But there is no classification in terms of severity for those last events.

comment: *85* comment by: *UK CAA*

Attachment #7

Section 9, Events caused by engine/APU air contamination

Paragraph 3 "… No UK event figures are available to EASA for 2007 and 2008 …"

Comment: Updated UK events are available.

Justification: Updated information available at Appendix 1 attached.

Proposed Text: "UK events from the MORS database for 2007, 2008 and 2009 (Jan-Jun) are attached as Appendix 1."

response: Noted.
Thank you for this update. We regret that the events are not classified in terms of severity like it was done between 1999 and 2006.

comment: *86* comment by: *UK CAA*

Section 9, Events caused by engine/APU air contamination

Paragraph 5 "… Maintenance Manual to avoid oil tank over-servicing."

Comment: The problem was identified as over-filling with oil.

Justification: The term "over-servicing" is incorrect.

Proposed Text: "… Maintenance Manual to avoid oil tank over-filling."

response Accepted.

comment *96* comment by: *cfdt france*

What contaminants are released to the cabin and in which quantity?

What is the effect on flight safety?

Can it induce a health concern?

What is the frequency of this kind of event?
ETF Comment : There has been and is still great difficulty in collecting and interpreting the mounting data and identifying toxic/irritant products in oil substances used in the airline industry. The physiological effects of gases and vapours in cabin air is now becoming clear and the defining of maximum acceptable quantities or concentrations must become a subject for legislation and standards.

ETF comment : "What contaminants are released to the cabin and in which quantity"?
The ETF Cabin crew committee refer to statements published by Dr. Mackerer in 1999 and to the Henschler report in 1958 "Engine oils contain a mixture of tricresylphosphates, of which
TOCP in not the most toxic".
TOCP is NOT the only ortho isomer in TCP - the more toxic MOCP& DOCP are in the oil in far higher quantities.
Mobil advised the Australian Senate Inquiry that the ortho isomers were in the TCP in it's oil at >0.3%. The more toxic MOCP & DOCP were not mentioned.
ORTHO isomers divide into: **TOCP**, **DOCP** and **MOCP**.
Focus has been on TOCP with UK House of Lords and CAA reports of 2000 and 2004. These reports fail to ever mention DOCP or MOCP.

TOCP 0.006 ppm Toxicity factor x 1
DOCP 6 ppm Toxicity factor x 5
MOCP 3070 ppm Toxicity factor x 10

In ignoring DOCP and MOCP the total ORTHO toxicity is underestimated by a factor of **6.14 million** which has been known since 1958 (Henschler).

It has been known for years that when aviation engine oils are heated, a potent neurotoxic chemical called TMPP (trimethylolpropane phosphate) can be formed. TMPP is even worse than TCPs and exposure is associated with epileptic type seizures, convulsion, tremors, and changes to social/emotional behaviors. To the knowledge of ETF , it has never been found on aircraft. But to ETF's knowledge, nobody has ever looked for into this..
A 1989 US Navy report stating that Exxon 2380 (now BP2380) generated high levels of TMPP when it was heated to temperatures at or above 350C. The TCPs in the oil react with TMP chemicals in the "base stock" of the oil. **The**

levels of TMPP were so significant that the authors recommended that Exxon 2380 not be used on US naval vessels. But BP2380 is still widely used in commercial aviation.

A 1996 US Air Force paper raised concerns about the potential for being exposed to highly toxic TMPP, and stated that TMPP could be formed when oils that contain TCPs and TMP are heated to temperatures as low as 250C. This is important because these temperatures are more likely to be reached in the engine/bleed air system. Wright also stated that TMPP can NOT be formed if the engine oil base stock contains PE chemicals instead of TMP. *WRIGHT R. L. Formation of the neurotoxin TMPP from TMPE-phosphate formulations - Tribiology transactions 1996, vol. 39, no4, pp. 827-834*

Another US navy report in 1992 also expressed concern about the hazards
1) What engine oil(s) are used (e.g., Mobil Jet Oil II, BP2380, etc).
2) What APU and engine types are installed on what aircraft types (e.g. Pratt Whitney 4000, Honeywell Series 85, etc).

Oils and lubricants used on the aircraft and in the engines contain not only the neurotoxins (TCPs and triphenylphosphates) but **sensitizers (N-phenyl-L-naphthylamine, PAN),** and **asphyxiants (carbon monoxide**).. Pyrolysis studies have confirmed the presence of these toxins when commercial oils are heated (van Netten, 2000; Marshman, 2001; Fox, 2001). A Material SafetyData Sheet for engine oils acknowledge only the TCP content and the fact that "toxicfumes may be evolved on burning or exposure to heat" (BP, 2001).

ETF cabin crew committee ask that Studies include the potential impact of exposure to the mixture of these and other chemicals in a reduced pressure environment.
ETF Suggests that the EASA review all data and see if a less toxic alternative oil can be recommended that would be compatible with given aircraft engines/APUs.
Ultimately, all of the engine oils should be analyzed for their base stock content (rather than relying on the analysis of the oil companies), as well as for the potential to form TMPP, and temperature range of TMPP formation.

ETF Comment : "What is the effect on flight safety"?
The ETF Cabin crew committee refers to the following statements and documents:

2001: "Incidents have been reported of impaired performance of flight crew…events could have been
caused by inhalation of agents… leaking from oil or APU and contaminating the Environmental control
system."
(CAA AD 002-03-2001)

2002: "oil leaks and cabin / flight deck odours must be regarded as a potential threat to flight safety, theyshould not be dismissed as a mere nuisance and should be addressed as soon as possible."
(BAe ISB 21-150 2001 / ISB 21-156, 2002)

2003: "Any oil leaking from an engine, entering the aircraft customer bleed offtake, is classified as
HAZARDOUS"

(Rolls Royce, Germany 2003, BRE air quality Conference, London)

2004: "This amendment adopts a new airworthiness directive (AD), applicable to all BAE Systems
(Operations) Limited Model BAe 146 series airplanes, that requires repetitive detailed inspections of the inside of each air conditioning sound-attenuating duct, and corrective actions as necessary. This action is necessary to prevent impairment of the operational skills and abilities of the flightcrew caused by the inhalation of agents released from oil or oil breakdown products, which could result in reduced controllability of the airplane. This action is intended to address the identified unsafe condition."
(FAA AD 2004-12-05)

2006: "The serious incident is attributable to the fact that on approach to Zurich Airport the cockpit filled with fumes which caused a toxic effect, leading to a limited capability of acting of the copilot. These fumes were caused by an oil leak as a result of a bearing damage in engine No. 1" "The
medical examination of the copilot after the flight showed that during the flight toxic exposure took place."
(Swiss Federal Department of Environment, Transport Energy and Communications Investigation Report No u1884 by the Aircraft Accident Investigation Bureau, 2 March 2006)

TheETF Cabin crew committee also refers the EASA to the manual written by Prof. S. Michaelis, (renowned expert on Cabin air contamination): "*Aviation Contaminated Air Reference Manual,*" Michaelis, S., ed. ISBN 9780955567209, London,

ETF comment : "Can it induce a health concern?"
The ETF Cabin committee feel that there is now sufficient available material and literature on cabin air being contaminated by toxic substances used on the aircraft. Studies are now available giving indications that the health of aircraft occupants may be severely affected by the inhalation & contact with gases and vapours of lubricants, anti-freeze agents and others.

ETF refers the EASA to the following statements and studies :

"individuals exposed to a single large toxic dose, or to small subclinical doses, of ***organophosphorus compounds***have developed a chronic neurotoxicity that persists for years after exposure and is distinct from both cholinergic and OPIDN"(AbouDonia, 2003; *Arch. Environ. Health***58**:484-97).

- Abou-Donia MB (2004) Organophosphorus ester-induced chronic neurotoxicity. Archives of Environmental Health 58:484–497

- Organophosphate Ester Induced Chronic Neurotoxicity (OPICN)- Mohamed B Abou-Donia : Proceedings of the BALPA 'Contaminated Air Protection Air Safety and Cabin Air Quality International Aero Industry Conference'. Held at Imperial College, London, 20-21 April 2005: ISBN 0-7334-2282-9

- Journal of Occupational Health & Safety, Australia & New Zealand, Vol 21, Number 5 ,August 2005 - Special edition: New findings in aircrew exposed to airborne contaminants: Long-term health effects confirmed. - Organophosphate Ester Induced Chronic Neurotoxicity (OPICN)- Mohamed B Abou-Donia

1981: Engine Lube Oil: "At temperatures above 320C this oil breaks down into irritating and toxic compounds."
(SAE Aviation Information Report: 1539, issued 1-30-81)
1983: "All of these toxic substances (includes engine oil) have acute and long-term effects"
(Rayman R.B., McNaughton G.B. Smoke/fumes in the cockpit. Aviation, Space and Environmental Medicine, August 1983, pp 738-740. Current Director of the Aerospace Medical Association)
1998: "Repeated low level exposure leads to cumulative toxicity." (1981 ed)
"Acute and repeated exposure can produce harmful effects in man, and it has been suggested that chronic exposure at lower doses may cause long-term ill health." (1998 ed)
(UK HSE: Organophosphates: HSE: MS17: Medical aspects of occupational exposures to organophosphates. Draft revision 23, November, 1998.)
1999: "Neuropsychological outcomes - Neuropsychological abnormalities can occur as a long-term complication of acute OP poisoning"
(UK COT report. Long term sequelae of acute poisoning: 1999. Committee on Toxicity of Chemicals in Food, Consumer Products and the Environment: Organophosphates: Executive Summary. Published by the Department of Health, 1999, London)
1999: "The inhalation of mist (containing tricresylphosphate) which can be produced by high pressure systems, or direct contact with the skin, would be hazardous."
(UK Government Hansard 66599, 4 February 1999, column 737)
1999: "TCP is toxic"
(UK Government: Hansard 82322 6 May 1999 : Column: 428)
2000: "With the weight of human evidence and suffering, which is quite clear, there must be something there" "There is absolutely no doubt in our mind that there is a general health issue here"
(BAe Systems verbal evidence to Australian senate Inquiry 2000)
2001: "Incidents have been reported of impaired performance of flight crew…events could have been caused by inhalation of agents… leaking from oil or APU and contaminating the Environmental control system."
(CAA AD 002-03-2001)
2002: "oil leaks and cabin / flight deck odours must be regarded as a potential threat to flight safety, they should not be dismissed as a mere nuisance and should be addressed as soon as possible."
(BAe ISB 21-150 2001 / ISB 21-156, 2002)

2002: "FAA rulemaking has not kept pace with public expectation and concern about air quality and doesnot afford explicit protection from particulate matter and other chemical and biological hazards." "No present airplane design fulfills the intent of 25.831 because no airplane design incorporates an air Contaminant monitoring system to ensure that the air provided to the occupants is free of hazardous contaminants"
2003: "Any oil leaking from an engine, entering the aircraft customer bleed offtake, is classified as HAZARDOUS"
(Rolls Royce, Germany 2003, BRE air quality Conference, London)
2003: "It is found that the sound attenuating material used in the air-conditioning ducts can absorb oil and can become a source of persistent air contamination."
(CASA AD /BAe 146/102, 23 January 2003)
2004: "In the event of oil leakage there is the opportunity, therefore, for the pyrolysis products of engine lubricant/fuel to enter the cabin air supply and exert toxic effects on both passengers and crew."
(CAA Air Quality report 2004)

2004: "This amendment adopts a new airworthiness directive (AD), applicable to all BAE Systems (Operations) Limited Model BAe 146 series airplanes, that requires repetitive detailed inspections of the inside of each air conditioning sound-attenuating duct, and corrective actions as necessary. This action is necessary to prevent impairment of the operational skills and abilities of the flightcrew caused by the inhalation of agents released from oil or oil breakdown products, which could result in reduced controllability of the airplane. This action is intended to address the identified unsafe condition."
(FAA AD 2004-12-05)
2005: "Both Flight Crew Affected By Sore Throats And Other Symptoms After Flight." "Smells and irritants from burning organic compounds from within the engines are known to produce harmful volatile organic contaminants."
(UK Airline Air Safety Report, ASR G-CFAH, 4 July 2005)
2007: "Mobil Jet Oil II- Known to be harmful"
(CASA: AIR SAFETY & CABIN AIR QUALITY - Jim Coyne – A/g General Manager Manufacturing, Certification & New Technologies Office: 2007 presentation)
2007: "A35-12: Protection of the health of passengers and crews and prevention of the spread of communicable disease through international travel
-*Declares* that the protection of the health of passengers and crews on international flights is an integral element of safe air travel and that conditions should be in place to ensure its preservation in a timely and cost-effective manner;
-*Requests* the Council to support further research on the consequences of air transport on the health of passengers and crews"
(ICAO- Aviation Medicine (Med) Section Related ICAO Resolutions, 5 July 2007)
http://www.icao.int/icao/en/assembl/a36/wp/wp022_en.pdf
2007: "I call on the government to reveal whether information about defects has been withheld from the regulator, the courts or the parliament"
"I am gravely concerned that crew and passengers of BAe146 aircraft have been exposed to dangerous fumes produced by engine defects"
(Senate Hansard: Monday, 13 August 2007, Senator O'Brien
2009: "Product may decompose at elevated temperatures or under fire conditions and produce harmful gases or vapours. Vapours or mist of heated product may be harmful by inhalation."
R 63.G3 Possible risk of harm to the unborn child.
R 62.F3 Possible risk of impaired fertility.
(NYCO MSDS 2009 , TURBONYCOIL 600)
2009: "Product may decompose at elevated temperatures or under fire conditions and give off irritating and/or harmful (carbon monoxide) gases/vapours/fumes. Symptoms from acute exposure to these decomposition products in confined spaces may include headache, nausea, eye, nose, and throat irritation."
(Mobil MJO2 MSDS EU 2009)
2009: Plus Minus: "Is inhaling of tricresyl phosphate (TCP) safe or dangerous?"
Professor D henschler (1958 TCP researcher): "I believe it to be dangerous."
(German TV: Plus Minus, March 2009)
2009: "Does the German Government believe that inhaling of heated engine oil fumes is harmless for the health of crew and passengers?". Answer "No"
German Ministry of Transport, Secretary of State Ulrich Kasparick.
(Question to MP Winfried Hermann of Bundnis90/Greenparty in regards to contaminated cabin air on board of civil airliners, printed matter 16/12023, 3 March 2009)
2009 "Smoke from pyrolysed oil can be hazardous to the eyes, mucous membranes and lungs"
(Turner V Eastwest Airlines [2009] NSWDDT 5 May 2009 , Australian Court)

2009: "Smoke or fumes in the flight deck or passenger cabin present the crew with a potentially hazardous situation"
AAIB Bulletin 6/2009 G-BYAO B757, EW/C2006/10/08

Bobb, A.J. and Still, K.R. (2003) "Known Harmful Effects of Constituents of Jet Oil Smoke," TOXDET-03-04, Naval Health Research Center Detachment (Toxicology), Wright-Patterson AFB, OH

Winder, C; Fonteyn, P; Balouet, JC. (2002) "Aerotoxic syndrome: a descriptive epidemiological survey of aircrew exposed to in-cabin airborne contaminants" J Occup Health Safety – Austr New Zealand, 18(4): 321-328

Winder, C. (2006) Hazardous chemicals on jet aircraft: Case study – Jet engine oils and aerotoxic syndrome. Current Topics in Toxicology. Vol 3, 2006

2008 -- Cognitive function following exposure to contaminated air on commercial aircraft: A case series of 27 pilots seen for clinical purposes -- S Mackenzie Ross -- Journal of Nutritional &Environmental Medicine -- June 2008; 17(2): 111–126 ***PDF File***

2006 -- Hazardous Chemicals on Jet Aircraft: Case Study-Jet Engine Oils and Aerotoxic Syndrome, -- C.Winder -- Current Topics in Toxicology. Vol 3 2006

The neuro-toxicity of products used in lubricants and other substances in the aircraft engines seem to provoke Long-term health problems including :

- Neurological effects: CNS,PNS: Jamal 1997, Jamal, Julu… 2002, 2005
- Autonomic nervous system effects: Jamal, Julu… 2002, 2005
- Working memory / cognitive problems. (neuropsychological), Coxon 2002 / Mackenzie Ross 2006
- Chronic neurotoxicity (OPICN): Abou-Donia 2004, 2005
- Neuronal brain cell death: Abou-Donia
- Respiratory disorders: Burdon, Glanville 2005
- Immune system effects, fatigue, chemical sensitivity etc..
- Blood pathology disorders
- Strong occupational link: Cone 1983,1999 / Harper 2005
- Individual susceptibility: Furlong
  - TCP Blood test: 6 of 10 TCP isomers are converted into the highly toxic metabolite – psp: that inhibits the activity of a number of important enzymes.
  - Gene expression: Gene expression effected by TCP at levels found in UK pilots' blood.

The US Federal Aviation Administration (FAA) has acknowledged that "no present airplane design fulfils the intent of [federal aviation regulation] 25.831 because no airplane design incorporates an air contaminant monitoring system to ensure that the air provided to the occupants is free of hazardous contaminants" (FAA, 2002),

ETF points out that there is a sizable (and growing) body of literature on the association between exposure to oil fumes and acute and chronic symptoms reported globally by crews and passengers alike (ACARM, 2007). The ETF CCC feels there is ample justification for regulations that dictate bleed air cleaning and monitoring with flight

deck indication to: (1) prevent exposure to oil fumes; (2) alert crewmembers if they are exposed inflight; and (3) enable maintenance workers to more effectively identify and remedy the contamination upon landing.

response

Noted.

1) Contaminants: Partially accepted.
Aviation oils toxicity knowledge can be improved and we have recommended studies to be conducted in this domain. The special cabin environment should be taken into account in those studies.

Analysis of all engine oils base stock content: The Agency could not do that because the Agency does not regulate aviation fluids, and therefore we do not inspect oil manufacturers' productions. Nevertheless, the specified toxic compounds and their concentrations are provided to the engine manufacturers which then conduct a safety analysis to verify that no hazardous quantities are released in the bleed air for identified failure scenarios. The Agency then reviews this analysis.

2) Effect on flight safety: Noted.

3) Effect on health: Not accepted.
Studies performed until today failed to demonstrate that cabin air can be contaminated in such a way that it could induce a safety or health issue. Cabin measurements found non-detectable or barely detectable levels of toxic contaminants. Concerning the symptoms reported by some crews or passengers: they are too generic to be directly linked to a toxic substance, although this is not rejected. Further investigation into this issue is recommended.

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What contaminants are released to the cabin and in which quantity?

What is the effect on flight safety?

Can it induce a health concern?

What is the frequency of this kind of event?
ETF Comment : There has been and is still great difficulty in collecting and interpreting the mounting data and identifying toxic/irritant products in oil substances used in the airline industry. The physiological effects of gases and vapours in cabin air is now becoming clear and the defining of maximum acceptable quantities or concentrations must become a subject for legislation and standards.

ETF comment : "What contaminants are released to the cabin and in which quantity"?
The ETF Cabin crew committee refer to statements published by Dr. Mackerer in 1999 and to the Henschler report in 1958 "Engine oils contain a mixture of tricresylphosphates, of which
TOCP in not the most toxic".
TOCP is NOT the only ortho isomer in TCP - the more toxic MOCP& DOCP are in the oil in far higher quantities.

Mobil advised the Australian Senate Inquiry that the ortho isomers were in the TCP in it's oil at >0.3%. The more toxic MOCP & DOCP were not mentioned.
ORTHO isomers divide into: **TOCP**, **DOCP** and **MOCP**.
Focus has been on TOCP with UK House of Lords and CAA reports of 2000 and 2004. These reports fail to ever mention DOCP or MOCP.

TOCP 0.006 ppm Toxicity factor x 1
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MOCP 3070 ppm Toxicity factor x 10

In ignoring DOCP and MOCP the total ORTHO toxicity is underestimated by a factor of **6.14 million** which has been known since 1958 (Henschler).

It has been known for years that when aviation engine oils are heated, a potent neurotoxic chemical called TMPP (trimethylolpropane phosphate) can be formed. TMPP is even worse than TCPs and exposure is associated with epileptic type seizures, convulsion, tremors, and changes to social/emotional behaviors. To the knowledge of ETF , it has never been found on aircraft. But to ETF's knowledge, nobody has ever looked for into this..
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Oils and lubricants used on the aircraft and in the engines contain not only the neurotoxins (TCPs and triphenylphosphates) but **sensitizers (N-phenyl-L-naphthylamine, PAN),** and **asphyxiants (carbon monoxide**).. Pyrolysis studies have confirmed the presence of these toxins when commercial oils are heated (van Netten, 2000; Marshman, 2001; Fox, 2001). A Material SafetyData Sheet for engine oils acknowledge only the TCP content and the fact that "toxicfumes may be evolved on burning or exposure to heat" (BP, 2001).

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ETF Comment : "What is the effect on flight safety"?
The ETF Cabin crew committee refers to the following statements and documents:

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(CAA AD 002-03-2001)

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decomposition products in confined spaces may include headache, nausea, eye, nose, and throat irritation."
(Mobil MJO2 MSDS EU 2009)
2009: Plus Minus: "Is inhaling of tricresyl phosphate (TCP) safe or dangerous?"
Professor D henschler (1958 TCP researcher): "I believe it to be dangerous."
(German TV: Plus Minus, March 2009)
2009: "Does the German Government believe that inhaling of heated engine oil fumes is harmless for the health of crew and passengers?". Answer "No"
German Ministry of Transport, Secretary of State Ulrich Kasparick.
(Question to MP Winfried Hermann of Bundnis90/Greenparty in regards to contaminated cabin air on board of civil airliners, printed matter 16/12023, 3 March 2009)
2009 "Smoke from pyrolysed oil can be hazardous to the eyes, mucous membranes and lungs"
(Turner V Eastwest Airlines [2009] NSWDDT 5 May 2009 , Australian Court)

2009: "Smoke or fumes in the flight deck or passenger cabin present the crew with a potentially hazardous situation"
AAIB Bulletin 6/2009 G-BYAO B757, EW/C2006/10/08

Bobb, A.J. and Still, K.R. (2003) "Known Harmful Effects of Constituents of Jet Oil Smoke," TOXDET-03-04, Naval Health Research Center Detachment (Toxicology), Wright-Patterson AFB, OH

Winder, C; Fonteyn, P; Balouet, JC. (2002) "Aerotoxic syndrome: a descriptive epidemiological survey of aircrew exposed to in-cabin airborne contaminants" J Occup Health Safety – Austr New Zealand, 18(4): 321-328

Winder, C. (2006) Hazardous chemicals on jet aircraft: Case study – Jet engine oils and aerotoxic syndrome. Current Topics in Toxicology. Vol 3, 2006

2008 -- Cognitive function following exposure to contaminated air on commercial aircraft: A case series of 27 pilots seen for clinical purposes -- S Mackenzie Ross -- Journal of Nutritional &Environmental Medicine -- June 2008; 17(2): 111–126 ***PDF File***

2006 -- Hazardous Chemicals on Jet Aircraft: Case Study-Jet Engine Oils and Aerotoxic Syndrome, -- C.Winder -- Current Topics in Toxicology. Vol 3 2006

The neuro-toxicity of products used in lubricants and other substances in the aircraft engines seem to provoke Long-term health problems including :

- Neurological effects: CNS,PNS: Jamal 1997, Jamal, Julu… 2002, 2005
- Autonomic nervous system effects: Jamal, Julu… 2002, 2005
- Working memory / cognitive problems. (neuropsychological), Coxon 2002 / Mackenzie Ross 2006
- Chronic neurotoxicity (OPICN): Abou-Donia 2004, 2005
- Neuronal brain cell death: Abou-Donia
- Respiratory disorders: Burdon, Glanville 2005
- Immune system effects, fatigue, chemical sensitivity etc..
- Blood pathology disorders
- Strong occupational link: Cone 1983,1999 / Harper 2005
- Individual susceptibility: Furlong
    - TCP Blood test: 6 of 10 TCP isomers are converted into

the highly toxic metabolite – psp: that inhibits the activity of a number of important enzymes.
- Gene expression: Gene expression effected by TCP at levels found in UK pilots' blood.

The US Federal Aviation Administration (FAA) has acknowledged that "no present airplane design fulfils the intent of [federal aviation regulation] 25.831 because no airplane design incorporates an air contaminant monitoring system to ensure that the air provided to the occupants is free of hazardous contaminants" (FAA, 2002),

ETF points out that there is a sizable (and growing) body of literature on the association between exposure to oil fumes and acute and chronic symptoms reported globally by crews and passengers alike (ACARM, 2007). The ETF CCC feels there is ample justification for regulations that dictate bleed air cleaning and monitoring with flight deck indication to: (1) prevent exposure to oil fumes; (2) alert crewmembers if they are exposed inflight; and (3) enable maintenance workers to more effectively identify and remedy the contamination upon landing.

response

Noted.

1) Contaminants: Partially accepted.
Aviation oils toxicity knowledge can be improved and we have recommended studies to be conducted in this domain. The special cabin environment should be taken into account in those studies.

Analysis of all engine oils base stock content: The Agency could not do that because the Agency does not regulate aviation fluids, and therefore we do not inspect oil manufacturers' productions. Nevertheless, the specified toxic compounds and their concentrations are provided to the engine manufacturers which then conduct a safety analysis to verify that no hazardous quantities are released in the bleed air for identified failure scenarios. The Agency then reviews this analysis.

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2009: Plus Minus: "Is inhaling of tricresyl phosphate (TCP) safe or dangerous?"
Professor D henschler (1958 TCP researcher): "I believe it to be dangerous."
(German TV: Plus Minus, March 2009)
2009: "Does the German Government believe that inhaling of heated engine oil fumes is harmless for the health of crew and passengers?". Answer "No"
German Ministry of Transport, Secretary of State Ulrich Kasparick.
(Question to MP Winfried Hermann of Bundnis90/Greenparty in regards to contaminated cabin air on board of civil airliners, printed matter 16/12023, 3 March 2009)
2009 "Smoke from pyrolysed oil can be hazardous to the eyes, mucous membranes and lungs"
(Turner V Eastwest Airlines [2009] NSWDDT 5 May 2009 , Australian Court)

2009: "Smoke or fumes in the flight deck or passenger cabin present the crew with a potentially hazardous situation"
AAIB Bulletin 6/2009 G-BYAO B757, EW/C2006/10/08

Bobb, A.J. and Still, K.R. (2003) "Known Harmful Effects of Constituents of Jet Oil Smoke," TOXDET-03-04, Naval Health Research Center Detachment (Toxicology), Wright-Patterson AFB, OH

Winder, C; Fonteyn, P; Balouet, JC. (2002) "Aerotoxic syndrome: a descriptive epidemiological survey of aircrew exposed to in-cabin airborne contaminants" J Occup Health Safety – Austr New Zealand, 18(4): 321-328

Winder, C. (2006) Hazardous chemicals on jet aircraft: Case study – Jet engine oils and aerotoxic syndrome. Current Topics in Toxicology. Vol 3, 2006

2008 -- Cognitive function following exposure to contaminated air on commercial aircraft: A case series of 27 pilots seen for clinical purposes -- S Mackenzie Ross -- Journal of Nutritional &Environmental Medicine -- June 2008; 17(2): 111–126 ***PDF File***

2006 -- Hazardous Chemicals on Jet Aircraft: Case Study-Jet Engine Oils and Aerotoxic Syndrome, -- C.Winder -- Current Topics in Toxicology. Vol 3 2006

The neuro-toxicity of products used in lubricants and other substances in the aircraft engines seem to provoke Long-term health problems including :

- Neurological effects: CNS,PNS: Jamal 1997, Jamal, Julu… 2002, 2005
- Autonomic nervous system effects: Jamal, Julu… 2002, 2005
- Working memory / cognitive problems. (neuropsychological), Coxon 2002 / Mackenzie Ross 2006
- Chronic neurotoxicity (OPICN): Abou-Donia 2004, 2005
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- Respiratory disorders: Burdon, Glanville 2005
- Immune system effects, fatigue, chemical sensitivity etc..
- Blood pathology disorders
- Strong occupational link: Cone 1983,1999 / Harper 2005
- Individual susceptibility: Furlong
  - TCP Blood test: 6 of 10 TCP isomers are converted into the highly toxic metabolite – psp: that inhibits the activity of a number of important enzymes.
  - Gene expression: Gene expression effected by TCP at levels found in UK pilots' blood.

The US Federal Aviation Administration (FAA) has acknowledged that "no present airplane design fulfils the intent of [federal aviation regulation] 25.831 because no airplane design incorporates an air contaminant monitoring system to ensure that the air provided to the occupants is free of hazardous contaminants" (FAA, 2002),

ETF points out that there is a sizable (and growing) body of literature on the association between exposure to oil fumes and acute and chronic symptoms reported globally by crews and passengers alike (ACARM, 2007). The ETF CCC feels there is ample justification for regulations that dictate bleed air cleaning and monitoring with flight deck indication to: (1) prevent exposure to oil fumes; (2) alert crewmembers if they are exposed inflight; and (3) enable maintenance workers to more effectively identify and remedy the contamination upon landing.

response

Noted.

