



**ADVANCE NOTICE OF PROPOSED AMENDMENT (A-NPA) No 2009-10**

*“Cabin Air Quality onboard Large Aeroplanes”*

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## A. EXPLANATORY NOTE

### I. General

1. The purpose of this Advance Notice of Proposed Amendment (A-NPA) is a discussion around a specific source of cabin air quality degradation onboard Large Aeroplanes. 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.

For these reasons, EASA (hereinafter referred to as the Agency) has decided to start a pre-rulemaking phase and publish this A-NPA.

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. This is intended to get a better assessment of the rate of occurrences and of the encountered symptoms. A confidential questionnaire is included at the end of this A-NPA and stakeholders (Flight crews, Cabin crews, Operators, Large Aeroplanes manufacturers, National Aviation Authorities) are invited to respond and provide supporting documents.

After the review of on-going research studies conclusions and the analysis of this A-NPA collected information, EASA 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.

2. The Agency is directly involved in the rule-shaping process. It assists the Commission in its executive tasks by preparing draft regulations, and amendments thereof, for the implementation of the Basic Regulation<sup>1</sup> which are adopted as "Opinions" (Article 19(1)). It also adopts Certification Specifications, including Airworthiness Codes and Acceptable Means of Compliance and Guidance Material (AMC/GM) to be used in the certification process (Article 19(2)).
3. When developing rules, the Agency is bound to following a structured process as required by Article 52(1) of the Basic Regulation. Such process has been adopted by the Agency's Management Board and is referred to as "The Rulemaking Procedure"<sup>2</sup>.
4. This rulemaking activity is included in the Agency's rulemaking programme for 2009-2012. It implements the rulemaking task 25.035 "Cabin environment – Air quality".
5. The text of this A-NPA has been developed by the Agency. It is submitted for consultation of all interested parties in accordance with Article 52 of the Basic Regulation and Articles 5(3) and 6 of the Rulemaking Procedure.

### II. Consultation

6. To achieve optimal consultation, the Agency is publishing this A-NPA on its internet site. First, comments on the content of the A-NPA document should be provided within 3 months in accordance with Article 6(4) of the Rulemaking Procedure. These comments should be submitted by one of the following methods:

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<sup>1</sup> Regulation (EC) No 216/2008 of the European Parliament and of the Council of 20 February 2008 on common rules in the field of civil aviation and establishing a European Aviation Safety Agency, and repealing Council Directive 91/670/EEC, Regulation (EC) No 1592/2002 and Directive 2004/36/EC (OJ L 79, 19.03.2008, p. 1)

<sup>2</sup> Management Board decision concerning the procedure to be applied by the Agency for the issuing of opinions, certification specifications and guidance material (Rulemaking Procedure), EASA MB 08-2007, 13.6.2007

- CRT:** Send your comments using the Comment-Response Tool (CRT) available at <http://hub.easa.europa.eu/crt/>
- E-mail:** In case the use of CRT is prevented by technical problems these should be reported to the [CRT webmaster](#) and comments sent by email to [NPA@easa.europa.eu](mailto:NPA@easa.europa.eu).
- Correspondence:** If you do not have access to internet or e-mail you can send your comment by mail to:  
Process Support  
Rulemaking Directorate  
EASA  
Postfach 10 12 53  
D-50452 Cologne  
Germany

Comments should be submitted by **8 January 2010**. If received after this deadline they might not be taken into account.

Second, [online questionnaires](#) are used to collect information from stakeholders. Explanations and links allowing access to these questionnaires are provided at the end of chapter IV. The questionnaires will also remain accessible during 3 months following the publication of this A-NPA, i.e. by **8 January 2010**.

### III. Comment response document

7. All comments related to the A-NPA document received in time will be responded to and incorporated in a comment response document (CRD). This may contain a list of all persons and/or organisations that have provided comments. The CRD will also provide an analysis of the responses to the on line questionnaires without any identification of the responders ("sanitized" information). The Agency guarantees the confidentiality of the identity of any communicated information from the responders; refer to the confidentiality statement provided in chapter IV.13 and also in the questionnaires. The CRD will be available on the Agency's website and in the Comment-Response Tool (CRT).

#### **IV. Content of the A-NPA – Cabin air quality onboard Large Aeroplanes**

##### **8. Background and description of the issue**

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.

Various sources of contamination are possible, either from inside or from outside the aeroplane. As a primary concern, the source of air contamination which is discussed here is an inside source which leads to contamination of the air conditioning system.

On currently certified modern Large Aeroplanes, which are equipped with turbine engines, the primary source of outside air used to pressurize and ventilate the cabin (so called "bleed air") is extracted either from the main engine(s) compressor(s) (in flight) or from the Auxiliary Power Unit (APU) (on ground). This unfiltered air then passes through the air conditioning packs of the Environmental Control System (ECS) before being distributed to the cabin.

One part of this airflow (typically 50% on recent aeroplanes) is then filtered and re-circulated. Most of the modern Large Aeroplanes use a fine High Efficiency Particulate Air (HEPA) filtration. 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).

Outside unfiltered air and re-circulated filtered air flow into a mixing chamber before being distributed to the cabin.

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?

##### **9. Events caused by engine/APU air contamination**

At the time of the introduction of the first aeroplanes equipped with bleed air systems, cabin air quality concerns were more considered as nuisances, mainly occasional unpleasant odours.