1) Contaminants: Partially accepted.
Aviation oils toxicity knowledge can be improved and we have recommended studies to be conducted in this domain. The special cabin environment should be taken into account in those studies.

Analysis of all engine oils base stock content: The Agency could not do that because the Agency does not regulate aviation fluids, and therefore we do not inspect oil manufacturers' productions. Nevertheless, the specified toxic compounds and their concentrations are provided to the engine manufacturers which then conduct a safety analysis to verify that no hazardous quantities are released in the bleed air for identified failure scenarios. The Agency then reviews this analysis.

2) Effect on flight safety: Noted.

3) Effect on health: Not accepted.
Studies performed until today failed to demonstrate that cabin air can be contaminated in such a way that it could induce a safety or health issue. Cabin measurements found non-detectable or barely detectable levels of toxic contaminants. Concerning the symptoms reported by some crews or

passengers: they are too generic to be directly linked to a toxic substance, although this is not rejected. Further investigation into this issue is recommended.

comment

99 comment by: *cfdt france*

What contaminants are released to the cabin and in which quantity?

What is the effect on flight safety?

Can it induce a health concern?

What is the frequency of this kind of event?
ETF Comment : There has been and is still great difficulty in collecting and interpreting the mounting data and identifying toxic/irritant products in oil substances used in the airline industry. The physiological effects of gases and vapours in cabin air is now becoming clear and the defining of maximum acceptable quantities or concentrations must become a subject for legislation and standards.

ETF comment : "What contaminants are released to the cabin and in which quantity"?
The ETF Cabin crew committee refer to statements published by Dr. Mackerer in 1999 and to the Henschler report in 1958 "Engine oils contain a mixture of tricresylphosphates, of which
TOCP in not the most toxic".
TOCP is NOT the only ortho isomer in TCP - the more toxic MOCP& DOCP are in the oil in far higher quantities.
Mobil advised the Australian Senate Inquiry that the ortho isomers were in the TCP in it's oil at >0.3%. The more toxic MOCP & DOCP were not mentioned.
ORTHO isomers divide into: **TOCP**, **DOCP** and **MOCP**.
Focus has been on TOCP with UK House of Lords and CAA reports of 2000 and 2004. These reports fail to ever mention DOCP or MOCP.

TOCP	**0.006 ppm**	**Toxicity factor x 1**
DOCP	**6 ppm**	**Toxicity factor x 5**
MOCP	**3070 ppm**	**Toxicity factor x 10**

In ignoring DOCP and MOCP the total ORTHO toxicity is underestimated by a factor of **6.14 million** which has been known since 1958 (Henschler).

It has been known for years that when aviation engine oils are heated, a potent neurotoxic chemical called TMPP (trimethylolpropane phosphate) can be formed. TMPP is even worse than TCPs and exposure is associated with epileptic type seizures, convulsion, tremors, and changes to social/emotional behaviors. To the knowledge of ETF , it has never been found on aircraft. But to ETF's knowledge, nobody has ever looked for into this..
A 1989 US Navy report stating that Exxon 2380 (now BP2380) generated high levels of TMPP when it was heated to temperatures at or above 350C. The TCPs in the oil react with TMP chemicals in the "base stock" of the oil. **The levels of TMPP were so significant that the authors recommended that Exxon 2380 not be used on US naval vessels. But BP2380 is still widely used in commercial aviation**

A 1996 US Air Force paper raised concerns about the potential for being exposed to highly toxic TMPP, and stated that TMPP could be formed when oils that contain TCPs and TMP are heated to temperatures as low as 250C. This is important because these temperatures are more likely to be reached in the

engine/bleed air system. Wright also stated that TMPP can NOT be formed if the engine oil base stock contains PE chemicals instead of TMP. *WRIGHT R. L. Formation of the neurotoxin TMPP from TMPE-phosphate formulations - Tribiology transactions 1996, vol. 39, no4, pp. 827-834*

Another US navy report in 1992 also expressed concern about the hazards
1) What engine oil(s) are used (e.g., Mobil Jet Oil II, BP2380, etc).
2) What APU and engine types are installed on what aircraft types (e.g. Pratt Whitney 4000, Honeywell Series 85, etc).

Oils and lubricants used on the aircraft and in the engines contain not only the neurotoxins (TCPs and triphenylphosphates) but **sensitizers (N-phenyl-L-naphthylamine, PAN),** and **asphyxiants (carbon monoxide**).. Pyrolysis studies have confirmed the presence of these toxins when commercial oils are heated (van Netten, 2000; Marshman, 2001; Fox, 2001). A Material SafetyData Sheet for engine oils acknowledge only the TCP content and the fact that "toxicfumes may be evolved on burning or exposure to heat" (BP, 2001).

ETF cabin crew committee ask that Studies include the potential impact of exposure to the mixture of these and other chemicals in a reduced pressure environment.
ETF Suggests that the EASA review all data and see if a less toxic alternative oil can be recommended that would be compatible with given aircraft engines/APUs.
Ultimately, all of the engine oils should be analyzed for their base stock content (rather than relying on the analysis of the oil companies), as well as for the potential to form TMPP, and temperature range of TMPP formation.

ETF Comment : "What is the effect on flight safety"?
The ETF Cabin crew committee refers to the following statements and documents:

2001: "Incidents have been reported of impaired performance of flight crew…events could have been caused by inhalation of agents… leaking from oil or APU and contaminating the Environmental control system."
(CAA AD 002-03-2001)

2002: "oil leaks and cabin / flight deck odours must be regarded as a potential threat to flight safety, theyshould not be dismissed as a mere nuisance and should be addressed as soon as possible."
(BAe ISB 21-150 2001 / ISB 21-156, 2002)

2003: "Any oil leaking from an engine, entering the aircraft customer bleed offtake, is classified as HAZARDOUS"
(Rolls Royce, Germany 2003, BRE air quality Conference, London)

2004: "This amendment adopts a new airworthiness directive (AD), applicable to all BAE Systems (Operations) Limited Model BAe 146 series airplanes, that requires repetitive detailed inspections of the inside of each air conditioning sound-attenuating duct, and corrective actions as necessary. This action is necessary to prevent impairment of the operational skills and abilities of the flightcrew caused by the inhalation of agents released from oil or oil breakdown products, which could result in reduced controllability of the airplane. This action is intended to address the identified unsafe condition."
(FAA AD 2004-12-05)

2006: "The serious incident is attributable to the fact that on approach to Zurich Airport the cockpit filled with fumes which caused a toxic effect, leading to a limited capability of acting of the copilot. These fumes were caused by an oil leak as a result of a bearing damage in engine No. 1" "The medical examination of the copilot after the flight showed that during the flight toxic exposure took place."
(Swiss Federal Department of Environment, Transport Energy and Communications Investigation Report No u1884 by the Aircraft Accident Investigation Bureau, 2 March 2006)

TheETF Cabin crew committee also refers the EASA to the manual written by Prof. S. Michaelis, (renowned expert on Cabin air contamination): "*Aviation Contaminated Air Reference Manual,*" Michaelis, S., ed. ISBN 9780955567209, London,

ETF comment : "Can it induce a health concern?"
The ETF Cabin committee feel that there is now sufficient available material and literature on cabin air being contaminated by toxic substances used on the aircraft. Studies are now available giving indications that the health of aircraft occupants may be severely affected by the inhalation & contact with gases and vapours of lubricants, anti-freeze agents and others.

ETF refers the EASA to the following statements and studies :

"individuals exposed to a single large toxic dose, or to small subclinical doses, of ***organophosphorus compounds***have developed a chronic neurotoxicity that persists for years after exposure and is distinct from both cholinergic and OPIDN"(AbouDonia, 2003; *Arch. Environ. Health***58**:484-97).

- Abou-Donia MB (2004) Organophosphorus ester-induced chronic neurotoxicity. Archives of Environmental Health 58:484–497
- Organophosphate Ester Induced Chronic Neurotoxicity (OPICN)- Mohamed B Abou-Donia : Proceedings of the BALPA 'Contaminated Air Protection Air Safety and Cabin Air Quality International Aero Industry Conference'. Held at Imperial College, London, 20-21 April 2005: ISBN 0-7334-2282-9
- Journal of Occupational Health & Safety, Australia & New Zealand, Vol 21, Number 5 ,August 2005 - Special edition: New findings in aircrew exposed to airborne contaminants: Long-term health effects confirmed. - Organophosphate Ester Induced Chronic Neurotoxicity (OPICN)- Mohamed B Abou-Donia

1981: Engine Lube Oil: "At temperatures above 320C this oil breaks down into irritating and toxic compounds."
(SAE Aviation Information Report: 1539, issued 1-30-81)
1983: "All of these toxic substances (includes engine oil) have acute and long-term effects"
(Rayman R.B., McNaughton G.B. Smoke/fumes in the cockpit. Aviation, Space and Environmental Medicine, August 1983, pp 738-740. Current Director of the Aerospace Medical Association)
1998: "Repeated low level exposure leads to cumulative toxicity." (1981 ed)
"Acute and repeated exposure can produce harmful effects in man, and it has been suggested that chronic exposure at lower doses may cause long-term ill health." (1998 ed)
(UK HSE: Organophosphates: HSE: MS17: Medical aspects of occupational exposures to organophosphates. Draft revision 23, November, 1998.)

1999: "Neuropsychological outcomes - Neuropsychological abnormalities can occur as a long-term complication of acute OP poisoning"
(UK COT report. Long term sequelae of acute poisoning: 1999. Committee on Toxicity of Chemicals in Food, Consumer Products and the Environment: Organophosphates: Executive Summary. Published by the Department of Health, 1999, London)
1999: "The inhalation of mist (containing tricresylphosphate) which can be produced by high pressure systems, or direct contact with the skin, would be hazardous."
(UK Government Hansard 66599, 4 February 1999, column 737)
1999: "TCP is toxic"
(UK Government: Hansard 82322 6 May 1999 : Column: 428)
2000: "With the weight of human evidence and suffering, which is quite clear, there must be something there" "There is absolutely no doubt in our mind that there is a general health issue here"
(BAe Systems verbal evidence to Australian senate Inquiry 2000)
2001: "Incidents have been reported of impaired performance of flight crew…events could have been caused by inhalation of agents… leaking from oil or APU and contaminating the Environmental control system."
(CAA AD 002-03-2001)
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(BAe ISB 21-150 2001 / ISB 21-156, 2002)

2002: "FAA rulemaking has not kept pace with public expectation and concern about air quality and doesnot afford explicit protection from particulate matter and other chemical and biological hazards." "No present airplane design fulfills the intent of 25.831 because no airplane design incorporates an air
Contaminant monitoring system to ensure that the air provided to the occupants is free of hazardous contaminants"
2003: "Any oil leaking from an engine, entering the aircraft customer bleed offtake, is classified as HAZARDOUS"
(Rolls Royce, Germany 2003, BRE air quality Conference, London)
2003: "It is found that the sound attenuating material used in the air-conditioning ducts can absorb oil and can become a source of persistent air contamination."
(CASA AD /BAe 146/102, 23 January 2003)
2004: "In the event of oil leakage there is the opportunity, therefore, for the pyrolysis products of engine lubricant/fuel to enter the cabin air supply and exert toxic effects on both passengers and crew."
(CAA Air Quality report 2004)
2004: "This amendment adopts a new airworthiness directive (AD), applicable to all BAE Systems (Operations) Limited Model BAe 146 series airplanes, that requires repetitive detailed inspections of the inside of each air conditioning sound-attenuating duct, and corrective actions as necessary. This action is necessary to prevent impairment of the operational skills and abilities of the flightcrew caused by the inhalation of agents released from oil or oil breakdown products, which could result in reduced controllability of the airplane. This action is intended to address the identified unsafe condition."
(FAA AD 2004-12-05)
2005: "Both Flight Crew Affected By Sore Throats And Other Symptoms After Flight." "Smells and irritants from burning organic compounds from within the engines are known to produce harmful volatile organic contaminants."
(UK Airline Air Safety Report, ASR G-CFAH, 4 July 2005)
2007: "Mobil Jet Oil II- Known to be harmful"

(CASA: AIR SAFETY & CABIN AIR QUALITY - Jim Coyne – A/g General Manager Manufacturing, Certification & New Technologies Office: 2007 presentation)
2007: "A35-12: Protection of the health of passengers and crews and prevention of the spread of communicable disease through international travel
-*Declares* that the protection of the health of passengers and crews on international flights is an integral element of safe air travel and that conditions should be in place to ensure its preservation in a timely and cost-effective manner;
-*Requests* the Council to support further research on the consequences of air transport on the health of passengers and crews"
(ICAO- Aviation Medicine (Med) Section Related ICAO Resolutions, 5 July 2007) http://www.icao.int/icao/en/assembl/a36/wp/wp022_en.pdf
2007: "I call on the government to reveal whether information about defects has been withheld from the regulator, the courts or the parliament"
"I am gravely concerned that crew and passengers of BAe146 aircraft have been exposed to dangerous fumes produced by engine defects"
(Senate Hansard: Monday, 13 August 2007, Senator O'Brien
2009: "Product may decompose at elevated temperatures or under fire conditions and produce harmful gases or vapours. Vapours or mist of heated product may be harmful by inhalation."
R 63.G3 Possible risk of harm to the unborn child.
R 62.F3 Possible risk of impaired fertility.
(NYCO MSDS 2009 , TURBONYCOIL 600)
2009: "Product may decompose at elevated temperatures or under fire conditions and give off irritating and/or harmful (carbon monoxide) gases/vapours/fumes. Symptoms from acute exposure to these decomposition products in confined spaces may include headache, nausea, eye, nose, and throat irritation."
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response

Noted.

1) Contaminants: Partially accepted.
Aviation oils toxicity knowledge can be improved and we have recommended studies to be conducted in this domain. The special cabin environment should be taken into account in those studies.

Analysis of all engine oils base stock content: The Agency could not do that because the Agency does not regulate aviation fluids, and therefore we do not

inspect oil manufacturers' productions. Nevertheless, the specified toxic compounds and their concentrations are provided to the engine manufacturers which then conduct a safety analysis to verify that no hazardous quantities are released in the bleed air for identified failure scenarios. The Agency then reviews this analysis.

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Studies performed until today failed to demonstrate that cabin air can be contaminated in such a way that it could induce a safety or health issue. Cabin measurements found non-detectable or barely detectable levels of toxic contaminants. Concerning the symptoms reported by some crews or passengers: they are too generic to be directly linked to a toxic substance, although this is not rejected. Further investigation into this issue is recommended.

comment

105 comment by: *cfdt france*

ETF Comment : The ETF cabin crew committee believe that there are more than 2 reports of single incapacitation in the UK – this can be checked by contacting the UK CAA.

response

Noted.
UK CAA provided to EASA data including the level of severity of events between 1999 and 2006, showing 2 cases of incapacitation. As a comment to this A-NPA, UK CAA provided data in terms of number of MORS for 2007, 2008 and 2009 (Jan-Jun). But there is no classification in terms of severity for those last events.

comment

116 comment by: *CUD*

"In the European Community, the majority of the reports are originated from the United Kingdom (UK), the other Member States reporting far less on this issue (refer to UK AAIB report 1/2004 published in February 2004). According to a presentation from the UK Civil Aviation Authority (CAA UK) to the Agency in March 2007, there were 104 flight deck occurrences on Large Aeroplanes between 1999 and 2006; a peak of events (26) appears in 2001, then followed by a significant decrease in 2002 and 2003. This decrease in the number of events can be explained by the measures taken in 2001-2002 towards the two aeroplane types generating the majority of the events (BAE146 and B757); these measures consisted in inspections and corrective actions to limit the risk of oil leakage from APU and engines. Then, after a very calm period, another peak of events appeared in 2006 (26 events). No official CAA UK events figures are available to EASA for 2007 and 2008, but according to them the tendency is a decrease in the number of reports."

Comment:
Despite claims that there is insufficient reporting **(please refer to ACARM (2007b) "Chapter 12: Frequency of Events and Underreporting" "*Aviation Contaminated Air Reference Manual,*" Michaelis, S., ed. ISBN 9780955567209, London, England, pp. 211-248)** and evidence to support casual relationship between exposure to oil contaminated air and pilot ill health the **UK COT report** concluded that it would be PRUDENT to PREVENT exposure to oil contaminated air. We fully support any study that the EASA undertakes to collect data regarding the number of events/incidents linked to oil

contaminated air and request that preventative measures be taken and included in new standards.
The FAA says it has recorded 900 fume events in 10 years. But in 2006 they said this:

'There have been concerns raised about numerous reports of "smoke/fumes in the cockpit/cabin" events on commercial air carrier/operator aircraft. During the FAA's analysis of this data, it appears as though there are numerous air carriers/operators who may not have reported these events as required by regulation. **Flight Standards Information Bulletin for Airworthiness (FSAW)06-05A, Guidance for Smoke/Fumes in the Cockpit/Cabin_29 March 2006.29 March 2006 (see attachment: Smoke-Cockpit-Ballough.ppt)**

Concerning the detection & reporting of oil leakage and vapours inside the aircraft cabin Professor Windsor states that "***The only technically functional way to identify the presence of poorly volatile contaminants present in aircraft environments is to place a direct reading machine on the aircraft during flight."***
The US FAA has acknowledged that "no present airplane design fulfils the intent of [federal aviation regulation] 25.831 because no airplane design incorporates an air contaminant monitoring system to ensure that the air provided to the occupants is free of hazardous contaminants"

response

Not accepted.

Health effect: Studies performed until today failed to demonstrate that cabin air can be contaminated in such a way that it could induce a safety or health issue. Cabin measurements found non-detectable or barely detectable levels of toxic contaminants. Concerning the symptoms reported by some crews or passengers: they are too generic to be directly linked to a toxic substance, although this is not rejected. Further investigation into this issue is recommended.

Reporting: The Agency accepts the possibility that the minor events may be underreported by some organisations, probably because these events are considered as nuisance (e.g. temporary bad odours or smells), and therefore they are not considered as safety related occurrences which must be reported.
Concerning the serious events involving a degree of crew or passengers' impairment or incapacitation, we believe they are reported and their number remains very limited. A regulation is already in place for this category of events through Directive 2003/42/EC of 13 June 2003 on occurrence reporting in civil aviation: it clearly identifies failures of engines or APU resulting in "Dense visible fumes or concentrations of toxic products sufficient to incapacitate crew or passengers". It is the responsibility of each Member State to ensure that stakeholders comply with this Directive. The Agency does not intend to create another mandatory reporting system.

comment

117 comment by: *CUD*

"The measures taken towards BAE146 and B757 types are summarised hereafter:
In the case of the European type BAE 146, two Inspection Service Bulletins (ISB) have been mandated through Airworthiness Directives (ADs) by the UK CAA in March 2001 and November 2002. The first ISB requires the inspection for contaminants in the Environmental Control Systems (ECS), and should any

be found, requires inspection of the engines and APU for any signs of oil leakage; inspection accomplishment is required every A-check or when a cabin air quality problem is reported. The second ISB, supplementing the first one, requires inspection of sound attenuating ducts within the ECS for signs of oil contamination; it also provides appropriate trouble shooting and rectification procedures, including replacement of contaminated ducts. In addition, in December 2002, CAA UK mandated the replacement of the inlet air connection to the APU by an improved design to prevent the induction of potentially contaminated air.

Concerning the B757, the engine manufacturer Rolls Royce identified overhaul improvements for the engine and Boeing updated the engine oil servicing procedure in the B757 Aircraft Maintenance Manual to avoid oil tank over-servicing."

Comment:
It seems that there is still a UK preoccupation with continued "leaking" of oil into the cabin as there is a new device that sterilizes aircraft cabin air to eradicate contaminants and pathogens such as swine flu which has been developed by BAE Systems and UK firm Quest International. BAE Systems plans to fit 2,600 aircraft with the devices – that is about 10% of the global total of commercial aircraft. Larger commercial jets require more than one. Five airlines are trialing the device, and one has recently placed an order for it's BAE Avro RJ fleet of regional jets.
The device is also installed on BAE System's own corporate jets. It has been certified for use on the BAE 146 and Avro RJ aircraft and has a supplemental certificate for Boeing 757s. **There still seems to be some concern over the effectiveness of this device to eliminate all toxic substances from heated oils and contaminants**.

response

Noted.

comment

118 comment by: *CUD*

"According to available reports, there is a variety of symptoms, and there is not a single symptom or type of symptoms which can be characteristic of cabin air quality event. This ranges from benign symptoms like unpleasant odour, light eye or nose irritation, light headache up to more serious symptoms like severe headache, difficulty to concentrate, nausea or muscle cramp. The most serious symptoms can substantially degrade flight crew awareness and performance of their duties. Then, the main associated safety threat would be a dual and simultaneous pilot incapacitation occurring during a critical phase of flight such as take-off or landing, which would be potentially catastrophic.
However, a majority of events involves low severity symptoms (irritation, feeling unwell), and the cases where incapacitation was reached are very rare (e.g. 2 reports of single incapacitation in UK as of 2006)."

Comment:
We believe that there are more than 2 reports of single incapacitation in the UK – this can be checked by contacting the UK CAA.

response

Noted.
UK CAA provided to the Agency data including the level of severity of events between 1999 and 2006, showing 2 cases of incapacitation. As a comment to this A-NPA, UK CAA provided data in terms of number of MORS for 2007, 2008 and 2009 (Jan-Jun). But there is no classification in terms of severity for those

last events.

comment

133 comment by: *Susan Michaelis*

Attachment #8

Comment 2:
The Agency also interrogated the ICAO database for events on Large Aeroplanes, between 1970 and April 2009. It shows that there was no reported events until the early 90's, then the number of yearly reports increased with a peak in 2001-2002 (respectively 27 and 29 events), before decreasing quickly (3 events in 2007, 0 in 2008 and 2009). The ICAO database shows the same evidence that the majority of events were generated by the two previously mentioned aeroplane types (BAE146 and B757). Similarly as from UK CAA statistics, a decrease of events can be seen after the introduction of corrective measures in 2001-2002.

Proposed text: The ICAO database cannot be seen as an accurate source of information on the number of contaminated air events:

Justification: ICAO is NOT being used as a reporting format for contaminated air events: Michaelis S. (2007) Aviation Contaminated Air Reference Manual. ISBN 9780955567209, and attached submission

Comment 3

Similarly as from UK CAA statistics, a decrease of events can be seen after the introduction of corrective measures in 2001-2002.

Proposed text
:The CAA and ICAO databases cannot be used as a source to suggest the problem of contaminated air has decreased.

Justification: Michaelis S. (2007) Aviation Contaminated Air Reference Manual. ISBN 9780955567209, chapters 12,17, appx 2 and 5 and attached submission.
The problem of contaminated bleed air occurs on all aircraft using bleed air dating back many years and can be seen as not isolated to just one cause. There are many modifications for example being undertaken on the BAe 146 dating back to 1984 at least and the corrections referred to were restricted mainly to the 146 and excluded the 146/RJ. It is likewise incorrect to suggest that there was one solution for the B757, as the problem has remained ongoing along with the failure of the reporting system. All other aircraft types have inappropriately been ignored.

Comment 4.

It has to be noticed that these events did not cause any catastrophic accident or fatal injuries. Some persons have been injured during the aeroplane evacuation. But there is no report mentioning that aeroplane handling was compromised and created a hazard or injury to occupants.

Proposed Text: It has to be noticed that while these events are believed not to have cuased any catastrophic accident or fatal injuries, there has been a high degree of crew impairment/ adverse effects reported, some incapacitation and along with reports of significant ill health.

	Justification: see Michaelis S. (2007) Aviation Contaminated Air Reference Manual. ISBN 9780955567209 , chapters 2,6,7,8,9,12, appx 2,6,7…. It is totally unacceptable to place emphasis on death and accidents when the regulators responsibility covers impairment of any sort and incidents, defects related to suspected contaminated air. Comment5 Considering a given event, it appears that the effects reported by the aeroplanes occupants are often very different from one person to another. For example, one pilot notices nothing though the other one declares symptoms. Sometimes, one person in the cabin feels unwell though there is no concern in the flight deck, or vice versa. According to available reports, there is a variety of symptoms, and there is not a single symptom or type of symptoms which can be characteristic of cabin air quality event. This ranges from benign symptoms like unpleasant odour, light eye or nose irritation, light headache up to more serious symptoms like severe headache, difficulty to concentrate, nausea or muscle cramp. The most serious symptoms can substantially degrade flight crew awareness and performance of their duties. Then, the main associated safety threat would be a dual and simultaneous pilot incapacitation occurring during a critical phase of flight such as take-off or landing, which would be potentially catastrophic. However, a majority of events involves low severity symptoms (irritation, feeling unwell), and the cases where incapacitation was reached are very rare (e.g. 2 reports of single incapacitation in UK as of 2006). Proposed Text: there are a wide variety of symptoms reported by aircrew during and after suspected contaminated air events. These range from irritation, through to a range of neurological, respiratory, cardiac,, neuropsychological and general symptoms all, which are a hazard in aviation. The effects reported range from short-term to long-term effects and vary amongst individuals, however there is a clear pattern. Justification: Refer to: Michaelis S. (2007) Aviation Contaminated Air Reference Manual. ISBN 9780955567209, ch 3,4, 6,7,8,9,12,16, appx 2,3,6,7,10 and C.Winder, S. Michaelis.(2005).'Aircraft Air Quality Malfunction Incidents - Crew Effects from Toxic Exposures on Aircraft'. Air Quality in airplane cabins and similar enclosed spaces -The Handbook of Environmental Chemistry - Publisher: Springer-Verlag GmbH. August 2005 - Many other published papers at: http://www.aopis.org/ScientificReports.html and attached submission
response	Not accepted. The Agency consults available official and controlled aviation safety databases in addition to its own database and information in order to evaluate safety threats. The ADREP and NAAs databases are accepted. Concerning your following comment: "there has been a high degree of crew impairment/ adverse effects reported, some incapacitation and along with reports of significant ill health". The Agency believes that serious events involving crew incapacitation or impairment are reported; the number of such events remains very low.

Regarding illness/health effect, although the Agency is not a responsible body in this domain, the previous studies we are aware of failed to demonstrate a health case caused by engine oil contamination. The symptoms reported by some crews are generic and may be caused by many other factors than exposure to oil contaminants. In addition, the fact that in general the symptoms are reported by one crew and not the other one does not help to conclude that there is a link. Therefore, the Agency has not found enough elements to conclude on a health case.

comment

147 comment by: *kapers Cabin Crew Union*

"In the European Community, the majority of the reports are originated from the United Kingdom (UK), the other Member States reporting far less on this issue (refer to UK AAIB report 1/2004 published in February 2004). According to a presentation from the UK Civil Aviation Authority (CAA UK) to the Agency in March 2007, there were 104 flight deck occurrences on Large Aeroplanes between 1999 and 2006; a peak of events (26) appears in 2001, then followed by a significant decrease in 2002 and 2003. This decrease in the number of events can be explained by the measures taken in 2001-2002 towards the two aeroplane types generating the majority of the events (BAE146 and B757); these measures consisted in inspections and corrective actions to limit the risk of oil leakage from APU and engines. Then, after a very calm period, another peak of events appeared in 2006 (26 events). No official CAA UK events figures are available to EASA for 2007 and 2008, but according to them the tendency is a decrease in the number of reports."

Comment:
Despite claims that there is insufficient reporting **(please refer to ACARM (2007b) "Chapter 12: Frequency of Events and Underreporting" "*Aviation Contaminated Air Reference Manual,*" Michaelis, S., ed. ISBN 9780955567209, London, England, pp. 211-248)** and evidence to support casual relationship between exposure to oil contaminated air and pilot ill health the **UK COT report** concluded that it would be PRUDENT to PREVENT exposure to oil contaminated air. We fully support any study that the EASA undertakes to collect data regarding the number of events/incidents linked to oil contaminated air and request that preventative measures be taken and included in new standards.
The FAA says it has recorded 900 fume events in 10 years. But in 2006 they said this:
'There have been concerns raised about numerous reports of "smoke/fumes in the cockpit/cabin" events on commercial air carrier/operator aircraft. During the FAA's analysis of this data, it appears as though there are numerous air carriers/operators who may not have reported these events as required by regulation. **Flight Standards Information Bulletin for Airworthiness (FSAW)06-05A, Guidance for Smoke/Fumes in the Cockpit/Cabin_29 March 2006.29 March 2006 (see attachment: Smoke-Cockpit-Ballough.ppt)**

Concerning the detection & reporting of oil leakage and vapours inside the aircraft cabin Professor Windsor states that "***The only technically functional way to identify the presence of poorly volatile contaminants present in aircraft environments is to place a direct reading machine on the aircraft during flight."***
The US FAA has acknowledged that "no present airplane design fulfils the intent of [federal aviation regulation] 25.831 because no airplane design incorporates an air contaminant monitoring system to ensure that the air

provided to the occupants is free of hazardous contaminants"

response

Not accepted.

Health effect: Studies performed until today failed to demonstrate that cabin air can be contaminated in such a way that it could induce a safety or health issue. Cabin measurements found non-detectable or barely detectable levels of toxic contaminants. Concerning the symptoms reported by some crews or passengers: they are too generic to be directly linked to a toxic substance, although this is not rejected. Further investigation into this issue is recommended.

Reporting: The Agency accepts the possibility that the minor events may be underreported by some organisations, probably because these events are considered as nuisance (e.g. temporary bad odours or smells), and therefore they are not considered as safety related occurrences which must be reported. Concerning the serious events involving a degree of crew or passengers' impairment or incapacitation, we believe they are reported and their number remains very limited. A regulation is already in place for this category of events through Directive 2003/42/EC of 13 June 2003 on occurrence reporting in civil aviation: it clearly identifies failures of engines or APU resulting in "Dense visible fumes or concentrations of toxic products sufficient to incapacitate crew or passengers". It is the responsibility of each Member State to ensure that stakeholders comply with this Directive. The Agency does not intend to create another mandatory reporting system.

comment

148 comment by: *kapers Cabin Crew Union*

"The measures taken towards BAE146 and B757 types are summarised hereafter:
In the case of the European type BAE 146, two Inspection Service Bulletins (ISB) have been mandated through Airworthiness Directives (ADs) by the UK CAA in March 2001 and November 2002. The first ISB requires the inspection for contaminants in the Environmental Control Systems (ECS), and should any be found, requires inspection of the engines and APU for any signs of oil leakage; inspection accomplishment is required every A-check or when a cabin air quality problem is reported. The second ISB, supplementing the first one, requires inspection of sound attenuating ducts within the ECS for signs of oil contamination; it also provides appropriate trouble shooting and rectification procedures, including replacement of contaminated ducts. In addition, in December 2002, CAA UK mandated the replacement of the inlet air connection to the APU by an improved design to prevent the induction of potentially contaminated air.

Concerning the B757, the engine manufacturer Rolls Royce identified overhaul improvements for the engine and Boeing updated the engine oil servicing procedure in the B757 Aircraft Maintenance Manual to avoid oil tank over-servicing."

Comment:
It seems that there is still a UK preoccupation with continued "leaking" of oil into the cabin as there is a new device that sterilizes aircraft cabin air to eradicate contaminants and pathogens such as swine flu which has been developed by BAE Systems and UK firm Quest International. BAE Systems plans to fit 2,600 aircraft with the devices – that is about 10% of the global total of commercial aircraft. Larger commercial jets require more than one.

Five airlines are trialing the device, and one has recently placed an order for it's BAE Avro RJ fleet of regional jets.
The device is also installed on BAE System's own corporate jets. It has been certified for use on the BAE 146 and Avro RJ aircraft and has a supplemental certificate for Boeing 757s. **There still seems to be some concern over the effectiveness of this device to eliminate all toxic substances from heated oils and contaminants**.

response

Noted.

comment

149 comment by: *kapers Cabin Crew Union*

"According to available reports, there is a variety of symptoms, and there is not a single symptom or type of symptoms which can be characteristic of cabin air quality event. This ranges from benign symptoms like unpleasant odour, light eye or nose irritation, light headache up to more serious symptoms like severe headache, difficulty to concentrate, nausea or muscle cramp. The most serious symptoms can substantially degrade flight crew awareness and performance of their duties. Then, the main associated safety threat would be a dual and simultaneous pilot incapacitation occurring during a critical phase of flight such as take-off or landing, which would be potentially catastrophic.
However, a majority of events involves low severity symptoms (irritation, feeling unwell), and the cases where incapacitation was reached are very rare (e.g. 2 reports of single incapacitation in UK as of 2006)."

Comment:
We believe that there are more than 2 reports of single incapacitation in the UK – this can be checked by contacting the UK CAA.

response

Noted.
UK CAA provided to EASA data including the level of severity of events between 1999 and 2006, showing 2 cases of incapacitation. As a comment to this A-NPA, UK CAA provided data in terms of number of MORS for 2007, 2008 and 2009 (Jan-Jun). But there is no classification in terms of severity for those last events.

A. Explanatory Note - IV. Content of the A-NPA - 10. Research outcomes p. 6-7

comment

8 comment by: *British Airways*

Comment:
This section confirms that the research evidence to date does not support the need for additional regulation. It would be premature to consider additional regulation before the on-going research studies are concluded and published.

Justification:
This brief summary of the evidence notes the potentially toxic substances contained in engine oils and their pyrolysed products, the low levels of these toxic substances and evidence which suggests that potential exposures would be very low. Attention is also drawn to the report of the UK Government's Committee on Toxicity, a comprehensive review of the scientific and technical evidence, which concluded that the available evidence does not support claims of long term ill-health attributable to cabin air contamination. Research currently in progress is intended to answer some of the specific questions on the nature and concentration of any toxic substances and will inform the need

	for any additional research to establish whether this is associated with any long-term health effects. The need for additional regulation can only be determined once the outcome of such research is known.
response	Accepted.

comment	*11* comment by: *NYCO* Attachment #9 See in attached file research funded by NYCO in an attempt to evaluate the relative toxicity of organo-phosphates additives in jet engine oil and proposed improvements.
response	Noted. The Agency appreciates your sharing of information and we welcome your proactive action in trying to decrease the toxicity of aviation oils. We are also interested in your future developments in this domain. We also recommend that the toxicity of pyrolised engine oils is further studied. It is interesting to learn that some organo-phosphates (OPs) could potentially be substantially less toxic while satisfying oil specifications for certification. This would probably need a validation by competent health authorities; for instance, the Agency is not able to decide what is the representativity of the "in-vitro" test using human butyrylcholineesterase (BChE). Moreover, it would also be necessary to evaluate what happens to the proposed OP when it is pyrolised in an engine (e.g. can it create again the toxic isomers?). Finally, the Agency has also been advised that assessing the toxicity of individual compounds is not sufficient because it is important to consider the synergetic effect of the different oil compounds when they are heated together and released in a reduced pressure cabin environment.

comment	*32* comment by: *FSC - CCOO* Aviation lubricants main constituents and pyrolysis products are: • chemical esters (2 main families: trimethylolpropane (TMP) esters and pentaerythritol (PE) esters), • additives: organophosphates, N-phenyl-1-naphtylamine, • low molecular weight organic acids, esters and ketones Here are the possible toxicity effects, if the contaminant is present at sufficient concentration in the air: • Organic acids: known to be irritants (e.g. eyes, nose, throat) and also have characteristic odours (often described as "old socks" or "body odours"), • Organophosphates: tricresylphosphates (TCP) and in particular its ortho isomer can induce irritations (e.g. eyes, nose, throat) and in the long term "Organophosphate Induced Delayed Neuropathy" (OPIDN); the toxicity of meta and para isomers is not clearly established, • Gases: toxic gases can be produced from oil pyrolysis, such as carbon monoxide and oxides of nitrogen

Comment:
We refer to statements published by Dr. Mackerer in 1999 and to the Henschler report in 1958 "Engine oils contain a mixture of tricresylphosphates, of which TOCP in not the most toxic".

TOCP is NOT the only ortho isomer in TCP - the more toxic MOCP& DOCP are in the oil in far higher quantities.
Mobil advised the Australian Senate Inquiry that the ortho isomers were in the TCP in it's oil at >0.3%. The more toxic MOCP & DOCP were not mentioned.
ORTHO isomers divide into: **TOCP**, **DOCP** and **MOCP**.
Focus has been on TOCP with UK House of Lords and CAA reports of 2000 and 2004. These reports fail to ever mention DOCP or MOCP.

TOCP 0.006 ppm Toxicity factor x 1
DOCP 6 ppm Toxicity factor x 5
MOCP 3070 ppm Toxicity factor x 10

In ignoring DOCP and MOCP the total ORTHO toxicity is underestimated by a factor of **6.14 million** which has been known since 1958 (Henschler).

It has been known for years that when aviation engine oils are heated, a potent neurotoxic chemical called TMPP (trimethylolpropane phosphate) can be formed. TMPP is even worse than TCPs and exposure is associated with epileptic type seizures, convulsion, tremors, and changes to social/emotional behaviors. To our knowledge, it has never been found on aircraft. But to our knowledge, nobody has ever looked for it.
A 1989 US Navy report stating that Exxon 2380 (now BP2380) generated high levels of TMPP when it was heated to temperatures at or above 350C. The TCPs in the oil react with TMP chemicals in the "base stock" of the oil. **The levels of TMPP were so significant that the authors recommended that Exxon 2380 not be used on US naval vessels. But BP2380 is still widely used in commercial aviation**.

A 1996 US Air Force paper raised concerns about the potential for being exposed to highly toxic TMPP, and stated that TMPP could be formed when oils that contain TCPs and TMP are heated to temperatures as low as 250C. This is important because these temperatures are more likely to be reached in the engine/bleed air system. Wright also stated that TMPP can NOT be formed if the engine oil base stock contains PE chemicals instead of TMP. *WRIGHT R. L. Formation of the neurotoxin TMPP from TMPE-phosphate formulations - Tribiology transactions 1996, vol. 39, no4, pp. 827-834*

Another US navy report in 1992 also expressed concern about the hazards
1) What engine oil(s) are used (e.g., Mobil Jet Oil II, BP2380, etc).
2) What APU and engine types are installed on what aircraft types (e.g. Pratt Whitney 4000, Honeywell Series 85, etc).

Oils and lubricants used on the aircraft and in the engines contain not only the neurotoxins (TCPs and triphenylphosphates) but **sensitizers (N-phenyl-L-naphthylamine, PAN),** and **asphyxiants (carbon monoxide**).. Pyrolysis studies have confirmed the presence of these toxins when commercial oils are heated (van Netten, 2000; Marshman, 2001; Fox, 2001). A Material SafetyData Sheet for engine oils acknowledge only the TCP content and the fact that "toxicfumes may be evolved on burning or exposure to heat" (BP, 2001).

We ask that studies include the potential impact of exposure to the <u>mixture</u> of these and other chemicals in a <u>reduced pressure</u>

	environment. We suggests that the EASA review all data and see if a less toxic alternative oil can be recommended that would be compatible with given aircraft engines/APUs. Ultimately, all of the engine oils should be analyzed for their base stock content (rather than relying on the word of the oil companies), as well as for the potential to form TMPP, and temperature range of TMPP formation.
response	Partially accepted. Aviation oils toxicity knowledge can be improved and we have recommended studies to be conducted in this domain. The special cabin environment should be taken into account in those studies. Analysis of all engine oils base stock content: The Agency could not do that because the Agency does not regulate aviation fluids, and therefore we do not inspect oil manufacturers' productions. Nevertheless, the specified toxic compounds and their concentrations are provided to the engine manufacturers which then conduct a safety analysis to verify that no hazardous quantities are released in the bleed air for identified failure scenarios. The Agency then reviews this analysis.
comment	*33* comment by: *FSC - CCOO* In this frame, the Agency is currently monitoring on-going research studies [Cranfield University for the Department for Transport in UK, ASHRAE (American society of Heating, Refrigerating and Air Conditioning Engineers), ACER CoE (Airliner Cabin Environment Research Center of Excellence), OHRCA (Occupational Health Research Consortium in Aviation) in the USA] which are expected to help identifying, by measurements in flight, the actually released contaminants and their quantity during a "fume event" (point B. above). Comment: Prof. C Winder (http://www.safesci.unsw.edu.au/contacts/cwinder.html), professor in applied toxicology at the University of New South Wales, Australia, says collecting air samples for later analysis (as is currently the used method) is not scientifically effective for "non-volatile mists". **He says the only effective method is active, real-time analysis of the suspended chemicals and their concentration using a "direct reading machine on the aircraft during flight".** Concerning the ASHRAE ,The RAAF expert Dr. Singh points out that judging aviation air contamination using toxicity standards (ASHRAE) that apply in normal workplaces is invalid: "Aircrew members perform complex tasks requiring high-level cognitive skills, which may be much more sensitive to insult by hazardous contaminants in the smoke/fumes, such as tri-cresyl phosphate."
response	Noted. We note your remark on the effectivity of the air samples collection method. This would be a point to be reviewed by the competent scientists when doing measurements. It could nevertheless be envisaged that, even if this is not the optimal method, because of constraints inherent to the installation into an airliner environment, this method may be accepted.

comment

46 comment by: *Unionen/Sweden*

Aviation lubricants main constituents and pyrolysis products are:

- chemical esters (2 main families: trimethylolpropane (TMP) esters and pentaerythritol (PE) esters),
- additives: organophosphates, N-phenyl-1-naphtylamine,
- low molecular weight organic acids, esters and ketones

Here are the possible toxicity effects, if the contaminant is present at sufficient concentration in the air:

- Organic acids: known to be irritants (e.g. eyes, nose, throat) and also have characteristic odours (often described as "old socks" or "body odours"),
- Organophosphates: tricresylphosphates (TCP) and in particular its ortho isomer can induce irritations (e.g. eyes, nose, throat) and in the long term "Organophosphate Induced Delayed Neuropathy" (OPIDN); the toxicity of meta and para isomers is not clearly established,
- Gases: toxic gases can be produced from oil pyrolysis, such as carbon monoxide and oxides of nitrogen

Comment:
We refer to statements published by Dr. Mackerer in 1999 and to the Henschler report in 1958 "Engine oils contain a mixture of tricresylphosphates, of which TOCP in not the most toxic".

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It has been known for years that when aviation engine oils are heated, a potent neurotoxic chemical called TMPP (trimethylolpropane phosphate) can be formed. TMPP is even worse than TCPs and exposure is associated with epileptic type seizures, convulsion, tremors, and changes to social/emotional behaviors. To our knowledge, it has never been found on aircraft. But to our knowledge, nobody has ever looked for it.
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A 1996 US Air Force paper raised concerns about the potential for being exposed to highly toxic TMPP, and stated that TMPP could be formed when oils that contain TCPs and TMP are heated to temperatures as low as 250C. This is important because these temperatures are more likely to be reached in the

engine/bleed air system. Wright also stated that TMPP can NOT be formed if the engine oil base stock contains PE chemicals instead of TMP. *WRIGHT R. L. Formation of the neurotoxin TMPP from TMPE-phosphate formulations - Tribiology transactions 1996, vol. 39, no4, pp. 827-834*

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We ask that studies include the potential impact of exposure to the mixture of these and other chemicals in a reduced pressure environment.
We suggests that the EASA review all data and see if a less toxic alternative oil can be recommended that would be compatible with given aircraft engines/APUs.
Ultimately, all of the engine oils should be analyzed for their base stock content (rather than relying on the word of the oil companies), as well as for the potential to form TMPP, and temperature range of TMPP formation.

response

Partially accepted.

Aviation oils toxicity knowledge can be improved and we have recommended studies to be conducted in this domain. The special cabin environment should be taken into account in those studies.

Analysis of all engine oils base stock content: The Agency could not do that because the Agency does not regulate aviation fluids, and therefore we do not inspect oil manufacturers' productions. Nevertheless, the specified toxic compounds and their concentrations are provided to the engine manufacturers which then conduct a safety analysis to verify that no hazardous quantities are released in the bleed air for identified failure scenarios. The Agency then reviews this analysis.

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comment

62 comment by: *cfdt france*

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In this frame, the Agency is currently monitoring on-going research studies [Cranfield University for the Department for Transport in UK, ASHRAE (American society of Heating, Refrigerating and Air Conditioning Engineers), ACER CoE (Airliner Cabin Environment Research Center of Excellence), OHRCA (Occupational Health Research Consortium in Aviation) in the USA] which are expected to help identifying, by measurements in flight, the actually released contaminants and their quantity during a "fume event" (point B. above).

Comment:
Prof. C Winder (http://www.safesci.unsw.edu.au/contacts/cwinder.html), professor in applied toxicology at the University of New South Wales, Australia, says collecting air samples for later analysis (as is currently the used method) is not scientifically effective for "non-volatile mists". **He says the only effective method is active, real-time analysis of the suspended chemicals and their concentration using a "direct reading machine on the aircraft during flight".**

Concerning the ASHRAE ,The RAAF expert Dr. Singh points out that judging aviation air contamination using toxicity standards (ASHRAE) that apply in normal workplaces is invalid: "Aircrew members perform complex tasks requiring high-level cognitive skills, which may be much more sensitive to insult by hazardous contaminants in the smoke/fumes, such as tri-cresyl phosphate."

response

Noted.

We note your remark on the effectivity of the air samples collection method. This would be a point to be reviewed by the competent scientists when doing measurements. It could nevertheless be envisaged that, even if this is not the optimal method because of constraints inherent to the installation into an airliner environment, this method may be accepted.

comment

78 comment by: *Fédération des transports CGT*

Aviation lubricants main constituents and pyrolysis products are:

- chemical esters (2 main families: trimethylolpropane (TMP) esters and pentaerythritol (PE) esters),
- additives: organophosphates, N-phenyl-1-naphtylamine,
- low molecular weight organic acids, esters and ketones

Here are the possible toxicity effects, if the contaminant is present at sufficient concentration in the air:

- Organic acids: known to be irritants (e.g. eyes, nose, throat) and also have characteristic odours (often described as "old socks" or "body

odours"),

- Organophosphates: tricresylphosphates (TCP) and in particular its ortho isomer can induce irritations (e.g. eyes, nose, throat) and in the long term "Organophosphate Induced Delayed Neuropathy" (OPIDN); the toxicity of meta and para isomers is not clearly established,
- Gases: toxic gases can be produced from oil pyrolysis, such as carbon monoxide and oxides of nitrogen

Comment:
We refer to statements published by Dr. Mackerer in 1999 and to the Henschler report in 1958 "Engine oils contain a mixture of tricresylphosphates, of which TOCP in not the most toxic".

TOCP is NOT the only ortho isomer in TCP - the more toxic MOCP& DOCP are in the oil in far higher quantities.
Mobil advised the Australian Senate Inquiry that the ortho isomers were in the TCP in it's oil at >0.3%. The more toxic MOCP & DOCP were not mentioned.
ORTHO isomers divide into: **TOCP**, **DOCP** and **MOCP**.
Focus has been on TOCP with UK House of Lords and CAA reports of 2000 and 2004. These reports fail to ever mention DOCP or MOCP.

TOCP 0.006 ppm Toxicity factor x 1
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MOCP 3070 ppm Toxicity factor x 10

In ignoring DOCP and MOCP the total ORTHO toxicity is underestimated by a factor of **6.14 million** which has been known since 1958 (Henschler).

It has been known for years that when aviation engine oils are heated, a potent neurotoxic chemical called TMPP (trimethylolpropane phosphate) can be formed. TMPP is even worse than TCPs and exposure is associated with epileptic type seizures, convulsion, tremors, and changes to social/emotional behaviors. To our knowledge, it has never been found on aircraft. But to our knowledge, nobody has ever looked for it.
A 1989 US Navy report stating that Exxon 2380 (now BP2380) generated high levels of TMPP when it was heated to temperatures at or above 350C. The TCPs in the oil react with TMP chemicals in the "base stock" of the oil. **The levels of TMPP were so significant that the authors recommended that Exxon 2380 not be used on US naval vessels. But BP2380 is still widely used in commercial aviation**.

A 1996 US Air Force paper raised concerns about the potential for being exposed to highly toxic TMPP, and stated that TMPP could be formed when oils that contain TCPs and TMP are heated to temperatures as low as 250C. This is important because these temperatures are more likely to be reached in the engine/bleed air system. Wright also stated that TMPP can NOT be formed if the engine oil base stock contains PE chemicals instead of TMP. *WRIGHT R. L. Formation of the neurotoxin TMPP from TMPE-phosphate formulations - Tribiology transactions 1996, vol. 39, no4, pp. 827-834.*

Another US navy report in 1992 also expressed concern about the hazards
1) What engine oil(s) are used (e.g., Mobil Jet Oil II, BP2380, etc).
2) What APU and engine types are installed on what aircraft types (e.g. Pratt Whitney 4000, Honeywell Series 85, etc).

Oils and lubricants used on the aircraft and in the engines contain not only the neurotoxins (TCPs and triphenylphosphates) but **sensitizers (N-phenyl-L-naphthylamine, PAN),** and **asphyxiants**

(carbon monoxide).. Pyrolysis studies have confirmed the presence of these toxins when commercial oils are heated (van Netten, 2000; Marshman, 2001; Fox, 2001). A Material SafetyData Sheet for engine oils acknowledge only the TCP content and the fact that "toxicfumes may be evolved on burning or exposure to heat" (BP, 2001).

We ask that studies include the potential impact of exposure to the mixture of these and other chemicals in a reduced pressure environment.
We suggests that the EASA review all data and see if a less toxic alternative oil can be recommended that would be compatible with given aircraft engines/APUs.
Ultimately, all of the engine oils should be analyzed for their base stock content (rather than relying on the word of the oil companies), as well as for the potential to form TMPP, and temperature range of TMPP formation.

response

Partially accepted.

Aviation oils toxicity knowledge can be improved and we have recommended studies to be conducted in this domain. The special cabin environment should be taken into account in those studies.

Analysis of all engine oils base stock content: The Agency could not do that because the Agency does not regulate aviation fluids, and therefore we do not inspect oil manufacturers' productions. Nevertheless, the specified toxic compounds and their concentrations are provided to the engine manufacturers which then conduct a safety analysis to verify that no hazardous quantities are released in the bleed air for identified failure scenarios. The Agency then reviews this analysis.

comment

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comment

87 comment by: *UK CAA*

Section 10, Research outcomes

Paragraph 5 "… cause the symptoms reported in the cabin air quality incidents …"

Comment: The Committee on Toxicity (COT) produced its report in 2007 with valuable information on the issues surrounding cabin air quality.

www.advisorybodies.doh.gov.uk/cotnonfood/index.htm

Justification: Updated additional information.

Proposed Text: "… cause the symptoms reported in cabin air quality incidents. The Committee on Toxicity report stated that it was not possible to conclude whether cabin air exposures (general or following incidents) cause ill health in commercial air crews. The Committee proposed research to ascertain whether substances in the aircraft cabin could potentially harm health. It stressed that the research should not focus on one substance, but include as wide a range as possible."

response

Accepted.

comment

100 comment by: *cfdt france*

What contaminants are released to the cabin and in which quantity?

What is the effect on flight safety?

Can it induce a health concern?

What is the frequency of this kind of event?
ETF Comment : There has been and is still great difficulty in collecting and interpreting the mounting data and identifying toxic/irritant products in oil substances used in the airline industry. The physiological effects of gases and vapours in cabin air is now becoming clear and the defining of maximum acceptable quantities or concentrations must become a subject for legislation and standards.

ETF comment : "What contaminants are released to the cabin and in which quantity"?
The ETF Cabin crew committee refer to statements published by Dr. Mackerer in 1999 and to the Henschler report in 1958 "Engine oils contain a mixture of tricresylphosphates, of which
TOCP in not the most toxic".
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Ultimately, all of the engine oils should be analyzed for their base stock content (rather than relying on the analysis of the oil companies), as well as for the potential to form TMPP, and temperature range of TMPP formation.

ETF Comment : "What is the effect on flight safety"?
The ETF Cabin crew committee refers to the following statements and documents:

2001: "Incidents have been reported of impaired performance of flight crew…events could have been caused by inhalation of agents… leaking from oil or APU and contaminating the Environmental control system."
(CAA AD 002-03-2001)

2002: "oil leaks and cabin / flight deck odours must be regarded as a potential threat to flight safety, theyshould not be dismissed as a mere nuisance and should be addressed as soon as possible."
(BAe ISB 21-150 2001 / ISB 21-156, 2002)

2003: "Any oil leaking from an engine, entering the aircraft customer bleed offtake, is classified as HAZARDOUS"
(Rolls Royce, Germany 2003, BRE air quality Conference, London)

2004: "This amendment adopts a new airworthiness directive (AD), applicable to all BAE Systems (Operations) Limited Model BAe 146 series airplanes, that requires repetitive detailed inspections of the inside of each air conditioning sound-attenuating duct, and corrective actions as necessary. This action is necessary to prevent impairment of the operational skills and abilities of the flightcrew caused by the inhalation of agents released from oil or oil breakdown products, which could result in reduced controllability of the airplane. This action is intended to address the identified unsafe condition."
(FAA AD 2004-12-05)

2006: "The serious incident is attributable to the fact that on approach to Zurich Airport the cockpit filled with fumes which caused a toxic effect, leading to a limited capability of acting of the copilot. These fumes were caused by an oil leak as a result of a bearing damage in engine No. 1" "The medical examination of the copilot after the flight showed that during the flight toxic exposure took place."
(Swiss Federal Department of Environment, Transport Energy and Communications Investigation Report No u1884 by the Aircraft Accident Investigation Bureau, 2 March 2006)

TheETF Cabin crew committee also refers the EASA to the manual written by Prof. S. Michaelis, (renowned expert on Cabin air contamination): "*Aviation Contaminated Air Reference Manual,*" Michaelis, S., ed. ISBN 9780955567209, London,

ETF comment : "Can it induce a health concern?"
The ETF Cabin committee feel that there is now sufficient available material and literature on cabin air being contaminated by toxic substances used on the aircraft. Studies are now available giving indications that the health of aircraft occupants may be severely affected by the inhalation & contact with gases and vapours of lubricants, anti-freeze agents and others.

ETF refers the EASA to the following statements and studies :

"individuals exposed to a single large toxic dose, or to small subclinical doses, of ***organophosphorus compounds***have developed a chronic neurotoxicity that persists for years after exposure and is distinct from both cholinergic and

OPIDN"(AbouDonia, 2003; *Arch. Environ. Health***58**:484-97).