Since the last past fifteen years, more serious incidents have been reported, typically named "fume event", "smoke in the cockpit" or "smoke in the cabin". The vast majority of these events are associated with an abnormal leakage of engine or APU lubrication fluid (aviation engine oil), and they constitute the primary issue of concern which is discussed here.

However, the number and the nature of these reports are highly variable depending on the aeroplane type, the reporting entity or the country.

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.

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.

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.

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.

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).

## 10. Research outcomes

Various research studies, in different countries, have attempted to answer the various questions raised from these cabin air contamination events. In particular, some of these studies tried to scientifically identify the relationship between symptoms reported by aeroplane occupants and the identified source of contamination, essentially aviation engine oil.

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.

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."

Further research would be needed to:

- A. Deeply assess the toxicity of each contaminant (short term and long term), including the effect of the conditions of reduced dioxygen which exist onboard aeroplanes. Combined effect of contaminants should be considered as well,
- B. Determine the actual concentrations of contaminants in the inspired cabin air during an event.

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).

#### 11. EASA Large Aeroplanes Certification Specifications

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 m<sup>3</sup>/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.

## 12. Objective of the A-NPA

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.

Meanwhile, this subject still generates debates and discussions from the various concerned stakeholders. Some of them believe that these events are under-reported; this is possible because they are considered as incidents, and the effects are often limited to slight individual discomfort.

Due to the fact that the number of reports appears to be very variable from one country to another one, it is not possible to determine a reliable rate of occurrence.

Moreover, there is no existing system to collect and analyse health effects.

In accordance with the Basic Regulation, the Agency's primary focus and concern is aviation safety and environmental protection. However, some elements of aviation health have been included within the scope of the Agency's competence, namely when those aspects have an effect on safety (for example, the regulation of medical fitness of certain categories of aviation professionals) and, in the field of aircraft design, for the protection of passengers during flight<sup>3</sup>. 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. Due to the debates and discussions that cabin air quality events still generate, and in order to improve its view and understanding of the situation, the Agency has decided to start a pre-rulemaking phase and publish this A-NPA.

The goal is to present the Agency's current understanding of the subject and also to collect detailed information on events and experiences involving cabin air contamination by engine or APU. This is intended to enable a better assessment of the rate of occurrences and of the encountered symptoms.

In the following chapter, you will find links to online questionnaires for Flight crews, Cabin crews, Operators, Large Aeroplanes manufacturers and National Aviation Authorities; every concerned organisation or individual is kindly invited to answer the applicable questionnaire and to provide supporting documents to the Agency.

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.

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<sup>3</sup> Refer to recital (20) of the Preamble to Regulation (EC) No 216/2008 of the European Parliament and of the Council of 20 February 2008 on common rules in the field of civil aviation and establishing a European Aviation Safety Agency, and repealing Council Directive 91/670/EEC, Regulation (EC) No 1592/2002 and Directive 2004/36/EC, which states: «In order to respond to increasing concerns about the health and welfare of passengers during flights, it is necessary to develop aircraft designs which better protect the safety and health of passengers.»

### 13. QUESTIONNAIRES

**CONFIDENTIALITY:** The Agency guarantees the confidentiality of the identity of any communicated information from the responders. The information provided to the Agency is for internal use only and it shall not be disseminated to third parties. The identity of responders will not be mentioned in any publication providing the results and the analysis of the questionnaire. All Intellectual Property Rights, including logo, copyrights, trademarks, and registered trademarks that may be contained within, remain the property of their respective owners. Any personal data included in or relating to the use of this questionnaire shall be processed pursuant to the provisions of Regulation (EC) No 45/2001 on the protection of individuals with regard to the processing of personal data by the Community institutions and bodies and on the free movement of such data.

**Please use one of the following links in order to access the online questionnaire related to your profile.**

- a. **FLIGHT CREWS** (working in the commercial air transportation on CS-25 Large Aeroplanes)  
<http://ec.europa.eu/yourvoice/ipm/forms/dispatch?form=CabinAirFC>
- b. **CABIN CREWS** (working in the commercial air transportation on CS-25 Large Aeroplanes)  
<http://ec.europa.eu/yourvoice/ipm/forms/dispatch?form=CabinAirCC>
- c. **OPERATORS** (commercial air transportation on CS-25 Large Aeroplanes)  
<http://ec.europa.eu/yourvoice/ipm/forms/dispatch?form=CabinAirOP>
- d. **LARGE AEROPLANE (CS-25) MANUFACTURERS**  
<http://ec.europa.eu/yourvoice/ipm/forms/dispatch?form=CabinAirTCH>
- e. **NATIONAL AVIATION AUTHORITIES**  
<http://ec.europa.eu/yourvoice/ipm/forms/dispatch?form=CabinAirNAA>

#### SUPPORTING DOCUMENTS:

As mentioned in the questionnaire, you are kindly invited to share supporting documents or reports with the Agency. Please send these documents to the following address:

- a. Electronic documents (preferred option):  
[CAQ.supporting\\_documents@easa.europa.eu](mailto:CAQ.supporting_documents@easa.europa.eu)
- b. Paper documents:  
European Aviation Safety Agency  
Rulemaking/Product Safety Secretariat (R4)  
Postfach 10 12 53  
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DEUTSCHLAND