- Abou-Donia MB (2004) Organophosphorus ester-induced chronic neurotoxicity. Archives of Environmental Health 58:484–497
- Organophosphate Ester Induced Chronic Neurotoxicity (OPICN)- Mohamed B Abou-Donia : Proceedings of the BALPA 'Contaminated Air Protection Air Safety and Cabin Air Quality International Aero Industry Conference'. Held at Imperial College, London, 20-21 April 2005: ISBN 0-7334-2282-9
- Journal of Occupational Health & Safety, Australia & New Zealand, Vol 21, Number 5 ,August 2005 - Special edition: New findings in aircrew exposed to airborne contaminants: Long-term health effects confirmed. - Organophosphate Ester Induced Chronic Neurotoxicity (OPICN)- Mohamed B Abou-Donia

1981: Engine Lube Oil: "At temperatures above 320C this oil breaks down into irritating and toxic compounds."
(SAE Aviation Information Report: 1539, issued 1-30-81)
1983: "All of these toxic substances (includes engine oil) have acute and long-term effects"
(Rayman R.B., McNaughton G.B. Smoke/fumes in the cockpit. Aviation, Space and Environmental
Medicine, August 1983, pp 738-740. Current Director of the Aerospace Medical Association)
1998: "Repeated low level exposure leads to cumulative toxicity." (1981 ed)
"Acute and repeated exposure can produce harmful effects in man, and it has been suggested that chronic exposure at lower doses may cause long-term ill health." (1998 ed)
(UK HSE: Organophosphates: HSE: MS17: Medical aspects of occupational exposures to organophosphates. Draft revision 23, November, 1998.)
1999: "Neuropsychological outcomes - Neuropsychological abnormalities can occur as a long-term complication of acute OP poisoning"
(UK COT report. Long term sequelae of acute poisoning: 1999. Committee on Toxicity of Chemicals in Food, Consumer Products and the Environment: Organophosphates: Executive Summary. Published by the Department of Health, 1999, London)
1999: "The inhalation of mist (containing tricresylphosphate) which can be produced by high pressure systems, or direct contact with the skin, would be hazardous."
(UK Government Hansard 66599, 4 February 1999, column 737)
1999: "TCP is toxic"
(UK Government: Hansard 82322 6 May 1999 : Column: 428)
2000: "With the weight of human evidence and suffering, which is quite clear, there must be something there" "There is absolutely no doubt in our mind that there is a general health issue here"
(BAe Systems verbal evidence to Australian senate Inquiry 2000)
2001: "Incidents have been reported of impaired performance of flight crew…events could have been caused by inhalation of agents… leaking from oil or APU and contaminating the Environmental control system."
(CAA AD 002-03-2001)
2002: "oil leaks and cabin / flight deck odours must be regarded as a potential threat to flight safety, they should not be dismissed as a mere nuisance and should be addressed as soon as possible."
(BAe ISB 21-150 2001 / ISB 21-156, 2002)

2002: "FAA rulemaking has not kept pace with public expectation and concern about air quality and doesnot afford explicit protection from particulate matter

and other chemical and biological hazards." "No present airplane design fulfills the intent of 25.831 because no airplane design incorporates an air Contaminant monitoring system to ensure that the air provided to the occupants is free of hazardous contaminants"
2003: "Any oil leaking from an engine, entering the aircraft customer bleed offtake, is classified as HAZARDOUS"
(Rolls Royce, Germany 2003, BRE air quality Conference, London)
2003: "It is found that the sound attenuating material used in the air-conditioning ducts can absorb oil and can become a source of persistent air contamination."
(CASA AD /BAe 146/102, 23 January 2003)
2004: "In the event of oil leakage there is the opportunity, therefore, for the pyrolysis products of engine lubricant/fuel to enter the cabin air supply and exert toxic effects on both passengers and crew."
(CAA Air Quality report 2004)
2004: "This amendment adopts a new airworthiness directive (AD), applicable to all BAE Systems (Operations) Limited Model BAe 146 series airplanes, that requires repetitive detailed inspections of the inside of each air conditioning sound-attenuating duct, and corrective actions as necessary. This action is necessary to prevent impairment of the operational skills and abilities of the flightcrew caused by the inhalation of agents released from oil or oil breakdown products, which could result in reduced controllability of the airplane. This action is intended to address the identified unsafe condition."
(FAA AD 2004-12-05)
2005: "Both Flight Crew Affected By Sore Throats And Other Symptoms After Flight." "Smells and irritants from burning organic compounds from within the engines are known to produce harmful volatile organic contaminants."
(UK Airline Air Safety Report, ASR G-CFAH, 4 July 2005)
2007: "Mobil Jet Oil II- Known to be harmful"
(CASA: AIR SAFETY & CABIN AIR QUALITY - Jim Coyne – A/g General Manager Manufacturing, Certification & New Technologies Office: 2007 presentation)
2007: "A35-12: Protection of the health of passengers and crews and prevention of the spread of communicable disease through international travel
-*Declares* that the protection of the health of passengers and crews on international flights is an integral element of safe air travel and that conditions should be in place to ensure its preservation in a timely and cost-effective manner;
-*Requests* the Council to support further research on the consequences of air transport on the health of passengers and crews"
(ICAO- Aviation Medicine (Med) Section Related ICAO Resolutions, 5 July 2007)
http://www.icao.int/icao/en/assembl/a36/wp/wp022_en.pdf
2007: "I call on the government to reveal whether information about defects has been withheld from the regulator, the courts or the parliament"
"I am gravely concerned that crew and passengers of BAe146 aircraft have been exposed to dangerous fumes produced by engine defects"
(Senate Hansard: Monday, 13 August 2007, Senator O'Brien
2009: "Product may decompose at elevated temperatures or under fire conditions and produce harmful gases or vapours. Vapours or mist of heated product may be harmful by inhalation."
R 63.G3 Possible risk of harm to the unborn child.
R 62.F3 Possible risk of impaired fertility.
(NYCO MSDS 2009 , TURBONYCOIL 600)
2009: "Product may decompose at elevated temperatures or under fire conditions and give off irritating and/or harmful (carbon monoxide) gases/vapours/fumes. Symptoms from acute exposure to these decomposition products in confined spaces may include headache, nausea, eye, nose, and

throat irritation."
(Mobil MJO2 MSDS EU 2009)
2009: Plus Minus: "Is inhaling of tricresyl phosphate (TCP) safe or dangerous?"
Professor D henschler (1958 TCP researcher): "I believe it to be dangerous."
(German TV: Plus Minus, March 2009)
2009: "Does the German Government believe that inhaling of heated engine oil fumes is harmless for the health of crew and passengers?". Answer "No"
German Ministry of Transport, Secretary of State Ulrich Kasparick.
(Question to MP Winfried Hermann of Bundnis90/Greenparty in regards to contaminated cabin air on board of civil airliners, printed matter 16/12023, 3 March 2009)
2009 "Smoke from pyrolysed oil can be hazardous to the eyes, mucous membranes and lungs"
(Turner V Eastwest Airlines [2009] NSWDDT 5 May 2009 , Australian Court)

2009: "Smoke or fumes in the flight deck or passenger cabin present the crew with a potentially hazardous situation"
AAIB Bulletin 6/2009 G-BYAO B757, EW/C2006/10/08

Bobb, A.J. and Still, K.R. (2003) "Known Harmful Effects of Constituents of Jet Oil Smoke," TOXDET-03-04, Naval Health Research Center Detachment (Toxicology), Wright-Patterson AFB, OH

Winder, C; Fonteyn, P; Balouet, JC. (2002) "Aerotoxic syndrome: a descriptive epidemiological survey of aircrew exposed to in-cabin airborne contaminants" J Occup Health Safety – Austr New Zealand, 18(4): 321-328

Winder, C. (2006) Hazardous chemicals on jet aircraft: Case study – Jet engine oils and aerotoxic syndrome. Current Topics in Toxicology. Vol 3, 2006

2008 -- Cognitive function following exposure to contaminated air on commercial aircraft: A case series of 27 pilots seen for clinical purposes -- S Mackenzie Ross -- Journal of Nutritional &Environmental Medicine -- June 2008; 17(2): 111–126 ***PDF File***

2006 -- Hazardous Chemicals on Jet Aircraft: Case Study-Jet Engine Oils and Aerotoxic Syndrome, -- C.Winder -- Current Topics in Toxicology. Vol 3 2006

The neuro-toxicity of products used in lubricants and other substances in the aircraft engines seem to provoke Long-term health problems including :

- Neurological effects: CNS,PNS: Jamal 1997, Jamal, Julu… 2002, 2005
- Autonomic nervous system effects: Jamal, Julu… 2002, 2005
- Working memory / cognitive problems. (neuropsychological), Coxon 2002 / Mackenzie Ross 2006
- Chronic neurotoxicity (OPICN): Abou-Donia 2004, 2005
- Neuronal brain cell death: Abou-Donia
- Respiratory disorders: Burdon, Glanville 2005
- Immune system effects, fatigue, chemical sensitivity etc..
- Blood pathology disorders
- Strong occupational link: Cone 1983,1999 / Harper 2005
- Individual susceptibility: Furlong
    - TCP Blood test: 6 of 10 TCP isomers are converted into the highly toxic metabolite – psp: that inhibits the

activity of a number of important enzymes.
- Gene expression: Gene expression effected by TCP at levels found in UK pilots' blood.

The US Federal Aviation Administration (FAA) has acknowledged that "no present airplane design fulfils the intent of [federal aviation regulation] 25.831 because no airplane design incorporates an air contaminant monitoring system to ensure that the air provided to the occupants is free of hazardous contaminants" (FAA, 2002),

ETF points out that there is a sizable (and growing) body of literature on the association between exposure to oil fumes and acute and chronic symptoms reported globally by crews and passengers alike (ACARM, 2007). The ETF CCC feels there is ample justification for regulations that dictate bleed air cleaning and monitoring with flight deck indication to: (1) prevent exposure to oil fumes; (2) alert crewmembers if they are exposed inflight; and (3) enable maintenance workers to more effectively identify and remedy the contamination upon landing.

response

Noted.

1) Contaminants: Partially accepted.
Aviation oils toxicity knowledge can be improved and we have recommended studies to be conducted in this domain. The special cabin environment should be taken into account in those studies.

Analysis of all engine oils base stock content: The Agency could not do that because the Agency does not regulate aviation fluids, and therefore we do not inspect oil manufacturers' productions. Nevertheless, the specified toxic compounds and their concentrations are provided to the engine manufacturers which then conduct a safety analysis to verify that no hazardous quantities are released in the bleed air for identified failure scenarios. The Agency then reviews this analysis.

2) Effect on flight safety: Noted.

3) Effect on health: Not accepted.
Studies performed until today failed to demonstrate that cabin air can be contaminated in such a way that it could induce a safety or health issue. Cabin measurements found non-detectable or barely detectable levels of toxic contaminants. Concerning the symptoms reported by some crews or passengers: they are too generic to be directly linked to a toxic substance, although this is not rejected. Further investigation into this issue is recommended.

comment

119 comment by: *CUD*

Aviation lubricants main constituents and pyrolysis products are:

- chemical esters (2 main families: trimethylolpropane (TMP) esters and pentaerythritol (PE) esters),
- additives: organophosphates, N-phenyl-1-naphtylamine,
- low molecular weight organic acids, esters and ketones

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Analysis of all engine oils base stock content: The Agency could not do that because the Agency does not regulate aviation fluids, and therefore we do not inspect oil manufacturers' productions. Nevertheless, the specified toxic compounds and their concentrations are provided to the engine manufacturers which then conduct a safety analysis to verify that no hazardous quantities are released in the bleed air for identified failure scenarios. The Agency then reviews this analysis.

comment

120 comment by: *CUD*

In this frame, the Agency is currently monitoring on-going research studies [Cranfield University for the Department for Transport in UK, ASHRAE (American society of Heating, Refrigerating and Air Conditioning Engineers), ACER CoE (Airliner Cabin Environment Research Center of Excellence), OHRCA (Occupational Health Research Consortium in Aviation) in the USA] which are expected to help identifying, by measurements in flight, the actually released contaminants and their quantity during a "fume event" (point B. above).

Comment:
Prof. C Winder (http://www.safesci.unsw.edu.au/contacts/cwinder.html), professor in applied toxicology at the University of New South Wales, Australia, says collecting air samples for later analysis (as is currently the used method) is not scientifically effective for "non-volatile mists". **He says the only effective method is active, real-time analysis of the suspended chemicals and their concentration using a "direct reading machine on the aircraft during flight".**

Concerning the ASHRAE ,The RAAF expert Dr. Singh points out that judging aviation air contamination using toxicity standards (ASHRAE) that apply in normal workplaces is invalid: "Aircrew members perform complex tasks

requiring high-level cognitive skills, which may be much more sensitive to insult by hazardous contaminants in the smoke/fumes, such as tri-cresyl phosphate."

response

Noted.

We note your remark on the effectivity of the air samples collection method. This would be a point to be reviewed by the competent scientists when doing measurements. It could nevertheless be envisaged that, even if this is not the optimal method because of constraints inherent to the installation into an airliner environment, this method may be accepted.

comment

134 comment by: *Susan Michaelis*

Attachment #10

comment 1
Here are the possible toxicity effects, if the contaminant is present at sufficient concentration in the air: - Organic acids: known to be irritants (e.g. eyes, nose, throat) and also have characteristic odours (often described as "old socks" or "body odours"), - Organophosphates: tricresylphosphates (TCP) and in particular its ortho isomer can induce irritations (e.g. eyes, nose, throat) and in the long term "Organophosphate Induced Delayed Neuropathy" (OPIDN); the toxicity of meta and para isomers is not clearly established, - Gases: toxic gases can be produced from oil pyrolysis, such as carbon monoxide and oxides of nitrogen.

proposed text
Organic acids: known to be irritants (e.g. eyes, nose, throat) and also have characteristic odours (often described as "old socks" or "body odours"), - Organophosphates: tricresylphosphates (TCP) and in particular its ortho isomer can induce irritations (e.g. eyes, nose, throat) and in the long term "Organophosphate Induced Delayed Neuropathy" (OPIDN) and organophosphate Induced Chronic neurotoxicity (OPICN) the toxicity of meta and para isomers must no longer be dismissed, - Gases: toxic gases can be produced from oil pyrolysis, such as carbon monoxide and oxides of nitrogen.

Justification: The synergistic cocktail of contaminants must be considered with regard to the repeated inhalation of heated synthetic engine oils and other fluids. Many other effects have been ignored in the A-NPA which is inappropriate: see:
Michaelis S. (2007) Aviation Contaminated Air Reference Manual. ISBN 9780955567209, ch 3,4,5,6,7, appx3,4, 10....&

C.Winder, S. Michaelis.(2005).'Aircraft Air Quality Malfunction Incidents - Crew Effects from Toxic Exposures on Aircraft'. Air Quality in airplane cabins and similar enclosed spaces -The Handbook of Environmental Chemistry - Publisher: Springer-Verlag GmbH. August 2005;
published papers stored at: http://www.aopis.org/ScientificReports.html
& attached submission

comment 2
It has to be noticed that the toxic elements are present in very low quantity in the oil compared to the main oil constituents, chemical esters, which have a very low toxicity. Despite the fact that it is recognised that engine oil contains some irritant and relatively toxic chemical substances, studies always conclude

	that there is no sufficient elements to demonstrate the relationship with reported symptoms; the main reasons are: the very low concentrations of these substances in the oil and its pyrolysed products, many of these substances have no published toxicity data, we don't know the nature and the quantity of contaminants which are actually released in the inspired cabin air during an incident, the experimentations which have been held didn't produce results corresponding to the symptoms reported in the cabin air quality incidents or the measured contaminants were in very low concentrations. As a typical example, UK CAA conducted a research to evaluate the effect of cabin air contamination by aviation lubricating oil on flight safety. The CAA paper 2004/04 published February 2004 concluded that "no single component or set of components can be identified which at conceivable concentrations would definitely cause the symptoms reported in cabin air quality incidents." Propsed text: This is totally unsuitable as it stands & needs a complete rewrite. Justification: The ortho isomers may not be the only toxic substances ; it is the inhaled, heated synergistic effect that has never been tested & is the main issue; other substances are toxic; exposure standards do not apply to aviation or passengers: It is not possible therefore to identify individual concentrations of chemicals that cause specific effects. it is the synergistic mixture, heated at altitude. The CAA paper was totally inappropriate, based on confidential data from BAe Systems & showed an appreciable lack of understanding of the toxicity of jet engine oils. see: Michaelis S. (2007) Aviation Contaminated Air Reference Manual. ISBN 9780955567209, ch 3,4,5, appx3,4, 10....& attached submission & many other published documents at: http://www.aopis.org/ScientificReports.html including: Winder C., Balouet JC.The Toxicity of Commercial Jet Oil. Enviromental Research. Section A 89,146-164, 2002 Winder C. (2006) Hazardous Chemicals on Jet Aircraft: Case Study-Jet Engine Oils and Aerotoxic Syndrome. Current Topics in Toxicology. Vol 3 2006 Comment 3: In this frame, the Agency is currently monitoring on-going research studies [Cranfield University for the Department for Transport in UK, ASHRAE (American society of Heating, Refrigerating and Air Conditioning Engineers), ACER CoE (Airliner Cabin Environment Research Center of Excellence), OHRCA (Occupational Health Research Consortium in Aviation) in the USA] which are expected to help identifying, by measurements in flight, the actually released contaminants and their quantity during a "fume event" proposed text: Include the following: Must review independent research as well as Industry affiliated research: EASA to date has failed to review the only collated source of data on this issue: Michaelis S. (2007) Aviation Contaminated Air Reference Manual. ISBN 9780955567209 & likely many other papers
response	Partially accepted. The Agency also recommends that the synergistic effect of contaminants should be evaluated in future studies.

comment

150 comment by: *kapers Cabin Crew Union*

Aviation lubricants main constituents and pyrolysis products are:

- chemical esters (2 main families: trimethylolpropane (TMP) esters and pentaerythritol (PE) esters),
- additives: organophosphates, N-phenyl-1-naphtylamine,
- low molecular weight organic acids, esters and ketones

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- Gases: toxic gases can be produced from oil pyrolysis, such as carbon monoxide and oxides of nitrogen

Comment:
We refer to statements published by Dr. Mackerer in 1999 and to the Henschler report in 1958 "Engine oils contain a mixture of tricresylphosphates, of which TOCP in not the most toxic".

TOCP is NOT the only ortho isomer in TCP - the more toxic MOCP& DOCP are in the oil in far higher quantities.
Mobil advised the Australian Senate Inquiry that the ortho isomers were in the TCP in it's oil at >0.3%. The more toxic MOCP & DOCP were not mentioned.
ORTHO isomers divide into: **TOCP**, **DOCP** and **MOCP**.
Focus has been on TOCP with UK House of Lords and CAA reports of 2000 and 2004. These reports fail to ever mention DOCP or MOCP.

TOCP 0.006 ppm Toxicity factor x 1
DOCP 6 ppm Toxicity factor x 5
MOCP 3070 ppm Toxicity factor x 10

In ignoring DOCP and MOCP the total ORTHO toxicity is underestimated by a factor of **6.14 million** which has been known since 1958 (Henschler).

It has been known for years that when aviation engine oils are heated, a potent neurotoxic chemical called TMPP (trimethylolpropane phosphate) can be formed. TMPP is even worse than TCPs and exposure is associated with epileptic type seizures, convulsion, tremors, and changes to social/emotional behaviors. To our knowledge, it has never been found on aircraft. But to our knowledge, nobody has ever looked for it.
A 1989 US Navy report stating that Exxon 2380 (now BP2380) generated high levels of TMPP when it was heated to temperatures at or above 350C. The TCPs in the oil react with TMP chemicals in the "base stock" of the oil. **The levels of TMPP were so significant that the authors recommended that Exxon 2380 not be used on US naval vessels. But BP2380 is still widely used in commercial aviation**.

A 1996 US Air Force paper raised concerns about the potential for being exposed to highly toxic TMPP, and stated that TMPP could be formed when oils that contain TCPs and TMP are heated to temperatures as low as 250C. This is important because these temperatures are more likely to be reached in the

engine/bleed air system. Wright also stated that TMPP can NOT be formed if the engine oil base stock contains PE chemicals instead of TMP. *WRIGHT R. L. Formation of the neurotoxin TMPP from TMPE-phosphate formulations - Tribiology transactions 1996, vol. 39, no4, pp. 827-834*

Another US navy report in 1992 also expressed concern about the hazards

1) What engine oil(s) are used (e.g., Mobil Jet Oil II, BP2380, etc).

2) What APU and engine types are installed on what aircraft types (e.g. Pratt Whitney 4000, Honeywell Series 85, etc).

Oils and lubricants used on the aircraft and in the engines contain not only the neurotoxins (TCPs and triphenylphosphates) but **sensitizers (N-phenyl-L-naphthylamine, PAN),** and **asphyxiants (carbon monoxide**).. Pyrolysis studies have confirmed the presence of these toxins when commercial oils are heated (van Netten, 2000; Marshman, 2001; Fox, 2001). A Material SafetyData Sheet for engine oils acknowledge only the TCP content and the fact that "toxicfumes may be evolved on burning or exposure to heat" (BP, 2001).

We ask that studies include the potential impact of exposure to the mixture of these and other chemicals in a reduced pressure environment.
We suggests that the EASA review all data and see if a less toxic alternative oil can be recommended that would be compatible with given aircraft engines/APUs.
Ultimately, all of the engine oils should be analyzed for their base stock content (rather than relying on the word of the oil companies), as well as for the potential to form TMPP, and temperature range of TMPP formation.

response

Partially accepted.

Aviation oils toxicity knowledge can be improved and we have recommended studies to be conducted in this domain. The special cabin environment should be taken into account in those studies.

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comment

151 comment by: *kapers Cabin Crew Union*

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A. Explanatory Note - IV. Content of the A-NPA - 11. EASA Large Aeroplanes Certification Specifications p. 7-8

comment

34 comment by: *FSC - CCOO*

CS-25 provisions related to cabin air contaminants can be found in CS 25.831 and 25.832:

- 25.831(a) provides for the ventilation of passenger and crew compartments, as well as for a minimum flow of fresh air (0.28 m3/min) in the crew compartment "to enable crewmembers to perform their duties without undue discomfort or fatigue". The related AMC also provides for a minimum flow per person (0.18 kg/min) for any period exceeding 5 minutes in case of loss of one source of fresh air.
- 25.831(b) provides for crew and passenger compartment air to be free from "harmful" or "hazardous" concentrations of gases and vapours. Some limits are provided for carbon monoxide and carbon dioxide.
- 25.831(d) provides for smoke evacuation to be "readily accomplished", if accumulation of hazardous quantities of smoke in the cockpit area is reasonably probable.
- 25.832 provides for ozone concentration limits during flight.

Concentration limits are thus provided for carbon monoxide, carbon dioxide and ozone. Other contaminants are not addressed. The terms "hazardous" and "harmful" are not defined.
It can be noticed that the situation is the same in FAA Part 25.

Comment:
We point out that CS and AMC material are not *binding* rules but advisory material on the subject of clean air - there are no regulatory certification requirements directly relating to engine and APU lubricating oils, with respect to ensuring as far as possible that they are free of any constituents that, potentially, could affect the occupants of aircraft should turbine engine oil leak into the bleed air system.

We furthermore point out that **JAR 25.831** requires that the flight deck and the passenger compartment to be free from "harmful or hazardous concentrations of gases or vapours', including after any reasonably probable failure of the air conditioning, ventilation, pressurisation and other systems. Additionally, **JAR APU-210** defines that an unacceptable level of contamination of the bleed air must be extremely remote. In respect of the engines, **JAR-E-690, JAR-E-510**and associated advisory material, also consider the subject of contamination of bleed air and specify that an unacceptable concentration of toxic products generated in the air supplied to the aircraft is regarded as being hazardous.
However, as the EASA points out, there is difficulty in interpreting the JAR dispositions as "harmful, hazardous" products have to be identified and maximum acceptable concentrations specified.

response

Partially accepted.

Comment on CS-25, CS-E, CS-APU: Even though these specifications are not binding as a stand-alone regulation, they become binding as soon as the EASA has received and accepted an application for a certificate by the industry. Then the applicant must comply with the rules provided in the Book 1 of the applicable CS. Book 2 provides acceptable means and guidance material to show compliance with the Book 1 rules. Refer to regulation (EC) 1702/2003 for more explanations on applications.

Contamination of cabin air by toxic compounds from engine or APU is classified Hazardous in the safety analysis when concentrations are sufficient to incapacitate crew or passengers. Refer to CS-E 510 and CS-E 690 (Certification Specifications for engines), CS-APU 210 and CS-APU 320 (Certification Specifications for auxiliary power unit). Therefore, compliance with CS-25, CS-E, CS-APU can be shown by identifying the concentration of possible contaminants and ensuring they remain well below toxicity limits. Nevertheless, the difficulty can appear when not enough toxicity knowledge is available. In this case, precautions shall be taken so that either the contaminants can only be present in very low concentration (not detectable) or they shall be eliminated.

comment

48 comment by: *Unionen/Sweden*

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64 comment by: *cfdt france*

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80 comment by: *Fédération des transports CGT*

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comment

88 comment by: *UK CAA*

Section 11, EASA Large Aeroplanes Certification Specifications

Paragraph 1

Comment: The applicable requirements should also, in addition to CS 25.831 and 832, include those in CS 25 Subpart E and also CS E and ETSO for APU to address the quality/contamination of the bleed air at source.

Justification: This has been discussed and agreed in principle previous to EASA.

response

Accepted.

The CS 25.1309 analysis is used to ensure that aircraft designs are safe. Contamination of cabin air by toxic compounds from engine or APU is classified Hazardous in the safety analysis when concentrations are sufficient to incapacitate crew or passengers. It should also be referred to CS-E 510 and CS-E 690 (Certification Specifications for engines), CS-APU 210 and CS-APU 320 (Certification Specifications for auxiliary power unit).

comment

101 comment by: *cfdt france*

What contaminants are released to the cabin and in which quantity?

What is the effect on flight safety?

Can it induce a health concern?

What is the frequency of this kind of event?
ETF Comment : There has been and is still great difficulty in collecting and interpreting the mounting data and identifying toxic/irritant products in oil substances used in the airline industry. The physiological effects of gases and vapours in cabin air is now becoming clear and the defining of maximum acceptable quantities or concentrations must become a subject for legislation and standards.

ETF comment : "What contaminants are released to the cabin and in which quantity"?

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TOCP in not the most toxic".
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ETF Suggests that the EASA review all data and see if a less toxic alternative oil can be recommended that would be compatible with given aircraft engines/APUs.
Ultimately, all of the engine oils should be analyzed for their base stock content (rather than relying on the analysis of the oil companies), as well as for the potential to form TMPP, and temperature range of TMPP formation.

ETF Comment : "What is the effect on flight safety"?
The ETF Cabin crew committee refers to the following statements and documents:

2001: "Incidents have been reported of impaired performance of flight crew…events could have been caused by inhalation of agents… leaking from oil or APU and contaminating the Environmental control system."
(CAA AD 002-03-2001)

2002: "oil leaks and cabin / flight deck odours must be regarded as a potential threat to flight safety, theyshould not be dismissed as a mere nuisance and should be addressed as soon as possible."
(BAe ISB 21-150 2001 / ISB 21-156, 2002)

2003: "Any oil leaking from an engine, entering the aircraft customer bleed offtake, is classified as HAZARDOUS"
(Rolls Royce, Germany 2003, BRE air quality Conference, London)

2004: "This amendment adopts a new airworthiness directive (AD), applicable to all BAE Systems (Operations) Limited Model BAe 146 series airplanes, that requires repetitive detailed inspections of the inside of each air conditioning sound-attenuating duct, and corrective actions as necessary. This action is necessary to prevent impairment of the operational skills and abilities of the flightcrew caused by the inhalation of agents released from oil or oil breakdown products, which could result in reduced controllability of the airplane. This action is intended to address the identified unsafe condition."
(FAA AD 2004-12-05)

2006: "The serious incident is attributable to the fact that on approach to Zurich Airport the cockpit filled with fumes which caused a toxic effect, leading to a limited capability of acting of the copilot. These fumes were caused by an oil leak as a result of a bearing damage in engine No. 1" "The medical examination of the copilot after the flight showed that during the flight toxic exposure took place."
(Swiss Federal Department of Environment, Transport Energy and Communications Investigation Report No u1884 by the Aircraft Accident Investigation Bureau, 2 March 2006)

TheETF Cabin crew committee also refers the EASA to the manual written by Prof. S. Michaelis, (renowned expert on Cabin air contamination): "*Aviation Contaminated Air Reference Manual,*" Michaelis, S., ed. ISBN 9780955567209, London,

ETF comment : "Can it induce a health concern?"
The ETF Cabin committee feel that there is now sufficient available material and literature on cabin air being contaminated by toxic substances used on the aircraft. Studies are now available giving indications that the health of aircraft

occupants may be severely affected by the inhalation & contact with gases and vapours of lubricants, anti-freeze agents and others.

ETF refers the EASA to the following statements and studies :

"individuals exposed to a single large toxic dose, or to small subclinical doses, of ***organophosphorus compounds***have developed a chronic neurotoxicity that persists for years after exposure and is distinct from both cholinergic and OPIDN"(AbouDonia, 2003; *Arch. Environ. Health***58**:484-97).

- Abou-Donia MB (2004) Organophosphorus ester-induced chronic neurotoxicity. Archives of Environmental Health 58:484–497
- Organophosphate Ester Induced Chronic Neurotoxicity (OPICN)- Mohamed B Abou-Donia : Proceedings of the BALPA 'Contaminated Air Protection Air Safety and Cabin Air Quality International Aero Industry Conference'. Held at Imperial College, London, 20-21 April 2005: ISBN 0-7334-2282-9
- Journal of Occupational Health & Safety, Australia & New Zealand, Vol 21, Number 5 ,August 2005 - Special edition: New findings in aircrew exposed to airborne contaminants: Long-term health effects confirmed. - Organophosphate Ester Induced Chronic Neurotoxicity (OPICN)- Mohamed B Abou-Donia

1981: Engine Lube Oil: "At temperatures above 320C this oil breaks down into irritating and toxic compounds."
(SAE Aviation Information Report: 1539, issued 1-30-81)
1983: "All of these toxic substances (includes engine oil) have acute and long-term effects"
(Rayman R.B., McNaughton G.B. Smoke/fumes in the cockpit. Aviation, Space and Environmental Medicine, August 1983, pp 738-740. Current Director of the Aerospace Medical Association)
1998: "Repeated low level exposure leads to cumulative toxicity." (1981 ed)
"Acute and repeated exposure can produce harmful effects in man, and it has been suggested that chronic exposure at lower doses may cause long-term ill health." (1998 ed)
(UK HSE: Organophosphates: HSE: MS17: Medical aspects of occupational exposures to organophosphates. Draft revision 23, November, 1998.)
1999: "Neuropsychological outcomes - Neuropsychological abnormalities can occur as a long-term complication of acute OP poisoning"
(UK COT report. Long term sequelae of acute poisoning: 1999. Committee on Toxicity of Chemicals in Food, Consumer Products and the Environment: Organophosphates: Executive Summary. Published by the Department of Health, 1999, London)
1999: "The inhalation of mist (containing tricresylphosphate) which can be produced by high pressure systems, or direct contact with the skin, would be hazardous."
(UK Government Hansard 66599, 4 February 1999, column 737)
1999: "TCP is toxic"
(UK Government: Hansard 82322 6 May 1999 : Column: 428)
2000: "With the weight of human evidence and suffering, which is quite clear, there must be something there" "There is absolutely no doubt in our mind that there is a general health issue here"
(BAe Systems verbal evidence to Australian senate Inquiry 2000)
2001: "Incidents have been reported of impaired performance of flight crew…events could have been caused by inhalation of agents… leaking from oil or APU and contaminating the Environmental control system."

(CAA AD 002-03-2001)
2002: "oil leaks and cabin / flight deck odours must be regarded as a potential threat to flight safety, they should not be dismissed as a mere nuisance and should be addressed as soon as possible."
(BAe ISB 21-150 2001 / ISB 21-156, 2002)

2002: "FAA rulemaking has not kept pace with public expectation and concern about air quality and doesnot afford explicit protection from particulate matter and other chemical and biological hazards." "No present airplane design fulfills the intent of 25.831 because no airplane design incorporates an air
Contaminant monitoring system to ensure that the air provided to the occupants is free of hazardous contaminants"
2003: "Any oil leaking from an engine, entering the aircraft customer bleed offtake, is classified as HAZARDOUS"
(Rolls Royce, Germany 2003, BRE air quality Conference, London)
2003: "It is found that the sound attenuating material used in the air-conditioning ducts can absorb oil and can become a source of persistent air contamination."
(CASA AD /BAe 146/102, 23 January 2003)
2004: "In the event of oil leakage there is the opportunity, therefore, for the pyrolysis products of engine lubricant/fuel to enter the cabin air supply and exert toxic effects on both passengers and crew."
(CAA Air Quality report 2004)
2004: "This amendment adopts a new airworthiness directive (AD), applicable to all BAE Systems (Operations) Limited Model BAe 146 series airplanes, that requires repetitive detailed inspections of the inside of each air conditioning sound-attenuating duct, and corrective actions as necessary. This action is necessary to prevent impairment of the operational skills and abilities of the flightcrew caused by the inhalation of agents released from oil or oil breakdown products, which could result in reduced controllability of the airplane. This action is intended to address the identified unsafe condition."
(FAA AD 2004-12-05)
2005: "Both Flight Crew Affected By Sore Throats And Other Symptoms After Flight." "Smells and irritants from burning organic compounds from within the engines are known to produce harmful volatile organic contaminants."
(UK Airline Air Safety Report, ASR G-CFAH, 4 July 2005)
2007: "Mobil Jet Oil II- Known to be harmful"
(CASA: AIR SAFETY & CABIN AIR QUALITY - Jim Coyne – A/g General Manager Manufacturing, Certification & New Technologies Office: 2007 presentation)
2007: "A35-12: Protection of the health of passengers and crews and prevention of the spread of communicable disease through international travel
-*Declares* that the protection of the health of passengers and crews on international flights is an integral element of safe air travel and that conditions should be in place to ensure its preservation in a timely and cost-effective manner;
-*Requests* the Council to support further research on the consequences of air transport on the health of passengers and crews"
(ICAO- Aviation Medicine (Med) Section Related ICAO Resolutions, 5 July 2007) http://www.icao.int/icao/en/assembl/a36/wp/wp022_en.pdf
2007: "I call on the government to reveal whether information about defects has been withheld from the regulator, the courts or the parliament"
"I am gravely concerned that crew and passengers of BAe146 aircraft have been exposed to dangerous fumes produced by engine defects"
(Senate Hansard: Monday, 13 August 2007, Senator O'Brien
2009: "Product may decompose at elevated temperatures or under fire conditions and produce harmful gases or vapours. Vapours or mist of heated

product may be harmful by inhalation."
R 63.G3 Possible risk of harm to the unborn child.
R 62.F3 Possible risk of impaired fertility.
(NYCO MSDS 2009 , TURBONYCOIL 600)
2009: "Product may decompose at elevated temperatures or under fire conditions and give off irritating and/or harmful (carbon monoxide) gases/vapours/fumes. Symptoms from acute exposure to these decomposition products in confined spaces may include headache, nausea, eye, nose, and throat irritation."
(Mobil MJO2 MSDS EU 2009)
2009: Plus Minus: "Is inhaling of tricresyl phosphate (TCP) safe or dangerous?"
Professor D henschler (1958 TCP researcher): "I believe it to be dangerous."
(German TV: Plus Minus, March 2009)
2009: "Does the German Government believe that inhaling of heated engine oil fumes is harmless for the health of crew and passengers?". Answer "No"
German Ministry of Transport, Secretary of State Ulrich Kasparick.
(Question to MP Winfried Hermann of Bundnis90/Greenparty in regards to contaminated cabin air on board of civil airliners, printed matter 16/12023, 3 March 2009)
2009 "Smoke from pyrolysed oil can be hazardous to the eyes, mucous membranes and lungs"
(Turner V Eastwest Airlines [2009] NSWDDT 5 May 2009 , Australian Court)

2009: "Smoke or fumes in the flight deck or passenger cabin present the crew with a potentially hazardous situation"
AAIB Bulletin 6/2009 G-BYAO B757, EW/C2006/10/08

Bobb, A.J. and Still, K.R. (2003) "Known Harmful Effects of Constituents of Jet Oil Smoke," TOXDET-03-04, Naval Health Research Center Detachment (Toxicology), Wright-Patterson AFB, OH

Winder, C; Fonteyn, P; Balouet, JC. (2002) "Aerotoxic syndrome: a descriptive epidemiological survey of aircrew exposed to in-cabin airborne contaminants" J Occup Health Safety – Austr New Zealand, 18(4): 321-328

Winder, C. (2006) Hazardous chemicals on jet aircraft: Case study – Jet engine oils and aerotoxic syndrome. Current Topics in Toxicology. Vol 3, 2006

2008 -- Cognitive function following exposure to contaminated air on commercial aircraft: A case series of 27 pilots seen for clinical purposes -- S Mackenzie Ross -- Journal of Nutritional &Environmental Medicine -- June 2008; 17(2): 111–126 ***PDF File***

2006 -- Hazardous Chemicals on Jet Aircraft: Case Study-Jet Engine Oils and Aerotoxic Syndrome, -- C.Winder -- Current Topics in Toxicology. Vol 3 2006

The neuro-toxicity of products used in lubricants and other substances in the aircraft engines seem to provoke Long-term health problems including :

- Neurological effects: CNS,PNS: Jamal 1997, Jamal, Julu… 2002, 2005
- Autonomic nervous system effects: Jamal, Julu… 2002, 2005
- Working memory / cognitive problems. (neuropsychological), Coxon 2002 / Mackenzie Ross 2006
- Chronic neurotoxicity (OPICN): Abou-Donia 2004, 2005

- Neuronal brain cell death: Abou-Donia
- Respiratory disorders: Burdon, Glanville 2005
- Immune system effects, fatigue, chemical sensitivity etc..
- Blood pathology disorders
- Strong occupational link: Cone 1983,1999 / Harper 2005
- Individual susceptibility: Furlong
  - TCP Blood test: 6 of 10 TCP isomers are converted into the highly toxic metabolite – psp: that inhibits the activity of a number of important enzymes.
  - Gene expression: Gene expression effected by TCP at levels found in UK pilots' blood.

The US Federal Aviation Administration (FAA) has acknowledged that "no present airplane design fulfils the intent of [federal aviation regulation] 25.831 because no airplane design incorporates an air contaminant monitoring system to ensure that the air provided to the occupants is free of hazardous contaminants" (FAA, 2002),

ETF points out that there is a sizable (and growing) body of literature on the association between exposure to oil fumes and acute and chronic symptoms reported globally by crews and passengers alike (ACARM, 2007). The ETF CCC feels there is ample justification for regulations that dictate bleed air cleaning and monitoring with flight deck indication to: (1) prevent exposure to oil fumes; (2) alert crewmembers if they are exposed inflight; and (3) enable maintenance workers to more effectively identify and remedy the contamination upon landing.

response

Noted.

1) Contaminants: Partially accepted.
Aviation oils toxicity knowledge can be improved and we have recommended studies to be conducted in this domain. The special cabin environment should be taken into account in those studies.

Analysis of all engine oils base stock content: The Agency could not do that because the Agency does not regulate aviation fluids, and therefore we do not inspect oil manufacturers' productions. Nevertheless, the specified toxic compounds and their concentrations are provided to the engine manufacturers which then conduct a safety analysis to verify that no hazardous quantities are released in the bleed air for identified failure scenarios. The Agency then reviews this analysis.

2) Effect on flight safety: Noted.

3) Effect on health: Not accepted.
Studies performed until today failed to demonstrate that cabin air can be contaminated in such a way that it could induce a safety or health issue. Cabin measurements found non-detectable or barely detectable levels of toxic contaminants. Concerning the symptoms reported by some crews or passengers: they are too generic to be directly linked to a toxic substance, although this is not rejected. Further investigation into this issue is recommended.

comment

104 comment by: *cfdt france*

ETF points out that there is a sizable (and growing) body of literature on the association between exposure to oil fumes and acute and chronic symptoms reported globally by crews and passengers alike (ACARM, 2007). The ETF CCC feels there is ample justification for regulations that dictate bleed air cleaning and monitoring with flight deck indication to: (1) prevent exposure to oil fumes; (2) alert crewmembers if they are exposed inflight; and (3) enable maintenance workers to more effectively identify and remedy the contamination upon landing.

response

Not accepted.
See response to comment 101.

comment

121 comment by: *CUD*

CS-25 provisions related to cabin air contaminants can be found in CS 25.831 and 25.832:

- 25.831(a) provides for the ventilation of passenger and crew compartments, as well as for a minimum flow of fresh air (0.28 m3/min) in the crew compartment "to enable crewmembers to perform their duties without undue discomfort or fatigue". The related AMC also provides for a minimum flow per person (0.18 kg/min) for any period exceeding 5 minutes in case of loss of one source of fresh air.
- 25.831(b) provides for crew and passenger compartment air to be free from "harmful" or "hazardous" concentrations of gases and vapours. Some limits are provided for carbon monoxide and carbon dioxide.
- 25.831(d) provides for smoke evacuation to be "readily accomplished", if accumulation of hazardous quantities of smoke in the cockpit area is reasonably probable.
- 25.832 provides for ozone concentration limits during flight.

Concentration limits are thus provided for carbon monoxide, carbon dioxide and ozone. Other contaminants are not addressed. The terms "hazardous" and "harmful" are not defined.
It can be noticed that the situation is the same in FAA Part 25.

Comment:
We point out that CS and AMC material are not *binding* rules but advisory material on the subject of clean air - there are no regulatory certification requirements directly relating to engine and APU lubricating oils, with respect to ensuring as far as possible that they are free of any constituents that, potentially, could affect the occupants of aircraft should turbine engine oil leak into the bleed air system.

We furthermore point out that **JAR 25.831** requires that the flight deck and the passenger compartment to be free from "harmful or hazardous concentrations of gases or vapours', including after any reasonably probable failure of the air conditioning, ventilation, pressurisation and other systems. Additionally, **JAR APU-210** defines that an unacceptable level of contamination of the bleed air must be extremely remote. In respect of the engines, **JAR-E-690, JAR-E-510**and associated advisory material, also consider the subject of contamination of bleed air and specify that an unacceptable concentration of toxic products generated in the air supplied to the aircraft is regarded as being hazardous.
However, as the EASA points out, there is difficulty in interpreting the JAR dispositions as "harmful, hazardous" products have to be

identified and maximum acceptable concentrations specified.

response

Partially accepted.

Comment on CS-25, CS-E, CS-APU: Even though these specifications are not binding as a stand-alone regulation, they become binding as soon as the EASA has received and accepted an application for a certificate by the industry. Then the applicant must comply with the rules provided in the Book 1 of the applicable CS. Book 2 provides acceptable means and guidance material to show compliance with the Book 1 rules. Refer to regulation (EC) 1702/2003 for more explanations on applications.

Contamination of cabin air by toxic compounds from engine is classified Hazardous in the engine safety analysis when concentrations are sufficient to incapacitate crew or passengers (see CS-E 510). A bleed air contamination test is also required under CS-E 690. The same applies to APU, refer to CS-APU 210 and CS-APU 320. Therefore, compliance with CS-25, CS-E, CS-APU can be shown by identifying the concentration of possible contaminants and ensuring they remain well below toxicity limits (during normal and failure cases). Nevertheless, the difficulty can appear when not enough toxicity knowledge is available. In this case, precautions shall be taken so that either the contaminants can only be present in very low concentration (not detectable) or they shall be eliminated.

comment

136 comment by: *Susan Michaelis*

Attachment #11

comment 1
'Concentration limits are thus provided for carbon monoxide, carbon dioxide and ozone. Other contaminants are not addressed. The terms "hazardous" and "harmful" are not defined.'

proposed text: 'Concentration limits are thus provided for carbon monoxide, carbon dioxide and ozone. Other contaminants are not specifically addressed, however all contaminants must be kept below levels which are harmful (sufficient to create adverse effects/ discomfort or fatigue) or hazardous.

Justification: It is not acceptable to assume other contaminants (other than CO, CO2, ozone) are not covered by the airworthiness regulation. All substances must remain below levels at which adverse effects (discomfort or fatigue) can occur. Hazardous levels are specified for limited chemicals only, chemicals without set hazardous levels cannot be necessarily assume safe, exposure standards do not apply to aircraft and exposure standards do not apply to passengers, or mixtures. Therefore it is necessary to fall back to adverse effects related to suspected contaminated air. There is sufficient evidence of this occuring to indicate harmful levels of contaminants are leaking into the air supply.
See:Michaelis S. (2007) Aviation Contaminated Air Reference Manual. ISBN 9780955567209: Ch 5,16,15..... & attached submission
C.Winder, S. Michaelis.(2005). 'Aircraft Air Quality Malfunction Incidents: Causation, Regulatory, Reporting and Rates'. Air Quality in airplane cabins and similar enclosed spaces -The Handbook of Environmental Chemistry - Publisher: Springer-Verlag GmbH. August 2005.
Winder C. (2006) Hazardous Chemicals on Jet Aircraft: Case Study-Jet Engine Oils and Aerotoxic Syndrome. Current Topics in Toxicology. Vol 3 2006

response

Partially accepted.

Contamination of cabin air by toxic compounds from engine is classified Hazardous in the engine safety analysis when concentrations are sufficient to incapacitate crew or passengers (see CS-E 510). A bleed air contamination test is also required under CS-E 690. The same applies to APU, refer to CS-APU 210 and CS-APU 320. Therefore, compliance with CS-25, CS-E, CS-APU can be shown by identifying the concentration of possible contaminants and ensuring they remain well below toxicity limits (during normal and failure cases). Nevertheless the difficulty can appear when not enough toxicity knowledge is available. In this case precautions shall be taken so that either the contaminants can only be present in very low concentration (not detectable) or it shall be eliminated.

comment

152 comment by: *kapers Cabin Crew Union*

CS-25 provisions related to cabin air contaminants can be found in CS 25.831 and 25.832:

- 25.831(a) provides for the ventilation of passenger and crew compartments, as well as for a minimum flow of fresh air (0.28 m3/min) in the crew compartment "to enable crewmembers to perform their duties without undue discomfort or fatigue". The related AMC also provides for a minimum flow per person (0.18 kg/min) for any period exceeding 5 minutes in case of loss of one source of fresh air.
- 25.831(b) provides for crew and passenger compartment air to be free from "harmful" or "hazardous" concentrations of gases and vapours. Some limits are provided for carbon monoxide and carbon dioxide.
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- 25.832 provides for ozone concentration limits during flight.

Concentration limits are thus provided for carbon monoxide, carbon dioxide and ozone. Other contaminants are not addressed. The terms "hazardous" and "harmful" are not defined.
It can be noticed that the situation is the same in FAA Part 25.

Comment:
We point out that CS and AMC material are not *binding* rules but advisory material on the subject of clean air - there are no regulatory certification requirements directly relating to engine and APU lubricating oils, with respect to ensuring as far as possible that they are free of any constituents that, potentially, could affect the occupants of aircraft should turbine engine oil leak into the bleed air system.

We furthermore point out that **JAR 25.831** requires that the flight deck and the passenger compartment to be free from "harmful or hazardous concentrations of gases or vapours', including after any reasonably probable failure of the air conditioning, ventilation, pressurisation and other systems. Additionally, **JAR APU-210** defines that an unacceptable level of contamination of the bleed air must be extremely remote. In respect of the engines, **JAR-E-690, JAR-E-510**and associated advisory material, also consider the subject of contamination of bleed air and specify that an unacceptable concentration of toxic products generated in the air supplied to the aircraft is regarded as being hazardous.

	However, as the EASA points out, there is difficulty in interpreting the JAR dispositions as "harmful, hazardous" products have to be identified and maximum acceptable concentrations specified.
response	Partially accepted. Comment on CS-25, CS-E and CS-APU: Even though these specifications are not binding as a stand-alone regulation, they become binding as soon as the EASA has received and accepted an application for a certificate by the industry. Then the applicant must comply with the rules provided in the Book 1 of the applicable CS. Book 2 provides acceptable means and guidance material to show compliance with the Book 1 rules. Refer to regulation (EC) 1702/2003 for more explanations on applications. Contamination of cabin air by toxic compounds from engine is classified Hazardous in the engine safety analysis when concentrations are sufficient to incapacitate crew or passengers (see CS-E 510). A bleed air contamination test is also required under CS-E 690. The same applies to APU, refer to CS-APU 210 and CS-APU 320. Therefore, compliance with CS-25, CS-E, CS-APU can be shown by identifying the concentration of possible contaminants and ensuring they remain well below toxicity limits (during normal and failure cases). Nevertheless, the difficulty can appear when not enough toxicity knowledge is available. In this case, precautions shall be taken so that either the contaminants can only be present in very low concentration (not detectable) or they shall be eliminated.

A. Explanatory Note - IV. Content of the A-NPA - 12. Objective of the A-NPA p. 8

comment	*3* comment by: *Francis Fagegaltier Services* If read correctly, the explanatory text is mainly focused on effect of air contaminants on the health. One effect of fumes in the cockpit could be an inappropriate crew reaction (shutting down an engine, shutting down the wrong engine, using a fire extinguisher without fire, focusing on the fumes instead on flying the aircraft, etc ..). This human factor should not be forgotten in the analysis of the subject.
response	Accepted. Both safety and health aspects are considered by the Agency. Fumes and smokes can have different degrees of safety effect depending on the density and on the toxicity of the fumes or smokes. The safety analysis normally includes the review of Hazardous cases.
comment	*9* comment by: *British Airways* Comment: The collection of anecdotal information from a self-selected population of flight and cabin crew by means of an online questionnaire does not equate to the sort of robust information on which the need for additional regulation should be based.

Justification:
Regulatory authorities, aircraft and engine manufacturers, oil companies, airlines and flight/cabin crew representatives (e.g. the UK pilot's union, BALPA) have and continue to work together in collecting evidence and supporting research into the issue of cabin air contamination. Research such as that being carried out by Cranfield University for the UK Dept for Transport is scientific, peer-reviewed and will provide robust evidence. Enquires such as that carried out by the UK Government's Committee on Toxicity explicitly state how they have gathered their evidence and it is therefore possible to decide on their credence and to determine what additional evidence may be required. Online surveys open to anyone can only provide anecdotal information and cannot, therefore, be used as evidence to justify a decision on the need (or lack of need) for additional regulation.

response

Partially accepted.

The Agency recognises that the outcome from the on-line questionnaire does not provide the actual picture, as we do not control or select the responders. It is used as an indicator among others to take our decision. It was decided mainly to offer a direct and independent channel for stakeholders to report their opinions and concerns. Regarding the report of problems including health claims from crews, we have nevertheless required the concerned persons to provide supporting documents, which permits to examine and verify the claims and balance the outcome of the questionnaire.

comment

35 comment by: *FSC - CCOO*

"After the review of the above mentioned on-going research studies conclusions and the analysis of this A-NPA collected information, the Agency will evaluate if the situation actually reveals a safety concern and/or a threat for health of aeroplanes occupants. If deemed necessary, a rulemaking phase could be launched to create new airworthiness standards in order to limit as much as possible the occurrence of this kind of event."

Comment:
We hail the EASA review of studies and the collect of information as extremely positive. We support any demand on the part of the EASA for further information and data as a great step forward to create new airworthiness standards in Europe.
Safety recommendations and standards exist but are not in any way binding and we feel that this issue can no longer be ignored.

> Bleed air comes straight off the engines/APU into the cabin/flight deck. Engines/APU sometimes leak oil. Maintenance workers sometimes spill oil. **We ask EASA to issue a directive requiring bleed air cleaning to prevent fume events.**
>
> Even though it is generally accepted that engines/APU sometimes leak oil, the air supply system is not monitored. Pilots must rely on their sense of smell and whether a smoke/fume is present to determine if the air supply system is contaminated, and if it is, with what is it contaminated and whereabouts in the air supply system. This wastes precious time inflight. **We maintain that Pilots need contaminant monitoring in the air supply system with flight deck indication (per ASHRAE aircraft air quality standard 161-2007) to enable them to troubleshoot systems quickly and accurately. Also, contaminant monitoring would assist**

maintenance workers after landing. Monitoring systems should reduce the costs associated with diversions and delays

The ASHRAE Aircraft Air Quality Standard 161-2007 (**Contaminant monitoring (Section 7.2):** requires that sensors be installed in the air supply system to monitor for chemicals indicative of oil or hydraulic fluid contamination. It states that "The
sensors will provide immediate indication of a contaminant to the flight deck. If contaminant levels exceed an agreed upon level, then the sampling data must be entered into the aircraft technical log and made available to crewmembers who experience symptoms consistent with exposure to such fumes within 60 days after the flight. This will provide proof of exposure to affected flight attendants in order to assist their physicians in diagnosis and treatment. We also hope this proof of exposure will help to motivate airlines to prevent contamination events from occurring."

Lastly, we feel that the proposed aircraft quality standard Pr EN 4666 and Pr EN 4618 require major review and modification to include standards and legislation on contaminated cabin air :

The standard defines chemical limits based on "occupational exposure limits and regulatory limits from cognisant authorities"
We feel that the "cognisant authorities" are not relevant authorities. Rather, the limits are industrial exposure limits intended to protect the majority of healthy workers assigned to an 8-hour work day, not the general public or crews assigned to a 14 hour work day, all in an enclosed space at altitude, being supplied with air compressed in the engines that sometimes leak oil.

Both aircraft standards state that formaldehyde exposure shall not exceed 2 parts per million (ppm).
However, the US National Institute for Occupational Safety & Health sets a limit of 0.1 ppm and the German regulatory body (DFG/MAK) sets a 0.3 ppm limit. So, the proposed aircraft standard is 3-20 times higher than industrial limits.

The proposed 4666 standard endorses 2,438 metres (8,000 feet) as a maximum cabin altitude.
This design standard was first issued in 1957 and was applicable to the oxygen needs of fit military pilots.
Many studies since then have recommended 1,523-1,829 m (5,000-6,000 feet) based on the oxygen needs of the flying public.

The 4618 standard (as well as 4666) ignores the potential for exposure to a highly toxic family of chemicals called tricresyl phosphates ("TCPs"). They are used as anti-wear agents in engine oils which sometimes leak into the air supply. TCPs have been found in the cabin/flight deck air/surfaces/aircrew blood

Exposure to oil fumes that contain TCPs and a mixture of other chemicals can cause serious neurological and other impairment. There are many documented cases. **Neither standard addresses the oil fumes hazard, despite it being recognized in aviation since the 1950's.**
As part of this, the standards ignore the health and safety hazards posed by exposure to supply air contaminated with pyrolyzed engine oils and hydraulic fluids.

On page 3 of the proposed 4666, it says: "This standard was developed for the needs of the European Aerospace Industry." It does not seem to have been developed for the safety, health, or comfort needs of either the flying public or the crewmembers that must work in the aircraft environment.

response

Not accepted.

The Agency will not issue a "directive requiring bleed air cleaning". Maintenance procedures and programmes already exist and require air conditioning and bleed air systems regular cleaning. Operators shall follow those procedures. Issuing a directive would not bring an additional benefit over existing requirements.

Bleed air monitoring: although we cannot mandate such system today, we recommend studies to be conducted in order to determine how this could be put in place in the future, should a decision be taken that it is required. Refer to our conclusions.

EN4618 provides the available cabin air contaminants limits based on the best existing scientific knowledge and norms.

Concerning TCP, this compound is listed as part of oils, lubricants and hydraulics sources (table 1); however, it is true that no exposure limits are provided. Meanwhile, the Agency is aware that many countries use an average limit of 0.1mg/m3 (over an 8 hours workshift) based on the tri-ortho-isomer toxicity, however we do not know on which basis this limit has been established. It is nevertheless provided by OSHA, NIOSH, ACGIH. Further study is probably needed to consolidate safety and health limits, especially in an aeroplane cabin pressure and ventilation environment.

PrEN4666 provides for pressure conditions, thermal conditions, humidity conditions, noise and vibration standards. Therefore, this document is complementary to EN4618 and it is not relevant when recommending contaminants standards.

comment

49 comment by: *Unionen/Sweden*

After the review of the above mentioned on-going research studies conclusions and the analysis of this A-NPA collected information, the Agency will evaluate if the situation actually reveals a safety concern and/or a threat for health of aeroplanes occupants. If deemed necessary, a rulemaking phase could be launched to create new airworthiness standards in order to limit as much as possible the occurrence of this kind of event."

Comment:
We hail the EASA review of studies and the collect of information as extremely positive. We support any demand on the part of the EASA for further information and data as a great step forward to create new airworthiness standards in Europe.
Safety recommendations and standards exist but are not in any way binding and we feel that this issue can no longer be ignored.

Bleed air comes straight off the engines/APU into the cabin/flight deck. Engines/APU sometimes leak oil. Maintenance workers sometimes spill oil. **We ask EASA to issue a directive requiring bleed air cleaning to**

prevent fume events.

Even though it is generally accepted that engines/APU sometimes leak oil, the air supply system is not monitored. Pilots must rely on their sense of smell and whether a smoke/fume is present to determine if the air supply system is contaminated, and if it is, with what is it contaminated and whereabouts in the air supply system. This wastes precious time inflight. **We maintain that Pilots need contaminant monitoring in the air supply system with flight deck indication (per ASHRAE aircraft air quality standard 161-2007) to enable them to troubleshoot systems quickly and accurately. Also, contaminant monitoring would assist maintenance workers after landing. Monitoring systems should reduce the costs associated with diversions and delays**

The ASHRAE Aircraft Air Quality Standard 161-2007 (**Contaminant monitoring (Section 7.2):** requires that sensors be installed in the air supply system to monitor for chemicals indicative of oil or hydraulic fluid contamination. It states that "The
sensors will provide immediate indication of a contaminant to the flight deck. If contaminant levels exceed an agreed upon level, then the sampling data must be entered into the aircraft technical log and made available to crewmembers who experience symptoms consistent with exposure to such fumes within 60 days after the flight. This will provide proof of exposure to affected flight attendants in order to assist their physicians in diagnosis and treatment. We also hope this proof of exposure will help to motivate airlines to prevent contamination events from occurring."

Lastly, we feel that the proposed aircraft quality standard Pr EN 4666 and Pr EN 4618 require major review and modification to include standards and legislation on contaminated cabin air :

The standard defines chemical limits based on "occupational exposure limits and regulatory limits from cognisant authorities"
We feel that the "cognisant authorities" are not relevant authorities. Rather, the limits are industrial exposure limits intended to protect the majority of healthy workers assigned to an 8-hour work day, not the general public or crews assigned to a 14 hour work day, all in an enclosed space at altitude, being supplied with air compressed in the engines that sometimes leak oil.

Both aircraft standards state that formaldehyde exposure shall not exceed 2 parts per million (ppm).
However, the US National Institute for Occupational Safety & Health sets a limit of 0.1 ppm and the German regulatory body (DFG/MAK) sets a 0.3 ppm limit. So, the proposed aircraft standard is 3-20 times higher than industrial limits.

The proposed 4666 standard endorses 2,438 metres (8,000 feet) as a maximum cabin altitude.
This design standard was first issued in 1957 and was applicable to the oxygen needs of fit military pilots.
Many studies since then have recommended 1,523-1,829 m (5,000-6,000 feet) based on the oxygen needs of the flying public.

The 4618 standard (as well as 4666) ignores the potential for exposure to a highly toxic family of chemicals called tricresyl phosphates ("TCPs"). They are used as anti-wear agents in engine

oils which sometimes leak into the air supply. TCPs have been found in the cabin / flight deck air / surfaces / aircrew blood

Exposure to oil fumes that contain TCPs and a mixture of other chemicals can cause serious neurological and other impairment. There are many documented cases. **Neither standard addresses the oil fumes hazard, despite it being recognized in aviation since the 1950's.**
As part of this, the standards ignore the health and safety hazards posed by exposure to supply air contaminated with pyrolyzed engine oils and hydraulic fluids.

On page 3 of the proposed 4666, it says: "This standard was developed for the needs of the European Aerospace Industry." It does not seem to have been developed for the safety, health, or comfort needs of either the flying public or the crewmembers that must work in the aircraft environment.

response

Not accepted.

The Agency will not issue a "directive requiring bleed air cleaning". Maintenance procedures and programmes already exist and require air conditioning and bleed air systems regular cleaning. Operators shall follow those procedures. Issuing a directive would not bring an additional benefit over existing requirements.

Bleed air monitoring: although we cannot mandate such system today, we recommend studies to be conducted in order to determine how this could be put in place in the future, should a decision be taken that it is required. Refer to our conclusions.

EN4618 provides the available cabin air contaminants limits based on the best existing scientific knowledge and norms.

Concerning TCP, this compound is listed as part of oils, lubricants and hydraulics sources (table 1); however, it is true that no exposure limits are provided. Meanwhile, the Agency is aware that many countries use an average limit of 0.1mg/m3 (over an 8 hours workshift) based on the tri-ortho-isomer toxicity. However we do not know on which basis this limit has been established. It is nevertheless provided by OSHA, NIOSH, ACGIH. Further study is probably needed to consolidate safety and health limits, especially in an aeroplane cabin pressure and ventilation environment.

PrEN4666 provides for pressure conditions, thermal conditions, humidity conditions, noise and vibration standards. Therefore, this document is complementary to EN4618 and it is not relevant when recommending contaminants standards.

comment

65 comment by: *cfdt france*

"After the review of the above mentioned on-going research studies conclusions and the analysis of this A-NPA collected information, the Agency will evaluate if the situation actually reveals a safety concern and/or a threat for health of aeroplanes occupants. If deemed necessary, a rulemaking phase could be launched to create new airworthiness standards in order to limit as much as possible the occurrence of this kind of event."

Comment:
We hail the EASA review of studies and the collect of information as extremely positive. We support any demand on the part of the EASA for further information and data as a great step forward to create new airworthiness standards in Europe.
Safety recommendations and standards exist but are not in any way binding and we feel that this issue can no longer be ignored.

Bleed air comes straight off the engines/APU into the cabin/flight deck. Engines/APU sometimes leak oil. Maintenance workers sometimes spill oil. **We ask EASA to issue a directive requiring bleed air cleaning to prevent fume events.**

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contaminants standards.

comment

66 comment by: *cfdt france*

Attachment #12

ORIGINAL RESEARCH Cognitive function following exposure to contaminated air on commercial aircraft: A case series of 27 pilots seen for clinical purposes
SARAH MACKENZIE ROSS Sub-department of Clinical Health Psychology, University College London, Gower Street, London WC1E 6BT, UK
Abstract
Background
. Cabin air on commercial aircraft is sometimes contaminated with hydraulic fluids, synthetic jet engine oils and combusted or pyrolized materials. The incidence of contaminated air events is hard to quantify as commercial aircraft do not have air quality monitoring systems on board.
In the UK, around 350 aircrew have advised their union that they may be suffering physical and psychological ill health following exposure to contaminated air.
Design
. This paper presents a case series of 27 pilots referred for psychological assessment. The general aim of the assessment was to determine whether pilots show evidence of cognitive impairment and whether this relates to exposure history.
Materials and method
. All pilots underwent neuropsychological and adult mental health assessment, undertaken by 12 examiners, instructed to search for alternative explanations other than exposure to
toxic fumes for any symptoms reported.
Results
. Pilots reported alarming cognitive failures at work such as being unable to retain or confusing
numerical information from Air Traffic Control. Nine pilots were excluded from further analysis because they had a medical or psychiatric condition which might otherwise explain these difficulties.
In the remaining 18 pilots, language, perceptual skills and general intellectual ability were preserved, but performance on tests of psychomotor speed, attention and executive functioning was below expected levels.
Conclusions
. The cognitive deficits identified in this cohort of pilots cannot be attributed to factors such as mood disorder or malingering. However, the evidence available in this study does not enable firm conclusions to be drawn regarding a causal link with contaminated air; the cohort of pilots was self-selected and only crude indices of exposure were available. Further research is warranted given the scientific uncertainty regarding the health effects of inhalation of heated or pyrolized engine oil.
Key words:
Aviation air quality, cognitive impairment, memory, occupational exposure, organophosphates, pilots Introduction
To enable passengers and crews to live in a reduced pressure environment, aircraft cabins are pressurized and the air supply to the passenger cabin and cockpit is supplied from the Correspondence: Sarah Mackenzie Ross, Sub-department of Clinical Health Psychology, University College London, Gower Street, London WC1E 6BT, UK. Tel: + 44 (0) 20 7679 1258. Fax: + 44 (0)20 7916 1989. Email: s.mackenzie-ross@ucl.ac.uk
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engines or auxiliary power unit. This air is unfiltered and known as 'bleed air' and is sometimes contaminated with hydraulic fluids, synthetic jet engine oils and/or the compounds released when these fluids and/or oils are heated or pyrolized (for example, carbon monoxide, phosphorus oxides, aldehydes). When the 'bleed air' becomes contaminated in this way it is referred to as a 'contaminated air' event. Contaminated air may contain a large number of chemicals which can cause irritation, skin sensitization and neurotoxicity such as the organophosphate tricresyl phosphate (TCP) [1–3]. It is recognized that all aircraft are subject to engine oil leaks occasionally but certain types of aircraft record statistically more events than others. These include the BAe 146, A320 and Boeing 757 [4].

The incidence of contaminated air events on commercial aircraft is difficult to quantify as commercial aircraft do not have air quality monitoring systems on board. Under-reporting of contaminated air events is common amongst aircrew due to lack of awareness, commercial pressure and fears over job security if crew complain about working conditions and many crews see contaminated air as a normal, everyday occurrence. A recent survey by the British Airline Pilots Association (BALPA) found that only 61 out of 1667 contaminated air events (that is, only 3.66%) were recorded on the UK Civil Aviation Authority (CAA) database [5].

No monitoring has ever been successfully undertaken during a contaminated air event [6]. Therefore, the nature of the contaminants within the cabin air and the levels of exposure to passengers and crews during a contaminated air event are unknown. The material data safety sheets for jet engine oils BP 2380 (widely used in BAe 146 aircraft) and Exxon Mobil Jet Oil II (widely used in Boeing 757 aircraft) states that TCP is present in the oil and warn that toxic and harmful fumes/vapours/mists may be evolved on burning or exposure to heat and that exposure to thermal decomposition products in an enclosed space may cause headache, nausea, eye, nose and throat irritation. One study found the

organophosphate tricresylphosphate (TCP) on the walls of BAe 146 aircraft, a BAe 146

pilots' trousers, Boeing 757 dust and HEPA filters [7].

Flight attendants, flight crew and some passengers around the world have been reporting ill health following contaminated air events for many years [3,5,8], but it is only recently that this issue has received attention in the UK. The immediate effects of exposure to contaminated air have been well documented and include eye irritation, respiratory problems, headache, skin problems, nausea, vertigo, loss of balance, dizziness, fatigue and cognitive impairment (disorientation, confusion and memory problems). These symptoms show a close temporal relationship with exposure and usually recede after cessation of exposure [1,5,9].

A number of individuals report persistent, chronic ill health lasting months or years after exposure, including lack of coordination, nausea/vomiting, diarrhoea, respiratory problems, chest pains, severe headaches, lightheadedness, dizziness, weakness and fatigue, parasthesias, tremors, increased heart rate, palpitations, irritation of ear, nose and throat, muscle weakness/ pain, joint pain, salivation, skin itching, rashes, blisters, hair loss, signs of immunosuppression and chemical sensitivity [3,10–12]. Persistent cognitive impairment has also been reported involving memory problems, reduced information processing speed, reaction time and fine motor skills [13].

Work incapacity may be as high as 35%[10]. A debate is ongoing in the UK and US about causation, diagnosis and treatment of long-term effects.
This paper presents a case series of 27 commercial airline pilots who requested or were referred by other specialists for neuropsychological assessment. The pilots had concerns about their health and a number suggested their symptoms might be related to exposure to 112 S. M. Ross contaminated air on commercial aircraft. All pilots underwent neuropsychological and adult mental health assessment and their medical records were reviewed to determine whether they had a previous medical or psychiatric history which might otherwise account for their symptoms.
Method
Basis for project
Around 350 UK pilots have advised their union that they may be suffering health effects from exposure to contaminated air. The pilots union maintains a database of these individuals. This paper presents a case series of 27 aircrew who underwent psychological assessment for clinical purposes. The general aims of this case study were:
(1) To establish whether aircrew with a history of exposure to contaminated air on
commercial aircraft show evidence of cognitive impairment.
(2) To examine the nature and extent of any cognitive deficits identified.
(3) To determine whether the pattern of cognitive deficit relates to exposure history.
Subjects
The subjects for this project were a self-selected sample of 27 commercial airline pilots who voluntarily underwent neuropsychological assessment and adult mental health assessment.
All bar one of the aircrew involved in this audit were current or former pilots on the Boeing 757 or BAe 146 aircraft types.
Seven pilots were referred by either a general medical practitioner or a medical specialist (consultant neurologist or consultant psychiatrist) for an opinion regarding their cognitive functioning. The remaining 20 aircrew referred themselves directly (self-referral) and were retired, suspended and working pilots who fly/flew the BAe146 and Boeing 757 aircraft, who had reported exposure to contaminated air to union officials.
Ethics approval
All pilots were asked if their results from psychometric testing could be entered into a group analysis and all pilots gave written consent for this. Ethical approval for this work was granted by the joint UCL/UCLH committee on the Ethics of Human Research, Committee A.
Clinical interview
A clinical interview collected information, as outlined in Table I. Whenever possible, a relative/carer was interviewed as well to obtain corroborating evidence.
In addition, a complete set of each individual's general medical notes and any relevant hospital records were reviewed by the author to search for alternative explanations for any symptoms or deficits identified during the assessment.
Neuropsychological assessment Subjects underwent a detailed neuropsychological assessment which lasted
,
3 hours. After
a short break they undertook a clinical interview and mental health assessment which lasted Contaminated aircraft air and cognitive function
113 , 2 hours. Twelve examiners were involved in assessing aircrew; all examiners were blind to exposure status.
Psychometric assessment

Psychometric testing was carried out first to ensure the examiners were blind to the precise exposure status of the aircrew they were testing. Examiners were only given basic demographic information such as the name and age of the study participant they were seeing and they were aware that the pilots had been referred because they believed their health to have been affected by exposure to contaminated air. All examiners were instructed to search for explanations other than exposure to toxic fumes, for any symptoms or deficits identified during assessment. In particular they were asked to consider the possibility that symptoms might be secondary to excessive alcohol consumption or substance abuse, previous neurological injury, medical or psychiatric history, lifestyle factors, malingering, mood disorder, psychosomatic disorder, stressful life events or attribution error. In addition, examiners were instructed to ask subjects if they had been examined by a Consultant Neurologist to exclude other potential explanations for their symptoms and to report what diagnoses they had been given by any other medical experts they might have seen.

Only well known, reliable and clinically sensitive measures were selected for inclusion in the Psychometric test battery [14]. Tests were selected which would assess a broad range of cognitive functions including premorbid and current IQ, language skills, memory functioning (verbal and visual), information-processing speed, executive function and visuo-perceptual ability. A test of malingering was also included in the battery. Finally, emotional state at the time of testing was assessed using the Hospital Anxiety and Depression Scale (see Table II).

Table I. Information collected during clinical interview.

Developmental and social history Educational and occupational background Past medical and psychiatric history; alcohol, drug and medication use Recent stressful life events (for example, bereavement, divorce) Exposure history. Pilots were asked to bring details of their career history including N
detailed records of flying hours (from their log books)
N
the year they began flying
N
which aircraft they had flown over the course of their career
N
how long they had spent flying each aircraft type
N
whether they thought they had ever experienced exposure to contaminated air, if so, did they suffer from any
physical or psychological symptoms
N
how long did the symptoms persist and did they recover
N
did they report the incident(s) to any authorities
N
were incident(s) investigated by engineers?
N
did they have any long-term/persistent health problems which they attribute to exposure to contaminated air?
N
had they consulted any doctors about their symptoms?
N
what diagnoses have been given?
Onset of physical/psychological problems and their temporal relationship with exposure, plus their evolution over
time

The nature of any medical treatment provided
Current symptoms/problems (physical, emotional, cognitive)
Impact on daily life
Mood state
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Descriptive information is provided for all 27 pilots regarding exposure history, physical
symptoms associated with exposure and the results of various medical tests aimed at
establishing the aetiology of these complaints.
Nine individuals were found to have a medical or psychiatric history which might
otherwise account for any cognitive deficits identified during assessment and these were
excluded from the group analysis of cognitive function. The rationale for this exclusion
process was to ensure the most conservative analyses of the data in order to reduce the risk
of false positive results. Reasons for exclusion were: alcohol intake above 21 units/week
(2 pilots); anxiety and/or depression (2 pilots); co-morbid neurodegenerative condition
(2 pilots); neurological symptoms of unknown aetiology (1 pilot); and 'others' (2 pilots).
Results
Demographic and exposure information
Demographic information is shown in Table III.
Flying hours.
Table IV shows the total number of hours and years that pilots had spent
flying throughout their career history and the total number of hours they had flown specific
aircraft types. None of the pilots who flew/fly the Boeing 757 had flown the BAe146 and
contrariwise, but all pilots had flown other aircraft types during their career history. The
sample was equally split with regard to aircraft type flown with nine pilots having flown the
Boeing 757 and nine having flown the BAe 146.
Table II. Psychometric battery.
Premorbid and current IQ
Wechsler Adult Reading Test (WTAR) [21]
Wechsler Adult Intelligence Scale–III (WAIS-III) [22]
Memory
Adult Memory and Information Processing Battery (AMIPB) [23]
Information Processing Battery and Psychomotor speed
Adult Memory and Information Processing Battery
Trail Making A
Language
Graded Naming [24]
Verbal Fluency (FAS) [25]
Semantic fluency (Animals)
Malingering test
Rey 15 item
Mental flexibility
STROOP [26]

Trail Making B
Perception
Benton Line Orientation [27]
Benton Face Recognition (short form)
Mood questionnaires
Hospital Anxiety and Depression Scale [28]
Beck Depression Inventory-II
Beck Anxiety Inventory
Life Events Checklist [29]
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Official reporting of fume incidents.
All of the pilots examined reported unpleasant, oily, chemical smells in the aircraft cabin which would increase in intensity under certain conditions.
Pilots who fly/flew the BAe 146 describe the cabin as having a distinctive and unpleasant oily, chemical smell, the intensity of which would increase under the following conditions:
(1) when the air conditioning system is turned on; (2) during 'pack burns', an operational procedure in which the aircraft air-conditioning system is operated at full heat so as to volatize hydrocarbons from the air conditioning system into the aircraft cabin whilst it is empty (although crew were sometimes present setting up the aircraft for its next flight [15,16]. Pack burns were reported to be performed regularly to remove oil contamination of the ductings and often caused visible fumes in the aircraft cabin which crews were exposed to (3) during take off, climb, descent and landing.
Pilots who fly/flew the Boeing 757 describe the cabin as having a distinctive and unpleasant oily, chemical smell, the intensity of which would vary depending on phase of flight and power settings on the engines.
Ten pilots stated that they had never formally reported contaminated air for the following reasons: (1) they assumed the distinctive smell in the cabin was part of the normal working environment and not something to be unduly concerned about; (2) fears over job security if contaminated air events were reported. Two pilots were threatened by senior colleagues when they suggested reporting an event; (3) a belief that the company would not act on the report; (4) not wishing to be delayed at work completing the
necessary paperwork; and (5) not attributing symptoms of ill health to contaminated air.
The remaining 17 pilots had reported a contaminated air event at some point during their career history.
Table III. Demographic characteristics of aircrew.
Characteristics
Pilots
whole sample (
n527) reduced sample (n5
18)
Gender 3 Female; 24 Male 2 Female; 16 Male
Mean age years (
iSD: range) 49.4 (i8.2: 36–63) 48.4 (i
8.8: 36–62)
Mean educational level (
iSD: range) 13.2 (i2.3: 10–18) 13.2 (i
2.3: 10–18)
Mean WAIS-III full scale IQ (
iSD: range) 119.9 (i13.9: 88–155) 119.3 (i
10.5: 103–139)
Working aircrew 13 9

Long-term sick leave or medical suspended? 5 4
Retired on ill health grounds 6 2
Retired for other reasons 3 3
Table IV. Flying time and hours on specific aircraft types (reduced sample).
Lifetime flying (hours) Lifetime flying (years) Boeing 757 hours BAe 146 hours
Mean 11 642 22 1978 2647
SD 5 349 10.7 2742 3052
Range 3 000–25 000 5.5–40 0–8000 0–8147
A flying hour is not the same as time in the aircraft environment as it does not include time in the cockpit prior to engine start or after engine shut down completing pre- and post-flight duties.
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Symptoms provoked by exposure and the development of chronic ill health
Acute symptoms.
Thirteen pilots describe one or more of the following acute symptoms which develop immediately after exposure to contaminated air; flu-like symptoms, watering eyes, sore nose, throat, nasal congestion, breathing difficulties, headache, nausea, gastrointestinal problems, dizziness, fatigue, cognitive impairment (that is inability to complete basic tasks such as mental arithmetic or to follow instructions in the correct sequence). A number of pilots describe a metallic taste in the mouth following exposure.
These symptoms usually resolve on cessation of exposure.
The cognitive impairment reported by pilots was alarming, bearing in mind the nature of the symptom and the consequences of an adverse outcome: being unable to retain numerical coordinates provided by Air Traffic Control regarding height, altitude, speed; mixing up the numerical coordinates provided by Air Traffic Control; completing tasks in the incorrect sequence; being able to hear Air Traffic Control or colleagues talking to them, but being unable to respond; feeling intoxicated; feeling unable to make decisions or problem-solve; losing track of conversations; word-finding difficulties; being easily distracted and unable to return to the task in hand; being unable to recall important matters such as whether the undercarriage had been raised or lowered. Several pilots reported being unaware of the extent of their impairment until it was pointed out to them by colleagues. Others found it necessary to request assistance from colleagues to complete their duties.
Long-term symptoms.
All bar one pilot reported the development of more persistent, chronic health problems over time including fatigue, sleep difficulties, fluctuating gastro-intestinal problems, numbness and tingling in fingers and toes, memory and word-finding difficulties.
Two of the BAe 146 pilots reported feeling so fatigued at work that they had micro-sleeps whilst flying aircraft, that is they fell asleep whilst in control of the aircraft. All of the pilots who complained of fatigue described it as being intense and overwhelming and quite unlike fatigue which is precipitated by exercise or sleep deprivation. They also report that this chronic fatigue persists even after sleep/rest. Nine continued to work, one pilot was on longterm sick leave, two have retired on ill health grounds and three have retired for personal choice.
In most cases long-term symptoms develop gradually or after a major fume event, but three 757 pilots describe a marked deterioration in health following a viral illness which left them with disabling levels of fatigue and an inability to work. One of these pilots has fully recovered (though he has not returned to work for other reasons) but the others have not and have ceased flying. None of these three pilots formally reported fume events, though they did consult their GP about recurrent flu-like symptoms in the years preceding the sudden

development of chronic ill health.
Neuropsychological functioning
Pilots underwent an extensive battery of more than 30 neuropsychological tests. There was no evidence of global intellectual decline or impairment, language or perceptual deficits in this cohort. Indeed, pilots were intact on the vast majority of tests. However, there was evidence of under-functioning on tests associated with psychomotor speed, executive functioning and attention.
Intellectual functioning.
The average level of intelligence was on the border of the high average/superior range for the general population (mean full scale IQ was 119, SD
i
10.5).
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Scores ranged from being average to very superior (IQ score range 103–139). None were below average.
With regard to WAIS-III sub-tests, 61% of the cohort obtained scores on a test of visual sequencing and psychomotor speed (digit symbol) which were statistically significantly different from their mean performance on other sub-tests within the WAIS-III. This means the likelihood of obtaining such a difference by chance is very low. Fifty per cent of the cohort obtained scores on a test of working memory/attention (digit span) which were statistically significantly different from their mean performance on other sub-tests within the WAIS-III; and 33% of the cohort obtained scores on another test of visual sequencing (picture arrangement) which were statistically significantly different from their mean performance on other sub-tests within the WAIS-III. TableV illustrates these findings, along with those of the only other neuropsychological study in this area [13]. The prevalence or frequency of most of the observed differences (that is two thirds) are rare in the standardization sample (that is less than 10% of the standardization sample would show differences of this magnitude).
To summarize, deviations in sub-test scores of this magnitude are unexpected. Not only are there a large number of participants who show deviations in sub-test scores, the deviations are apparent on the same sub-tests.
Executive functioning—mental flexibility.
Fifty per cent and 39% of pilots obtained scores below the 50
th
percentile on tests of attention/mental flexibility (Stroop and Trails B) and 44% obtained low scores on a test of semantic fluency. These tests are all associated with executive functioning.
Information processing speed.
Fifty per cent of pilots obtained scores below the 50
th
percentile on tests of mental information processing speed and 33% had a higher than
Table V. Psychometric test results.
Tests
Percentage impairments
Present study Coxon study [13]
Visual Sequencing
Digit Symbol 61% 87.5%
Picture Arrangement 33% 62.5%
Memory (verbal)
Digit Span (working memory) 55% 50%
Story Recall 78% 87% impaired on verbal recall

List Learning 55%
Memory (visual)
Figure Recall 5% 50% impaired on visual recall
Design Learning 16%
Executive (Frontal Lob) Function
Stroop 50% *
Trails B 39% 37.5%
Semantic Fluency 44%
Information Processing Speed
Mental Speed 50% *
Motor Speed 17% *
Increased Error Rate 33% *
* comparable data not available.
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average error rate on this test. In contrast, motor speed is relatively well preserved with only three pilots obtaining weak scores on this test.
Memory.
All but two pilots were of high average to very superior intelligence, yet 78% obtained scores in the average or low average range on some aspect of a story recall test, 33% obtaining scores 1–2 SD below the mean. Fifty per cent obtained scores in the average range on a list learning task, 28% obtained scores 1–2 SD below the mean on this test.
In contrast, visual memory seemed to be relatively well preserved with only two pilots showing a weakness in this area.
Malingering test.
None of the pilots included in the group analyses failed the malingering test.
Mood questionnaires.
Any pilot with elevated scores on the Hospital Anxiety and Depression Scale or Beck Inventories underwent a structured interview to determine whether they met DSM-IV criteria for Major Depression or Anxiety Disorder. None of the pilots included in the group analysis met DSM-IV criteria for a diagnosis of anxiety or depression.
Statistical analyses
Comparison with a control group.
As was mentioned at the beginning of this report this is not a research study, but an audit of a case series of aircrew examined during the course of clinical practice. Funding was not available to recruit a suitable, matched control group.
However, the author has data on 22 healthy, non-exposed individuals, recruited from local job centres within London and newspaper advertisements, who completed the same psychometric test battery as the pilots, although matched to the sample of pilots in terms of gender, age and years spent in education, level of intelligence differed between the groups.
The mean Wechsler Adult Intelligence Scale Full Scale IQ in the control group was at the top of the average range, whilst the average full scale IQ in the pilot cohort was at the top of the high average range (see Table VI).
As the two groups are not well matched in terms of IQ, statistical tests of differences in mean are less informative than tests of profile. In other words, while the pilot group had a higher overall mean, impairments in psychological performance might be indicated by a different pattern of performance across sub-tests. This was tested using profile analysis.
Bonferroni corrections were applied to control for Type 1 errors. The analysis confirmed an overall difference in mean between the two groups ($F(1,39)510.48$, p5

0.002), but more importantly showed a difference in the sub-test profiles of the two groups (
F(9,31)5
2.81,
p
5
0.016; see Figure 1). There was much greater variability in performance across the subtests amongst the pilots and this was primarily due to weaker scores on tests of digit span (working memory), similarities and picture arrangement (executive function) and digit symbol relative to performance on other intellectual sub-tests.
Table VI. Characteristics of pilots and controls.
Characteristics Pilots (
n518) Controls (n5
22)
Mean age (SD) in years 48 (8.8) 46 (10.9)
Mean educational level (SD) 13 (2.3) 12 (2.1)
Mean WAIS-R full scale IQ 119 (10.5) 109 (12.3)
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Correlations between exposure history (flying hours) and cognitive function.
Pearson Product
Moment Correlations (or Spearman when appropriate) were used to establish whether there is a relationship between cognitive function and exposure history. It was predicted that performance will worsen with increased exposure; therefore, due to the unidirectional nature of the hypothesis, one-tailed test of significance was used. The number of variables entered into the analysis was kept to a minimum to reduce the risk of Type 1 errors occurring as a result of multiple comparisons. Partial correlations were also performed to control for the potentially confounding effects of age which was associated with both flying hours/years and performance on psychometric tests (see Table VII).
Significant correlations were observed between total number of years spent flying and lowered scores on the following tests: picture arrangement (visual sequencing), the Stroop test of mental flexibility, the trails B test of mental flexibility and a test of verbal memory (r520.442, p,0.05; r520.414, p,0.05; r50.544, p,0.01; r520.422, p, 0.05).
Significant correlations were observed between total number of hours spent flying and lowered scores on the following tests: picture arrangement (visual sequencing), semantic fluency, the trails B test of mental flexibility and three different tests of verbal memory (r520.448, p,0.05; r520.400, p,0.05; r50.453, p,0.05; r520.415, p, 0.05; r 520.530, p,0.05; r520.462, p, 0.05).
Lowered scores on tests of semantic fluency, mental flexibility (trails B and Stroop) and mental speed correlated with hours on the BAe 146 (r520.463, p,0.05; r50.817, p, 0.01;r520.557, p,0.01; r520.651, p, 0.01). Correlations with hours on the Boeing 757aircraft were counter-intuitive and indicated improved performance on tests of mental flexibility and mental speed were associated with this variable (r520.565, p, 0.01;Figure 1. WAIS performance profiles.
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r
50.420, p,0.05; r50.667, p, 0.01). Number of months since last flight did not correlate
with any of the psychometric data.
Partial correlations were performed to control for the potentially confounding

effects of age and all of the observed correlations between hours/years spent flying and performance on psychometric tests were lost. Significant, but counter-intuitive correlations remained between hours spent flying the Boeing 757 aircraft type, mental flexibility and mental speed (
r520.4806, p,0.03; r50.6293, p, 0.003). Significant correlations in the predicted
direction remained between the number of hours spent flying the BAe146 aircraft type, mental speed and two tests of mental flexibility (r520.6061, p,0.005; r5 0.7867,p,0.0001; r520.4705, p, 0.03).
Discussion and conclusions
This paper presents a case series of 27 pilots who underwent neuropsychological assessmentat University College London. To reduce the risk of false positive results, nine pilots with a medical or psychiatric history which might otherwise accounted for any deficits or symptoms identified during assessment were excluded from group analyses of psychometric test data.
Pilots completed an extensive battery of more than 30 neuropsychological tests. There was no evidence of global intellectual decline, language or perceptual deficits in this cohort.
Indeed, pilots were intact on the vast majority of tests. However, there was evidence of under-functioning on tests associated with psychomotor speed, executive functioning and attention. Indeed pilots exhibited a different, more variable pattern of performance across intellectual sub-tests than healthy controls (matched for age, gender and years of education but not IQ).
Statistical analyses were carried out to look at the relationship between exposure history and cognitive deficits. A number of significant correlations were observed between exposure variables and verbal memory, executive function and information processing speed.
However, when the potentially confounding effects of age weres controlled for, some of these correlations became non-significant.
Table VII. Correlations between exposure indices and psychometric tests.
Psychometric test
Total
flying years
Total
flying hours
Hours on
Boeing 757
Hours on
BAe 146
Number of
months since last
flight
Digit Span ns ns ns ns ns
Picture Arr.
20.442* 2
0.448* ns ns ns
Digit Symbol ns ns ns ns ns
Semantic Flu. ns
20.400* ns 2
0.463* ns
Trail B 0.544** 0.453*
2
0.565** 0.817** ns
Stroop
20.414* ns 0.420* 2
0.557** ns

Story I ns ns ns ns ns
Story D ns
2
0.415* ns ns ns
List I
20.422* 2
0.530* ns ns ns
List D ns
2
0.462* ns ns ns
Mental Speed ns ns 0.667**
2
0.651** ns
Motor Speed ns ns ns ns ns
*
p,0.05; ** p,
0.01.
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The exposure indices available in this study were crude and may not be reliable or valid measures of exposure to contaminated air. For example, the pilots in this study had flown a variety of aircraft types over their career history, some of which will not have suffered engine oil leaks, therefore total number of hours or years spent flying may not be a good index of exposure to contaminated air. Even hours spent flying the BAe 146 or Boeing 757 aircraft types may also fail to capture exposure adequately, as exposure will depend on whether a fault occurs in a particular aircraft and some aircraft may be maintained to a higher standard than others. Reporting rate is also unlikely to correlate highly with exposure as a number of factors influence whether aircrew report fume events. However, it may be the case that factors other than exposure to contaminated air are responsible for the cognitive deficits identified in this analysis. Alternative explanations might include medical or psychiatric background, mood disorder/emotional distress, malingering or the general lifestyle of pilots.
Mood disorder, malingering, chance factors Examiners found little to substantiate the view that the deficits seen in pilots might be secondary to psychological distress, malingering or chance factors. None of the pilots
included in the group analysis were suffering from mood disorder and none failed a test of malingering. Working pilots were highly motivated to perform well as they expressed concern that if deficits were identified, they might lose their licence to fly. Furthermore, the profile of deficits seen in this group of pilots is not consistent with malingering and is unlikely to have occurred by chance as pilots were intact on the vast majority of psychometric tests and, when deficits were identified, they were in specific cognitive domains (that is attention, executive function and information processing speed). Malingering and chance factors (for example, regression to the mean) would produce a more random profile of results [17–19]. The pattern of deficits observed in each pilot were similar and consistent and are likely to be real rather than a result of faking or chance factors.
Medical or psychiatric history Another possibility is that the profile of cognitive deficits identified in this cohort is due to some other medical condition. Although pilots with a medical or psychiatric history (including substance abuse) that might otherwise account for any deficits identified during testing were excluded from the group analysis, the abnormalities detected may be multifactorial so that no obvious, single alternative cause can be established.
The general lifestyle of pilots Another possibility is that the profile of cognitive

deficits identified in this cohort relates to some lifestyle factor, specific to pilots, for example, exposure to radiation, shift working, time changes and jet lag, reduced pressure environment, poor diet, dehydration and humidity. This is considered to be an unlikely explanation for the deficits observed in this cohort, as 50% of the cohort were suspended from or had retired from flying and were no longer subject to these lifestyle factors. Furthermore, the Boeing 757 and BAe 146 aircraft are classified as short haul aircraft. As such they are subject to less radiation and pressurization than long-haul aircraft and pilots are subjected to fewer time zone changes than long haul pilots. However, the best way to confirm whether medical or lifestyle factors are relevant would be to carry out an epidemiological survey of all UK pilots looking at the 122 S. M. Ross incidence, prevalence and severity of physical and psychological symptoms and what if any relationship exists between medical history, the type of aircraft flown and shift patterns
pilots are assigned to.
Comparisons with previous research on aircrew exposed to engine oil emissions General symptoms.
With regard to general symptoms, the first paper found concerning ill health following exposure to contaminated air was published by Montgomery et al. [8] in 1977. The paper describes a 34 year old military navigator in a Lockheed C-130 Hercules transport aircraft who experienced acute intoxication following inhalation of vaporized or aerosol synthetic lubricating oil from a contaminated air supply. He reported a gradual onset of headache, nausea, dizziness, vomiting, incoordination and lethargy. By the time the plane could be landed he had difficulty standing. The authors conclude that 'further investigation into the potential hazards from inhalation of synthetic oil fumes…is definitely warranted'.
Since then a number of papers have been published which describe acute and chronic symptoms of ill health following reported exposure to contaminated air. The term 'Aerotoxic Syndrome' was proposed by Balouet and Winder [20] in 1999 to describe the association of symptoms observed among aircrew exposed to contaminated air.
The symptoms reported in these papers have much in common with those reported by the pilots we examined. For example, in 2002 Winder et al. [3] published the results of a health survey of 68 Australian and US aircrew who flew the BAe 146 and A320 aircraft types: 88% reported the following symptoms occurred after exposure to contaminated air:
irritation of eye, nose and throat and respiratory system, gastro-intestinal problems and cognitive impairment. Eighty-two per cent reported that these symptoms persisted for 1 month after exposure and 74% reported symptoms persisted for up to 6 months following exposure.
In 2002, Cox and Michaelis [9] published the results of a health survey of 21 Australian BAe 146 aircrew who reported increased cold-like symptoms, running nose and watery eyes, headaches, skin irritation, fatigue and cognitive impairment, which they associated with flying this particular aircraft type. Forty-seven pe cent thought their symptoms were associated with exposure to contaminated air whilst 37% thought their symptoms were a normal part of working on this particular aircraft type.
In 2003, Michaelis [5] published the findings of a survey of 106 British Boeing 757 pilots who reported a similar constellation of symptoms which they associated with flying the Boeing 757 aircraft type because symptoms increased whilst on duty and improved after duty or on days off work.
A 2005 survey by Harper [10] of 60 commercial aircrew found a close temporal relationship between exposure to fumes and the onset of ill health. Symptoms occurred during flight and a number of people were usually affected concurrently; 45% of symptoms reported were neurological, 22% respiratory,

14% fatigue, 10% gastrointestinal, 5% skin and 3% musculoskeletal. Abnormalities detected during medical investigations include reduction in small airway function, diffusing capacity and gas exchange, nasal and vocal cord polyps, neuropathies, cognitive impairment, abnormal brain scans and evoked potentials.

Cognitive function.

With regard to cognitive function, a research team in the US found radiological evidence of organic brain damage in crew complaining of ill health following exposure to contaminated air. Heuser et al. [11] examined 26 North American flight

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123 attendants who presented with a range of disabling physical complaints which had not been thoroughly investigated and had often been trivialized by physicians. Each flight attendant had a neurological examination and a neuropsychological assessment and 12 subjects underwent neuroimaging (PET scans). Neurological abnormalities were detected in 15 flight attendants. Many had impaired balance and coordination and some had developed a movement disorder (postural bilateral tremor). All showed evidence of cognitive impairment. Abnormalities were found in all of the crew who had PET scans, involving imbalance of function between cortical (decrease) and subcortical (increase) areas, frontal (decrease) and occipital (increase) areas; and increased function in some limbic areas, especially the extended amygdale region. Heuser et al. concluded that aircrew, exposed to contaminated air, deserve more medical attention and sophisticated investigations (that is neuroimaging) than is routine and suggested a medical protocol is created which outlines the evaluations that flight personnel should undergo.

A pattern of cognitive deficits, similar to that seen in this study, was described by Coxon

[13] in eight Australian aircrew exposed to oil emissions on the BAe 146. Reduced performance on tests of reaction time, information processing speed, fine motor skills and verbal memory were confirmed.

Limitations of this study

This study has several weaknesses, which should be considered when interpreting the results. Weaknesses include sample size, sample bias, limited indices of exposure and the lack of a matched control group.

The number of participants in this study was relatively small and they were a self-selected sample. Therefore, it is unclear how representative they are of the aviation industry as a whole; and the sample size may be too small for associations between indices of exposure and cognitive function, to be detected. It would have been useful to have a control group of pilots who have not been exposed to contaminated air to determine whether the profile of cognitive strengths and weaknesses observed in this cohort is common amongst pilots or related to lifestyle factors.

Limited indices of exposure were available to us other than pilot's self-report. Air quality monitoring systems need to be developed and placed onboard aircraft to determine the incidence of contaminated air events and the nature of any contaminants involved.

Implications for future research

The above limitations make it impossible to establish or rule out a link between the abnormalities detected and exposure to contaminated air. In order to determine whether such a link exists, a large scale epidemiological survey should be undertaken to establish the prevalence of ill health (physical and psychological symptoms) amongst aircrew and relationship, if any, with working practices and exposure to contaminated air.

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The author reports no conflicts of interest. The author alone is responsible for the content and writing of the paper.
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response

Noted.

The study of S. Mackenzie Ross, like other studies, concludes that "the evidence available in this study does not enable firm conclusions to be drawn regarding a causal link with contaminated air; the cohort of pilots was self-selected and only crude indices of exposure were available. Further research is warranted given the scientific uncertainty regarding the health effects of inhalation of heated or pyrolized engine oil."
We agree with the proposal and recommend medical studies on pilots and cabin crews refer to our conclusions.

comment

81 comment by: *Fédération des transports CGT*

"After the review of the above mentioned on-going research studies conclusions and the analysis of this A-NPA collected information, the Agency will evaluate if the situation actually reveals a safety concern and/or a threat for health of aeroplanes occupants. If deemed necessary, a rulemaking phase could be launched to create new airworthiness standards in order to limit as much as possible the occurrence of this kind of event."

Comment:
We hail the EASA review of studies and the collect of information as extremely positive. We support any demand on the part of the EASA for further information and data as a great step forward to create new airworthiness standards in Europe.
Safety recommendations and standards exist but are not in any way binding and we feel that this issue can no longer be ignored.

Bleed air comes straight off the engines/APU into the cabin/flight deck. Engines/APU sometimes leak oil. Maintenance workers sometimes spill oil. **We ask EASA to issue a directive requiring bleed air cleaning to prevent fume events.**

Even though it is generally accepted that engines/APU sometimes leak oil, the air supply system is not monitored. Pilots must rely on their sense of smell and whether a smoke/fume is present to determine if the air supply system is contaminated, and if it is, with what is it contaminated and whereabouts in the air supply system. This wastes precious time inflight. **We maintain that Pilots need contaminant monitoring in the air supply system with flight deck indication (per ASHRAE aircraft air quality standard 161-2007) to enable them to troubleshoot systems quickly and accurately. Also, contaminant monitoring would assist maintenance workers after landing. Monitoring systems should reduce the costs associated with diversions and delays**

The ASHRAE Aircraft Air Quality Standard 161-2007 (**Contaminant monitoring (Section 7.2):** requires that sensors be installed in the air supply system to monitor for chemicals indicative of oil or hydraulic fluid

contamination. It states that "The
sensors will provide immediate indication of a contaminant to the flight deck. If contaminant levels exceed an agreed upon level, then the sampling data must be entered into the aircraft technical log and made available to crewmembers who experience symptoms consistent with exposure to such fumes within 60 days after the flight. This will provide proof of exposure to affected flight attendants in order to assist their physicians in diagnosis and treatment. We also hope this proof of exposure will help to motivate airlines to prevent contamination events from occurring."

Lastly, we feel that the proposed aircraft quality standard Pr EN 4666 and Pr EN 4618 require major review and modification to include standards and legislation on contaminated cabin air :

The standard defines chemical limits based on "occupational exposure limits and regulatory limits from cognisant authorities"
We feel that the "cognisant authorities" are not relevant authorities. Rather, the limits are industrial exposure limits intended to protect the majority of healthy workers assigned to an 8-hour work day, not the general public or crews assigned to a 14 hour work day, all in an enclosed space at altitude, being supplied with air compressed in the engines that sometimes leak oil.

Both aircraft standards state that formaldehyde exposure shall not exceed 2 parts per million (ppm).
However, the US National Institute for Occupational Safety & Health sets a limit of 0.1 ppm and the German regulatory body (DFG/MAK) sets a 0.3 ppm limit. So, the proposed aircraft standard is 3-20 times higher than industrial limits.

The proposed 4666 standard endorses 2,438 metres (8,000 feet) as a maximum cabin altitude.
This design standard was first issued in 1957 and was applicable to the oxygen needs of fit military pilots.
Many studies since then have recommended 1,523-1,829 m (5,000-6,000 feet) based on the oxygen needs of the flying public.

The 4618 standard (as well as 4666) ignores the potential for exposure to a highly toxic family of chemicals called tricresyl phosphates ("TCPs"). They are used as anti-wear agents in engine oils which sometimes leak into the air supply. TCPs have been found in the cabin/flight deck air/surfaces/aircrew blood

Exposure to oil fumes that contain TCPs and a mixture of other chemicals can cause serious neurological and other impairment. There are many documented cases. **Neither standard addresses the oil fumes hazard, despite it being recognized in aviation since the 1950's.**
As part of this, the standards ignore the health and safety hazards posed by exposure to supply air contaminated with pyrolyzed engine oils and hydraulic fluids.

On page 3 of the proposed 4666, it says: "This standard was developed for the needs of the European Aerospace Industry." It does not seem to have been developed for the safety, health, or comfort needs of either the flying public or the crewmembers that must work in the aircraft environment.

response

Not accepted.

The Agency will not issue a "directive requiring bleed air cleaning". Maintenance procedures and programmes already exist and require air conditioning and bleed air systems regular cleaning. Operators shall follow those procedures. Issuing a directive would not bring an additional benefit over existing requirements.

Bleed air monitoring: although we cannot mandate such system today, we recommend studies to be conducted in order to determine how this could be put in place in the future, should a decision be taken that it is required. Refer to our conclusions.

EN4618 provides the available cabin air contaminants limits based on the best existing scientific knowledge and norms.

Concerning TCP, this compound is listed as part of oils, lubricants and hydraulics sources (table 1); however, it is true that no exposure limits are provided. Meanwhile, the Agency is aware that many countries use an average limit of 0.1mg/m3 (over an 8 hours workshift) based on the tri-ortho-isomer toxicity. However, we do not know on which basis this limit has been established. It is nevertheless provided by OSHA, NIOSH, ACGIH. Further study is probably needed to consolidate safety and health limits, especially in an aeroplane cabin pressure and ventilation environment.

PrEN4666 provides for pressure conditions, thermal conditions, humidity conditions, noise and vibration standards. Therefore, this document is complementary to EN4618 and it is not relevant when recommending contaminants standards.

comment

89 comment by: *UK CAA*

Section 12, Objective of the A-NPA

Paragraph 1 "… engine or APU remain relatively rare …"

Comment: The COT Report gives an estimate of the event rate of 0.05% of flights.

Justification: Updated information.

Proposed Text: "… cabin air contamination by engine or APU remain relatively rare (0.05% of flights) and among these events …"

response

Partially accepted.

The Agency keeps the reference to the source when providing a rate of events. The 0.05% rate is an estimation of the COT based on data provided by three airlines.

comment

102 comment by: *cfdt france*

What contaminants are released to the cabin and in which quantity?

What is the effect on flight safety?

Can it induce a health concern?

What is the frequency of this kind of event?
ETF Comment : There has been and is still great difficulty in collecting and interpreting the mounting data and identifying toxic/irritant products in oil substances used in the airline industry. The physiological effects of gases and vapours in cabin air is now becoming clear and the defining of maximum acceptable quantities or concentrations must become a subject for legislation and standards.

ETF comment : "What contaminants are released to the cabin and in which quantity"?
The ETF Cabin crew committee refer to statements published by Dr. Mackerer in 1999 and to the Henschler report in 1958 "Engine oils contain a mixture of tricresylphosphates, of which
TOCP in not the most toxic".
TOCP is NOT the only ortho isomer in TCP - the more toxic MOCP& DOCP are in the oil in far higher quantities.
Mobil advised the Australian Senate Inquiry that the ortho isomers were in the TCP in it's oil at >0.3%. The more toxic MOCP & DOCP were not mentioned.
ORTHO isomers divide into: **TOCP**, **DOCP** and **MOCP**.
Focus has been on TOCP with UK House of Lords and CAA reports of 2000 and 2004. These reports fail to ever mention DOCP or MOCP.

TOCP 0.006 ppm Toxicity factor x 1
DOCP 6 ppm Toxicity factor x 5
MOCP 3070 ppm Toxicity factor x 10

In ignoring DOCP and MOCP the total ORTHO toxicity is underestimated by a factor of **6.14 million** which has been known since 1958 (Henschler).

It has been known for years that when aviation engine oils are heated, a potent neurotoxic chemical called TMPP (trimethylolpropane phosphate) can be formed. TMPP is even worse than TCPs and exposure is associated with epileptic type seizures, convulsion, tremors, and changes to social/emotional behaviors. To the knowledge of ETF , it has never been found on aircraft. But to ETF's knowledge, nobody has ever looked for into this..
A 1989 US Navy report stating that Exxon 2380 (now BP2380) generated high levels of TMPP when it was heated to temperatures at or above 350C. The TCPs in the oil react with TMP chemicals in the "base stock" of the oil. **The levels of TMPP were so significant that the authors recommended that Exxon 2380 not be used on US naval vessels. But BP2380 is still widely used in commercial aviation**.

A 1996 US Air Force paper raised concerns about the potential for being exposed to highly toxic TMPP, and stated that TMPP could be formed when oils that contain TCPs and TMP are heated to temperatures as low as 250C. This is important because these temperatures are more likely to be reached in the engine/bleed air system. Wright also stated that TMPP can NOT be formed if the engine oil base stock contains PE chemicals instead of TMP. *WRIGHT R. L. Formation of the neurotoxin TMPP from TMPE-phosphate formulations - Tribiology transactions 1996, vol. 39, no4, pp. 827-834*

Another US navy report in 1992 also expressed concern about the hazards
1) What engine oil(s) are used (e.g., Mobil Jet Oil II, BP2380, etc).
2) What APU and engine types are installed on what aircraft types (e.g. Pratt Whitney 4000, Honeywell Series 85, etc).

Oils and lubricants used on the aircraft and in the engines contain not only the neurotoxins (TCPs and triphenylphosphates) but **sensitizers (N-phenyl-L-naphthylamine, PAN),** and **asphyxiants (carbon monoxide**).. Pyrolysis studies have confirmed the presence of these toxins when commercial oils are heated (van Netten, 2000; Marshman, 2001; Fox, 2001). A Material SafetyData Sheet for engine oils acknowledge only the TCP content and the fact that "toxicfumes may be evolved on burning or exposure to heat" (BP, 2001).

ETF cabin crew committee ask that Studies include the potential impact of exposure to the mixture of these and other chemicals in a reduced pressure environment.
ETF Suggests that the EASA review all data and see if a less toxic alternative oil can be recommended that would be compatible with given aircraft engines/APUs.
Ultimately, all of the engine oils should be analyzed for their base stock content (rather than relying on the analysis of the oil companies), as well as for the potential to form TMPP, and temperature range of TMPP formation.

ETF Comment : "What is the effect on flight safety"?
The ETF Cabin crew committee refers to the following statements and documents:

2001: "Incidents have been reported of impaired performance of flight crew…events could have been
caused by inhalation of agents… leaking from oil or APU and contaminating the Environmental control
system."
(CAA AD 002-03-2001)

2002: "oil leaks and cabin / flight deck odours must be regarded as a potential threat to flight safety, theyshould not be dismissed as a mere nuisance and should be addressed as soon as possible."
(BAe ISB 21-150 2001 / ISB 21-156, 2002)

2003: "Any oil leaking from an engine, entering the aircraft customer bleed offtake, is classified as
HAZARDOUS"
(Rolls Royce, Germany 2003, BRE air quality Conference, London)

2004: "This amendment adopts a new airworthiness directive (AD), applicable to all BAE Systems
(Operations) Limited Model BAe 146 series airplanes, that requires repetitive detailed inspections of the inside of each air conditioning sound-attenuating duct, and corrective actions as necessary. This action is necessary to prevent impairment of the operational skills and abilities of the flightcrew caused by the inhalation of agents released from oil or oil breakdown products, which could result in reduced controllability of the airplane. This action is intended to address the identified unsafe condition."
(FAA AD 2004-12-05)

2006: "The serious incident is attributable to the fact that on approach to Zurich Airport the cockpit filled with fumes which caused a toxic effect, leading to a limited capability of acting of the copilot. These fumes were caused by an oil leak as a result of a bearing damage in engine No. 1" "The
medical examination of the copilot after the flight showed that during the flight

toxic exposure took place."
(Swiss Federal Department of Environment, Transport Energy and Communications Investigation Report No u1884 by the Aircraft Accident Investigation Bureau, 2 March 2006)

TheETF Cabin crew committee also refers the EASA to the manual written by Prof. S. Michaelis, (renowned expert on Cabin air contamination): "*Aviation Contaminated Air Reference Manual,*" Michaelis, S., ed. ISBN 9780955567209, London,

ETF comment : "Can it induce a health concern?"
The ETF Cabin committee feel that there is now sufficient available material and literature on cabin air being contaminated by toxic substances used on the aircraft. Studies are now available giving indications that the health of aircraft occupants may be severely affected by the inhalation & contact with gases and vapours of lubricants, anti-freeze agents and others.

ETF refers the EASA to the following statements and studies :

"individuals exposed to a single large toxic dose, or to small subclinical doses, of ***organophosphorus compounds***have developed a chronic neurotoxicity that persists for years after exposure and is distinct from both cholinergic and OPIDN"(AbouDonia, 2003; *Arch. Environ. Health***58**:484-97).

- Abou-Donia MB (2004) Organophosphorus ester-induced chronic neurotoxicity. Archives of Environmental Health 58:484–497
- Organophosphate Ester Induced Chronic Neurotoxicity (OPICN)- Mohamed B Abou-Donia : Proceedings of the BALPA 'Contaminated Air Protection Air Safety and Cabin Air Quality International Aero Industry Conference'. Held at Imperial College, London, 20-21 April 2005: ISBN 0-7334-2282-9
- Journal of Occupational Health & Safety, Australia & New Zealand, Vol 21, Number 5 ,August 2005 - Special edition: New findings in aircrew exposed to airborne contaminants: Long-term health effects confirmed. - Organophosphate Ester Induced Chronic Neurotoxicity (OPICN)- Mohamed B Abou-Donia

1981: Engine Lube Oil: "At temperatures above 320C this oil breaks down into irritating and toxic compounds."
(SAE Aviation Information Report: 1539, issued 1-30-81)
1983: "All of these toxic substances (includes engine oil) have acute and long-term effects"
(Rayman R.B., McNaughton G.B. Smoke/fumes in the cockpit. Aviation, Space and Environmental
Medicine, August 1983, pp 738-740. Current Director of the Aerospace Medical Association)
1998: "Repeated low level exposure leads to cumulative toxicity." (1981 ed)
"Acute and repeated exposure can produce harmful effects in man, and it has been suggested that chronic exposure at lower doses may cause long-term ill health." (1998 ed)
(UK HSE: Organophosphates: HSE: MS17: Medical aspects of occupational exposures to organophosphates. Draft revision 23, November, 1998.)
1999: "Neuropsychological outcomes - Neuropsychological abnormalities can occur as a long-term complication of acute OP poisoning"
(UK COT report. Long term sequelae of acute poisoning: 1999. Committee on Toxicity of Chemicals in Food, Consumer Products and the Environment:

Organophosphates: Executive Summary. Published by the Department of Health, 1999, London)
1999: "The inhalation of mist (containing tricresylphosphate) which can be produced by high pressure systems, or direct contact with the skin, would be hazardous."
(UK Government Hansard 66599, 4 February 1999, column 737)
1999: "TCP is toxic"
(UK Government: Hansard 82322 6 May 1999 : Column: 428)
2000: "With the weight of human evidence and suffering, which is quite clear, there must be something there" "There is absolutely no doubt in our mind that there is a general health issue here"
(BAe Systems verbal evidence to Australian senate Inquiry 2000)
2001: "Incidents have been reported of impaired performance of flight crew…events could have been caused by inhalation of agents… leaking from oil or APU and contaminating the Environmental control system."
(CAA AD 002-03-2001)
2002: "oil leaks and cabin / flight deck odours must be regarded as a potential threat to flight safety, they should not be dismissed as a mere nuisance and should be addressed as soon as possible."
(BAe ISB 21-150 2001 / ISB 21-156, 2002)

2002: "FAA rulemaking has not kept pace with public expectation and concern about air quality and doesnot afford explicit protection from particulate matter and other chemical and biological hazards." "No present airplane design fulfills the intent of 25.831 because no airplane design incorporates an air
Contaminant monitoring system to ensure that the air provided to the occupants is free of hazardous contaminants"
2003: "Any oil leaking from an engine, entering the aircraft customer bleed offtake, is classified as HAZARDOUS"
(Rolls Royce, Germany 2003, BRE air quality Conference, London)
2003: "It is found that the sound attenuating material used in the air-conditioning ducts can absorb oil and can become a source of persistent air contamination."
(CASA AD /BAe 146/102, 23 January 2003)
2004: "In the event of oil leakage there is the opportunity, therefore, for the pyrolysis products of engine lubricant/fuel to enter the cabin air supply and exert toxic effects on both passengers and crew."
(CAA Air Quality report 2004)
2004: "This amendment adopts a new airworthiness directive (AD), applicable to all BAE Systems (Operations) Limited Model BAe 146 series airplanes, that requires repetitive detailed inspections of the inside of each air conditioning sound-attenuating duct, and corrective actions as necessary. This action is necessary to prevent impairment of the operational skills and abilities of the flightcrew caused by the inhalation of agents released from oil or oil breakdown products, which could result in reduced controllability of the airplane. This action is intended to address the identified unsafe condition."
(FAA AD 2004-12-05)
2005: "Both Flight Crew Affected By Sore Throats And Other Symptoms After Flight." "Smells and irritants from burning organic compounds from within the engines are known to produce harmful volatile organic contaminants."
(UK Airline Air Safety Report, ASR G-CFAH, 4 July 2005)
2007: "Mobil Jet Oil II- Known to be harmful"
(CASA: AIR SAFETY & CABIN AIR QUALITY - Jim Coyne – A/g General Manager Manufacturing, Certification & New Technologies Office: 2007 presentation)
2007: "A35-12: Protection of the health of passengers and crews and prevention of the spread of

communicable disease through international travel
-*Declares* that the protection of the health of passengers and crews on international flights is an integral element of safe air travel and that conditions should be in place to ensure its preservation in a timely and cost-effective manner;
-*Requests* the Council to support further research on the consequences of air transport on the health of passengers and crews"
(ICAO- Aviation Medicine (Med) Section Related ICAO Resolutions, 5 July 2007) http://www.icao.int/icao/en/assembl/a36/wp/wp022_en.pdf
2007: "I call on the government to reveal whether information about defects has been withheld from the regulator, the courts or the parliament"
"I am gravely concerned that crew and passengers of BAe146 aircraft have been exposed to dangerous fumes produced by engine defects"
(Senate Hansard: Monday, 13 August 2007, Senator O'Brien
2009: "Product may decompose at elevated temperatures or under fire conditions and produce harmful gases or vapours. Vapours or mist of heated product may be harmful by inhalation."
R 63.G3 Possible risk of harm to the unborn child.
R 62.F3 Possible risk of impaired fertility.
(NYCO MSDS 2009 , TURBONYCOIL 600)
2009: "Product may decompose at elevated temperatures or under fire conditions and give off irritating and/or harmful (carbon monoxide) gases/vapours/fumes. Symptoms from acute exposure to these decomposition products in confined spaces may include headache, nausea, eye, nose, and throat irritation."
(Mobil MJO2 MSDS EU 2009)
2009: Plus Minus: "Is inhaling of tricresyl phosphate (TCP) safe or dangerous?"
Professor D henschler (1958 TCP researcher): "I believe it to be dangerous."
(German TV: Plus Minus, March 2009)
2009: "Does the German Government believe that inhaling of heated engine oil fumes is harmless for the health of crew and passengers?". Answer "No"
German Ministry of Transport, Secretary of State Ulrich Kasparick.
(Question to MP Winfried Hermann of Bundnis90/Greenparty in regards to contaminated cabin air on board of civil airliners, printed matter 16/12023, 3 March 2009)
2009 "Smoke from pyrolysed oil can be hazardous to the eyes, mucous membranes and lungs"
(Turner V Eastwest Airlines [2009] NSWDDT 5 May 2009 , Australian Court)

2009: "Smoke or fumes in the flight deck or passenger cabin present the crew with a potentially hazardous situation"
AAIB Bulletin 6/2009 G-BYAO B757, EW/C2006/10/08

Bobb, A.J. and Still, K.R. (2003) "Known Harmful Effects of Constituents of Jet Oil Smoke," TOXDET-03-04, Naval Health Research Center Detachment (Toxicology), Wright-Patterson AFB, OH

Winder, C; Fonteyn, P; Balouet, JC. (2002) "Aerotoxic syndrome: a descriptive epidemiological survey of aircrew exposed to in-cabin airborne contaminants" J Occup Health Safety – Austr New Zealand, 18(4): 321-328

Winder, C. (2006) Hazardous chemicals on jet aircraft: Case study – Jet engine oils and aerotoxic syndrome. Current Topics in Toxicology. Vol 3, 2006

2008 -- Cognitive function following exposure to contaminated air on

commercial aircraft: A case series of 27 pilots seen for clinical purposes -- S Mackenzie Ross -- Journal of Nutritional &Environmental Medicine -- June 2008; 17(2): 111–126 ***PDF File***

2006 -- Hazardous Chemicals on Jet Aircraft: Case Study-Jet Engine Oils and Aerotoxic Syndrome, -- C.Winder -- Current Topics in Toxicology. Vol 3 2006

The neuro-toxicity of products used in lubricants and other substances in the aircraft engines seem to provoke Long-term health problems including :

- Neurological effects: CNS,PNS: Jamal 1997, Jamal, Julu… 2002, 2005
- Autonomic nervous system effects: Jamal, Julu… 2002, 2005
- Working memory / cognitive problems. (neuropsychological), Coxon 2002 / Mackenzie Ross 2006
- Chronic neurotoxicity (OPICN): Abou-Donia 2004, 2005
- Neuronal brain cell death: Abou-Donia
- Respiratory disorders: Burdon, Glanville 2005
- Immune system effects, fatigue, chemical sensitivity etc..
- Blood pathology disorders
- Strong occupational link: Cone 1983,1999 / Harper 2005
- Individual susceptibility: Furlong
  - TCP Blood test: 6 of 10 TCP isomers are converted into the highly toxic metabolite – psp: that inhibits the activity of a number of important enzymes.
  - Gene expression: Gene expression effected by TCP at levels found in UK pilots' blood.

The US Federal Aviation Administration (FAA) has acknowledged that "no present airplane design fulfils the intent of [federal aviation regulation] 25.831 because no airplane design incorporates an air contaminant monitoring system to ensure that the air provided to the occupants is free of hazardous contaminants" (FAA, 2002),

ETF points out that there is a sizable (and growing) body of literature on the association between exposure to oil fumes and acute and chronic symptoms reported globally by crews and passengers alike (ACARM, 2007). The ETF CCC feels there is ample justification for regulations that dictate bleed air cleaning and monitoring with flight deck indication to: (1) prevent exposure to oil fumes; (2) alert crewmembers if they are exposed inflight; and (3) enable maintenance workers to more effectively identify and remedy the contamination upon landing.

response

Noted.

1) Contaminants: Partially accepted.
Aviation oils toxicity knowledge can be improved and we have recommended studies to be conducted in this domain. The special cabin environment should be taken into account in those studies.

Analysis of all engine oils base stock content: The Agency could not do that because the Agency does not regulate aviation fluids, and therefore we do not inspect oil manufacturers' productions. Nevertheless, the specified toxic compounds and their concentrations are provided to the engine manufacturers which then conduct a safety analysis to verify that no hazardous quantities are

released in the bleed air for identified failure scenarios. The Agency then reviews this analysis.

2) Effect on flight safety: Noted.

3) Effect on health: Not accepted.
Studies performed until today failed to demonstrate that cabin air can be contaminated in such a way that it could induce a safety or health issue. Cabin measurements found non-detectable or barely detectable levels of toxic contaminants. Concerning the symptoms reported by some crews or passengers: they are too generic to be directly linked to a toxic substance, although this is not rejected. Further investigation into this issue is recommended.

comment *103* comment by: *cfdt france*

ETF comment : The ETF Cabin crew committee hail the EASA review of studies and the collect of information as extremely positive. We support any demand on the part of the EASA for further information and data as a great step forward to create new airworthiness standards in Europe.
Safety recommendations & standards exist but are not in any way binding & the ETF feel that this issue can no longer be ignored.

Bleed air comes straight off the engines/APU into the cabin/flight deck. Engines/APU sometimes leak oil. Maintenance workers sometimes spill oil. The **ETF asks EASA to issue a directive requiring bleed air cleaning to prevent fume events.**

Even though it is generally accepted that engines/APU sometimes leak oil, the air supply system is not monitored. Pilots must rely on their sense of smell and whether a smoke/fume is present to determine if the air supply system is contaminated, and if it is, with what is it contaminated and whereabouts in the air supply system. This wastes precious time inflight. **The ETF Maintain that Pilots need contaminant monitoring in the air supply system with flight deck indication (per ASHRAE aircraft air quality standard 161-2007) to enable them to troubleshoot systems quickly and accurately. Also, contaminant monitoring would assist maintenance workers after landing. Monitoring systems should reduce the costs associated with diversions and delays**

The ASHRAE Aircraft Air Quality Standard 161-2007 (**Contaminant monitoring (Section 7.2):** requires that sensors be installed in the air supply system to monitor for chemicals indicative of oil or hydraulic fluid contamination. It states that "The
sensors will provide immediate indication of a contaminant to the flight deck. If contaminant levels exceed an agreed upon level, then the sampling data must be entered into the aircraft technical log and made available to crewmembers who experience symptoms consistent with exposure to such fumes within 60 days after the flight. This will provide proof of exposure to affected flight attendants in order to assist their physicians in diagnosis and treatment. We also hope this proof of exposure will help to motivate airlines to prevent contamination events from occurring."

Lastly , ETF Cabin Crew Committee feel that the proposed aircraft quality standard Pr EN 4666 and Pr EN 4618 require major review and

modification to include standards and legislation on contaminated cabin air :

The standard defines chemical limits based on "occupational exposure limits and regulatory limits from cognisant authorities"
ETF feel that the "cognisant authorities" are not relevant authorities. Rather, the limits are industrial exposure limits intended to protect the majority of healthy workers assigned to an 8-hour work day, not the general public or crews assigned to a 14 hour work day, all in an enclosed space at altitude, being supplied with air compressed in the engines that sometimes leak oil.

Both aircraft standards state that formaldehyde exposure shall not exceed 2 parts per million (ppm).
However, the US National Institute for Occupational Safety & Health sets a limit of 0.1 ppm and the German regulatory body (DFG/MAK) sets a 0.3 ppm limit. So, the proposed aircraft standard is 3-20 times higher than industrial limits.

The proposed 4666 standard endorses 2,438 metres (8,000 feet) as a maximum cabin altitude.
This design standard was first issued in 1957 and was applicable to the oxygen needs of fit military pilots.
Many studies since then have recommended 1,523-1,829 m (5,000-6,000 feet) based on the oxygen needs of the flying public.

The 4618 standard (as well as 4666) ignores the potential for exposure to a highly toxic family of chemicals called tricresyl phosphates ("TCPs"). They are used as anti-wear agents in engine oils which sometimes leak into the air supply. TCPs have been found in the cabin/flight deck air/surfaces/aircrew blood

Exposure to oil fumes that contain TCPs and a mixture of other chemicals can cause serious neurological and other impairment. There are many documented cases. **Neither standard addresses the oil fumes hazard, despite it being recognized in aviation since the 1950s.**
As part of this, the standards ignore the health and safety hazards posed by exposure to supply air contaminated with pyrolyzed engine oils & hydraulic fluids.

On page 3 of the proposed 4666, it says: "This standard was developed for the needs of the European Aerospace Industry." It does not seem to have been developed for the safety, health, or comfort needs of either the flying public or the crewmembers that must work in the aircraft environment.

response

Not accepted.

The Agency will not issue a "directive requiring bleed air cleaning". Maintenance procedures and programmes already exist and require air conditioning and bleed air systems regular cleaning. Operators shall follow those procedures. Issuing a directive would not bring an additional benefit over existing requirements.

Bleed air monitoring: although we cannot mandate such system today, we recommend studies to be conducted in order to determine how this could be put in place in the future, should a decision be taken that it is required. Refer

to our conclusions.

EN4618 provides the available cabin air contaminants limits based on the best existing scientific knowledge and norms.

Concerning TCP, this compound is listed as part of oils, lubricants and hydraulics sources (table 1); however, it is true that no exposure limits are provided. Meanwhile, the Agency is aware that many countries use an average limit of 0.1mg/m3 (over an 8 hours workshift) based on the tri-ortho-isomer toxicity. However, we do not know on which basis this limit has been established. It is nevertheless provided by OSHA, NIOSH, ACGIH. Further study is probably needed to consolidate safety and health limits, especially in an aeroplane cabin pressure and ventilation environment.

PrEN4666 provides for pressure conditions, thermal conditions, humidity conditions, noise and vibration standards. Therefore, this document is complementary to EN4618 and it is not relevant when recommending contaminants standards.

comment

122 comment by: *CUD*

"After the review of the above mentioned on-going research studies conclusions and the analysis of this A-NPA collected information, the Agency will evaluate if the situation actually reveals a safety concern and/or a threat for health of aeroplanes occupants. If deemed necessary, a rulemaking phase could be launched to create new airworthiness standards in order to limit as much as possible the occurrence of this kind of event."

Comment:
We hail the EASA review of studies and the collect of information as extremely positive. We support any demand on the part of the EASA for further information and data as a great step forward to create new airworthiness standards in Europe.
Safety recommendations and standards exist but are not in any way binding and we feel that this issue can no longer be ignored.

Bleed air comes straight off the engines/APU into the cabin/flight deck. Engines/APU sometimes leak oil. Maintenance workers sometimes spill oil. **We ask EASA to issue a directive requiring bleed air cleaning to prevent fume events.**

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Lastly, we feel that the proposed aircraft quality standard Pr EN 4666 and Pr EN 4618 require major review and modification to include standards and legislation on contaminated cabin air :

The standard defines chemical limits based on "occupational exposure limits and regulatory limits from cognisant authorities"
We feel that the "cognisant authorities" are not relevant authorities. Rather, the limits are industrial exposure limits intended to protect the majority of healthy workers assigned to an 8-hour work day, not the general public or crews assigned to a 14 hour work day, all in an enclosed space at altitude, being supplied with air compressed in the engines that sometimes leak oil.

Both aircraft standards state that formaldehyde exposure shall not exceed 2 parts per million (ppm).
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Many studies since then have recommended 1,523-1,829 m (5,000-6,000 feet) based on the oxygen needs of the flying public.

The 4618 standard (as well as 4666) ignores the potential for exposure to a highly toxic family of chemicals called tricresyl phosphates ("TCPs"). They are used as anti-wear agents in engine oils which sometimes leak into the air supply. TCPs have been found in the cabin/flight deck air/surfaces/aircrew blood

Exposure to oil fumes that contain TCPs and a mixture of other chemicals can cause serious neurological and other impairment. There are many documented cases. **Neither standard addresses the oil fumes hazard, despite it being recognized in aviation since the 1950's.**
As part of this, the standards ignore the health and safety hazards posed by exposure to supply air contaminated with pyrolyzed engine oils and hydraulic fluids.

On page 3 of the proposed 4666, it says: "This standard was developed for the needs of the European Aerospace Industry." It does not seem to have been developed for the safety, health, or comfort needs of either the flying public or the crewmembers that must work in the aircraft environment.

response

Not accepted.

The Agency will not issue a "directive requiring bleed air cleaning". Maintenance procedures and programmes already exist and require air conditioning and bleed air systems regular cleaning. Operators shall follow those procedures. Issuing a directive would not bring an additional benefit over existing requirements.

Bleed air monitoring: although we cannot mandate such system today, we recommend studies to be conducted in order to determine how this could be put in place in the future, should a decision be taken that it is required. Refer to our conclusions.

EN4618 provides the available cabin air contaminants limits based on the best existing scientific knowledge and norms.

Concerning TCP, this compound is listed as part of oils, lubricants and hydraulics sources (table 1); however it is true that no exposure limits are provided. Meanwhile, the Agency is aware that many countries use an average limit of 0.1mg/m3 (over an 8 hours workshift) based on the tri-ortho-isomer toxicity. However, we do not know on which basis this limit has been established. It is nevertheless provided by OSHA, NIOSH, ACGIH. Further study is probably needed to consolidate safety and health limits, especially in an aeroplane cabin pressure and ventilation environment.

PrEN4666 provides for pressure conditions, thermal conditions, humidity conditions, noise and vibration standards. Therefore, this document is complementary to EN4618 and it is not relevant when recommending contaminants standards.

comment

138 comment by: *Susan Michaelis*

Attachment #13

comment 1 Today, the events of cabin air contamination by engine or APU remain relatively rare, and among these events the proportion for which flight crew performance degradation has been reported is very low. Since the entry into service of the first jet airliners in the 1950's, there has never been any single catastrophic record caused by this kind of event. Concerning health, there is no known scientifically proven case of serious illness attributed to exposition to cabin air contamination by engine/APU. Among the reported events, a major part have been generated by two aeroplane types for which mandatory measures have been taken to mitigate the occurrence of ECS contamination by engine or APU oil. Thus, based on available evidence, the current overall risk of this kind of event could be considered acceptable.

proposed text: This whole section needs to be rewritten. It is totally unacceptable.

Justification: There are no contaminated air detection systems. There is a large body of evidence showing contaminated air events are occuring & under-reporting is a major problem. Therefore it is purer speculation to suggest such events are rare. It is not acceptable to rely on a filaed reporting system.

It is not correct to suggest that of the known suspected contaminated air events, impairment or flight crew degradation remains low. Clearly EASA has

not refered to:Michaelis S. (2007) Aviation Contaminated Air Reference Manual. ISBN 9780955567209, ch 2,6,,8,9,12.17.....& appx 2,6,7..... or other published papers. Any form of adverse effect related to suspected contaminated air contravenes ES 25.831 a/b as per EASA regulations & EASA communications.

The public is entitled to more than simply being protected from fatal accidents. The regulations protect against impairment due to contaminated air & are not being adhered to or enforced. You cannot state positively that no fatal accident has occurred due to contaminated air as aircraft do NOT have detection systems fitted to identify contaminated air. There is ample evidence that regular incidents are occuring during contaminated air events, including serious incidents. Flight safety is compromized whenever a contaminated air events occurs as per BAe SB 21-150/156 and related ADs. This is of course applicable to all aircraft suffering contaminated air events.

It is totally inapprorpiate to dimish the reported health effects related to contaminated air based on lack of scientifically identifiable disease. There is a vast amout of data related to short and long-term health effects and much of this is related to inhalation of substances in the contaminated air. Any adverse effects are relevent, short-term effects are acknowledged and short-term effects can lead to long-term effects. Inhalation of hydrocarbons for example are known to injure the lungs. EASA has done NOTHING to investigate the short and long-term health effects, despite much published data. The Broad Street Pump was turned off in 1854, 30 years before cholera was identified as the scientific problem, however the outbreak was stopped by taking preventative action based on best evidence.

Contaminated air may well be a bigger problem on some aircraft than others, however all aircraft using bleed air suffer the problem, there is evidence to support this and the under-reporting problem should not be used to justify that all is aceptable with other aircraft experiencing bleed air contamination. The actions taken on the BAe 146 and B757 have not stopped the problems, under-reporting is continuing and any contaminated bleed air is contrary to the airworthiness regulations including CS 25.831. Therefore actions taken should apply to all aircraft so contaminated air is readily identified and addressed.

The current overall risk is far from acceptable. The evidence is overwhelming showing this is not the case. it is negligent to suggest this is the case, given the evidence that has been available over many years and indicates the view of a regulator turning a blind eye.

Contaminated air occurs as a function of the design and maintenance factors of using bleed air to supply the cabin air and as such the fact that this can occur, is occuring is the issue and not how often based on a broken reporting system.

The FAA states:
'No present airplane design fulfills the intent of 25.831 because no airplane design incorporates an air contaminant monitoring system to ensure that the air provided to the occupants is free of hazardous contaminants. ' FAA (2002) “Recommendation 1: Air quality and ventilation” From the FAA response to the US National Research Council. Federal Aviation Administration, Washington, DC. See:
http://www.faa.gov/safety/programs_initiatives/aircraft_aviation/cabin_safety/

	rec_impl/media/r1_Air_Quality_Ventilation.rtf Comment 2. The Agency has exercised its competence related to aircraft design already by including in CS-25 some provisions related to this issue, namely the ones on cabin air quality, as referred above. Proposed text: CS 25.831, while in theory protecting harmful and hazardous levels of contaminants, is not being interpreted correctly, adhered to or enforced and requires revision. Justification There is a huge amount of evidence showing CS 25.831 a/b is not being met. Adverse effects related to suspected contaminated air or identified contaminated air are occuring (undue discomfort and fatigue) and as there are no detection systems on aircraft, it is not possible to identify what levels are being experienced. Any contaminant leading to discomfort or fatigue/ adverse effects is deemed harmful or above. The FAA states: 'No present airplane design fulfills the intent of 25.831 because no airplane design incorporates an air contaminant monitoring system to ensure that the air provided to the occupants is free of hazardous contaminants. ' FAA (2002) "Recommendation 1: Air quality and ventilation" From the FAA response to the US National Research Council. Federal Aviation Administration, Washington, DC. See: http://www.faa.gov/safety/programs_initiatives/aircraft_aviation/cabin_safety/rec_impl/media/r1_Air_Quality_Ventilation.rtf EASA has stated:*'If there is a proven bleed air contamination (engine oils or hydraulic fluids) causing undue discomfort or fatigue, this does not meet 25.831.'* Email from Eric Duvivier, European Aviation Safety Agency, to Captain Tristan Loraine, CAQTG, BALPA. 14 January 2006. For further information: see: Michaelis S. (2007) Aviation Contaminated Air Reference Manual. ISBN 9780955567209, Published papers: http://www.aopis.org/ScientificReports.html it is quite clear that EASA has little understanding of the contaminated air issue, despite being advised of it for some years. EASA has demonstrated a strong industry reliance upon the airline industry for it's information and clearly lacks independent expertise. This can no longer remain unaddressed.
response	Not accepted. Comment 1: The Agency accepts the possibility that the minor events may be underreported by some organisations, probably because these events are considered as nuisance (e.g. temporary bad odours or smells), and therefore they are not considered as safety related occurrences which must be reported. Concerning the serious events involving a degree of crew or passengers' impairment or incapacitation, we believe they are reported and their number remains very limited. A regulation is already in place for this category of events through Directive 2003/42/EC of 13 June 2003 on occurrence reporting in civil aviation: it clearly identifies failures of engines or APU resulting in "Dense visible fumes or concentrations of toxic products sufficient to incapacitate crew or passengers". It is the responsibility of each Member State

to ensure that stakeholders comply with this Directive. The Agency does not intend to create another mandatory reporting system.

Comment 2: It is worth to be reminded that CS 25.831 is not the only relevant applicable rule for certification. The certification specifications for engines and APUs also requires a safety analysis to be conducted which shall consider the risk of contamination of cabin air by toxic compounds from engine or APU; this case is classified Hazardous in the safety analysis when concentrations are sufficient to incapacitate crew or passengers. In addition, a test is required to verify that the bleed air is not contaminated (purity test). Refer to CS-E 510 and CS-E 690 (Certification Specifications for engines), CS-APU 210 and CS-APU 320 (Certification Specifications for auxiliary power unit).

comment

153 comment by: *kapers Cabin Crew Union*

"After the review of the above mentioned on-going research studies conclusions and the analysis of this A-NPA collected information, the Agency will evaluate if the situation actually reveals a safety concern and/or a threat for health of aeroplanes occupants. If deemed necessary, a rulemaking phase could be launched to create new airworthiness standards in order to limit as much as possible the occurrence of this kind of event."

Comment:
We hail the EASA review of studies and the collect of information as extremely positive. We support any demand on the part of the EASA for further information and data as a great step forward to create new airworthiness standards in Europe.
Safety recommendations and standards exist but are not in any way binding and we feel that this issue can no longer be ignored.

Bleed air comes straight off the engines/APU into the cabin/flight deck. Engines/APU sometimes leak oil. Maintenance workers sometimes spill oil. **We ask EASA to issue a directive requiring bleed air cleaning to prevent fume events.**

Even though it is generally accepted that engines/APU sometimes leak oil, the air supply system is not monitored. Pilots must rely on their sense of smell and whether a smoke/fume is present to determine if the air supply system is contaminated, and if it is, with what is it contaminated and whereabouts in the air supply system. This wastes precious time inflight. **We maintain that Pilots need contaminant monitoring in the air supply system with flight deck indication (per ASHRAE aircraft air quality standard 161-2007) to enable them to troubleshoot systems quickly and accurately. Also, contaminant monitoring would assist maintenance workers after landing. Monitoring systems should reduce the costs associated with diversions and delays**

The ASHRAE Aircraft Air Quality Standard 161-2007 (**Contaminant monitoring (Section 7.2):** requires that sensors be installed in the air supply system to monitor for chemicals indicative of oil or hydraulic fluid contamination. It states that "The
sensors will provide immediate indication of a contaminant to the flight deck. If contaminant levels exceed an agreed upon level, then the sampling data must be entered into the aircraft technical log and made available to crewmembers who experience symptoms consistent with exposure to such fumes within 60 days after the flight. This will provide proof of exposure to

affected flight attendants in order to assist their physicians in diagnosis and treatment. We also hope this proof of exposure will help to motivate airlines to prevent contamination events from occurring."

Lastly, we feel that the proposed aircraft quality standard Pr EN 4666 and Pr EN 4618 require major review and modification to include standards and legislation on contaminated cabin air :

The standard defines chemical limits based on "occupational exposure limits and regulatory limits from cognisant authorities"
We feel that the "cognisant authorities" are not relevant authorities. Rather, the limits are industrial exposure limits intended to protect the majority of healthy workers assigned to an 8-hour work day, not the general public or crews assigned to a 14 hour work day, all in an enclosed space at altitude, being supplied with air compressed in the engines that sometimes leak oil.

Both aircraft standards state that formaldehyde exposure shall not exceed 2 parts per million (ppm).
However, the US National Institute for Occupational Safety & Health sets a limit of 0.1 ppm and the German regulatory body (DFG/MAK) sets a 0.3 ppm limit. So, the proposed aircraft standard is 3-20 times higher than industrial limits.

The proposed 4666 standard endorses 2,438 metres (8,000 feet) as a maximum cabin altitude.
This design standard was first issued in 1957 and was applicable to the oxygen needs of fit military pilots.
Many studies since then have recommended 1,523-1,829 m (5,000-6,000 feet) based on the oxygen needs of the flying public.

The 4618 standard (as well as 4666) ignores the potential for exposure to a highly toxic family of chemicals called tricresyl phosphates ("TCPs"). They are used as anti-wear agents in engine oils which sometimes leak into the air supply. TCPs have been found in the cabin/flight deck air/surfaces/aircrew blood

Exposure to oil fumes that contain TCPs and a mixture of other chemicals can cause serious neurological and other impairment. There are many documented cases. **Neither standard addresses the oil fumes hazard, despite it being recognized in aviation since the 1950's.**
As part of this, the standards ignore the health and safety hazards posed by exposure to supply air contaminated with pyrolyzed engine oils and hydraulic fluids.

On page 3 of the proposed 4666, it says: "This standard was developed for the needs of the European Aerospace Industry." It does not seem to have been developed for the safety, health, or comfort needs of either the flying public or the crewmembers that must work in the aircraft environment.

response

Not accepted.

The Agency will not issue a "directive requiring bleed air cleaning". Maintenance procedures and programmes already exist and require air conditioning and bleed air systems regular cleaning. Operators shall follow those procedures. Issuing a directive would not bring an additional benefit over

existing requirements.

Bleed air monitoring: although we cannot mandate such system today, we recommend studies to be conducted in order to determine how this could be put in place in the future, should a decision be taken that it is required. Refer to our conclusions.

EN4618 provides the available cabin air contaminants limits based on the best existing scientific knowledge and norms.

Concerning TCP, this compound is listed as part of oils, lubricants and hydraulics sources (table 1); however, it is true that no exposure limits are provided. Meanwhile, the Agency is aware that many countries use an average limit of 0.1mg/m3 (over an 8 hours workshift) based on the tri-ortho-isomer toxicity. However we do not know on which basis this limit has been established. It is nevertheless provided by OSHA, NIOSH, ACGIH. Further study is probably needed to consolidate safety and health limits, especially in an aeroplane cabin pressure and ventilation environment.

PrEN4666 provides for pressure conditions, thermal conditions, humidity conditions, noise and vibration standards. Therefore, this document is complementary to EN4618 and it is not relevant when recommending contaminants standards.

A. Explanatory Note - IV. Content of the A-NPA - 13. QUESTIONNAIRES p. 9

comment

1 comment by: *Francis Fagegaltier Services*

The engine and APU designers may have their own data and opinion, especialy in relation to CS-E requirements on bleed air contamination.

Direct consultation of such designers would be worth considering.

response

Accepted.

The Agency also discussed this subject with engine manufacturers. However, the aeroplane manufacturers' databases normally show the full picture as operators must report this kind of event to them in addition to the engine manufacturer.

comment

10 comment by: *British Airways*

Comment:
The collection of anecdotal information from a self-selected population of flight and cabin crew by means of an online questionnaire does not equate to the sort of robust information on which the need for additional regulation should be based.

Justification:
Online surveys open to anyone can only provide anecdotal information and cannot, therefore, be used as evidence to justify a decision on the need (or lack of need) for additional regulation.

response

Partially accepted.

	The Agency recognises that the outcome from the on-line questionnaire does not provide the actual picture as we do not control or select the responders. It is used as an indicator among others to take our decision. It was decided mainly to offer a direct and independent channel for stakeholders to report their opinions and concerns. Regarding the report of problems including health claims from crews, we have nevertheless required the concerned persons to provide supporting documents, which permits to examine and verify the claims and balance the outcome of the questionnaire.
comment	*90* comment by: *UK CAA* The UK CAA has submitted the completed questionnaire for NAAs.
response	Noted.
comment	*106* comment by: *Fokker* Name of the company Fokker Services Country of Head Office (compulsory) The Netherlands Email address Eelco.bakker@stork.com Total number of in-service CS-25 Large Aeroplanes At present there are 700 operational Fokker aircraft across the world. Average number of flight hours per year of your in-service CS-25 Large Aeroplanes fleet Around 750.000 Flight Hours per year Do you have any statistical data in which you track cabin air contamination by engine or APU that occurred on your fleet? At Fokker Services we have a system in place to monitor all relevant in-service events with potential airworthiness effects, including any cabin air contamination. The operators of our aircraft report these events and we are therefore dependant on the willingness of the operators and their procedures of event reporting. Therefore we cannot provide any reliable statistical figures and can only see trends. • If yes, can you share these data with the Agency? To be usable, these data should provide as a minimum for each event: date of event, aeroplane type, event phase of flight, occupants affected and the associated symptoms, description of how the flight was managed up to the landing airport (particularly flight crew when they were affected), root cause of the bleed air contamination, corrective action after the event. Please send the documents to the address provided at the end of the A-NPA document.(compulsory) As stated above we cannot provide hard statistical data about these events. The trends Fokker Services can distinguish are related to e.g. “wet sock smell”, smoke and odors from e.g. ovens, occasional event of the smell of oils and crew complaints without any traceability to causes. Fokker Services has investigated that the first category can be related to e.g. moist insulation blankets, duct problems of the air-conditioning system and the setting of the air-conditioning system itself (e.g. the cost driven choice of an

operator of the economy setting while the aircraft configuration at hand requires a higher setting). All these three subjects have been subject of improvements, which have been communicated to our customers.
The second category can be related to product defects or misuse of galley equipment (coffee heaters not set to off, buns too long in the oven etc).
The third category can be related to in-flight oil leak events in or near parts of the air-condition system. The effect of this category may be strongly dependent on the oils used.
The fourth and last category is of course the most elusive. However, especially in this category also the most unsubstantiated health and safety claims are made.
In the cases where we have traced back the events to clear causes, where airworthiness was related, FS has of course as part of the continuous airworthiness obligations taken appropriate actions.

• Based on these reported events, what is your analysis of the safety implications?
At Fokker Services we are of the opinion that the set-up of this A-NPA is not an adequate means to improve the view of EASA on the understanding of the situation or to come to an amendment of a rulemaking document. As the reports will be rather of an incidental nature and in most cases do not contain hard facts on causes, particularly in the fourth category as mentioned above, Fokker Services would like to urge the EASA to first conduct (scientific) research and only thereafter start the discussion with (local) Authorities, Operators, Type Certificate Holders and Maintenance Organizations as well as oil manufacturers.
The research of Cranfield University was until now primarily focused on air quality on the flight deck. The researchers indicate that doing (scientific) research in the main cabin is a far greater challenge because of the vast size and influences of passengers. This questionnaire however does not make any segregation between the flight deck and the cabin. The segregation between these two are of importance because of the huge difference in impact of safety implications.
Furthermore, Fokker Services would suggest to EASA to investigate the standards that were/are used in the current airworthiness specifications and the history of those airworthiness specifications. These standards are based on certain postulations and it has to be researched whether or not these postulations still stand in view of the current research.

In short: Before any A-NPA action is pursued, the extent and severity of the health and safety issue must be established by scientific research. Therefore, the remainder of this questionnaire has not been completed.

• Are you aware of any proven serious health concern linked to an occurrence of cabin air contamination by engine or APU?
See above

• If yes, please provide details on these cases.
No

• Did you investigate technical solutions to protect the aeroplane from this type of bleed air contamination, for existing aeroplane Types and for future aeroplane Types?
See above

• If yes, please briefly describe the outcome of this investigation and the main

	promising solutions. Please also send any available report to the Agency using the address provided at the end of the A-NPA. See above • Do you consider it would be beneficial to amend the current CS-25 certification specifications to better protect Large Aeroplanes from cabin air contamination by engine or APU? See before • If yes, what kind of amendment would you propose? (compulsory) See before • If other, please specify? (compulsory) See before • Do you envisage proposing a modification of in-service aeroplanes to better protect from engine and APU bleed air contamination? (compulsory) See before • If yes, which kind of modification? (compulsory) See before • Do you consider that further research should be first conducted? Yes, see before
response	Noted.

Appendix A - Attachments

BCAcmts_A-NPA_2009-10_Cabin_Air.pdf
Attachment #1 to comment #19

ETF answer EASA CRT NPA Air Quality 80110 .pdf
Attachment #2 to comment #130

Susan Michaelis_EASA_A-NPA_ Cabin Air Quality submission.pdf
Attachment #3 to comment #131

Winder_Hazardous_Chemicals_on_Jet_Aircraft_2006.pdf
Attachment #4 to comment #27

pilots.pdf
Attachment #5 to comment #27

Susan Michaelis_EASA_A-NPA_ Cabin Air Quality submission.pdf
Attachment #6 to comment #132

AttachmentToCRT.pdf
Attachment #7 to comment #85

Susan Michaelis_EASA_A-NPA_ Cabin Air Quality submission.pdf
Attachment #8 to comment #133

Letter EASA_engine oil tox_24Nov09.pdf
Attachment #9 to comment #11

Susan Michaelis_EASA_A-NPA_ Cabin Air Quality submission.pdf
Attachment #10 to comment #134

Susan Michaelis_EASA_A-NPA_ Cabin Air Quality submission.pdf
Attachment #11 to comment #136

Winder_Hazardous_Chemicals_on_Jet_Ai_.pdf
Attachment #12 to comment #66

Susan Michaelis_EASA_A-NPA_ Cabin Air Quality submission.pdf
Attachment #13 to comment #138