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Kakovost zraka v kabini civilnih letal - Kemijske spojine

Cabin air quality on civil aircraft - Chemical compounds

Kabinenluftqualität in Verkehrsflugzeugen - Chemische Parameter

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Cabin air quality on civil aircraft - Chemical compounds

Kabinenluftqualität in Verkehrsflugzeugen - Chemische Parameter

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European foreword

This document (prEN 17436:2019) has been prepared by Technical Committee CEN/TC 436 “Cabin Air Quality on civil aircraft – Chemical Agents”, the secretariat of which is held by AFNOR.

This document is currently submitted to the CEN Enquiry.

Introduction

Air quality on civil aircraft differs in many important ways from air quality in other indoor environments.

The cabin environment is, by definition, enclosed and confined. The aircraft cabin is a densely occupied environment with only a small amount of per person dilution volume, creating the potential for elevated levels of bio-effluents in the cabin, such as carbon dioxide.

The partial pressure of air and the amount of oxygen is reduced inflight. Aircraft are designed to ensure that the effective cabin altitude does not exceed 2 438 m which corresponds to a partial pressure of 0.74 atm (75.2 kPa) (CS25.841).

An environmental control system (ECS) is used to regulate the aircraft cabin pressure and temperature to provide a safe and comfortable environment for the passengers and crew. The ECS provides fresh air, thermal control and cabin pressurization for the crew, attendants and passengers so as to ensure a suitable composition of the air. ECS architecture on civil passenger aircraft can be broadly separated in two categories: bleed air ECS systems and bleed free ECS systems. In a conventional ECS, the air source can be pneumatic (bled from the engine) or electric. Most commercial passenger aircrafts manufactured today and nearly all such aircraft in service have ECS's using engine bleed air.

This document sets out requirements and recommendations and supporting annexes to enable operators to eliminate and mitigate exposure to contaminants in the cabin air, including a special emphasis on the bleed air contaminants sourced to engine oil and hydraulic fluid.

Fluids used in aviation and jet engine oils and their pyrolysis products are complex mixtures. Chronic low-level exposure to complex mixtures, including organophosphates and the interdependence of chronic low dose exposure to subsequent higher dose fume events appears to make air crew more susceptible to harm. In addition to the effects, ultrafine particles generated in association with pyrolyzed oil entering the bleed air, while known to have associated long-term health effects may also increase the transference of toxicants to the brain. Most chemicals that produce systemic toxicity do not cause a similar degree of toxicity in all organs but usually produce their major toxicity in one or two organs. These are referred to as target organs of toxicity for that chemical. Examples would be the hepato-toxicity of alcohol and the neurotoxicity of organophosphorus compounds. A major reason why the brain is susceptible to target organ toxicity in mammals is that nerve cells last for the lifetime of the organism and cannot, like most other tissues, repair by cell proliferation. In assessing the risks and potential harm, on average a pilot over a 20,000-h flying career will, conservatively breathe 9,000,000 l of engine bleed air.

This document sets out requirements and recommendations to enable the industry to meet their legal obligations and provide a safer working environment for the air crew, and safer travel for passengers. Emphasis is placed upon increasing knowledge and understanding of air quality issues on civil aircraft through a wider use of testing, sensor technology and collation of data and information from aircrew and passengers.

NOTE Numerous aircraft accident investigation agencies, Regulators from the EU and US and the International Civil Aviation Organization (ICAO) have recognized that bleed air contamination may pose a threat to flight safety.

The requirements set out in the document takes into account current and developing regulation and the acknowledgement at the European Commission level, of the value of using the Precautionary Principle in relation to risk management and the use of risk assessment in this industry to protect workers and the environment.

Safety Management Systems (SMS) are a vital tool in the consideration, analysis and problem solving within the operation of an aircraft. The use of an SMS is particularly vital on the issue of cabin air quality and is referred to in this document. This document does acknowledge that whilst an SMS is the main methodology used by airline operators, not all operators use such a system and deploy other methodologies consistent with the objectives of an SMS.

A number of studies have been carried out in relation to the quality of aircraft cabin air. The spreadsheet in Annex H contains a comprehensive list of studies in the public domain of chemicals detected in various air monitoring studies. The studies are of cabin air or engine or APU bleed air studies. The maximal levels of the compounds recorded in each specific study are presented. It is needful to refer to the original studies to determine the respective methodology employed.

1 Scope

This document defines requirements and recommendations dealing with the quality of the air on civil aircraft concerning chemical compounds potentially originating from, but not limited, to, the ventilation air supplied to the cabin and flight deck.

A special emphasis is on the engine and APU bleed air contaminants potentially brought into the cabin through the air conditioning, pressurization and ventilation systems.

The document is applicable to civil aircraft in operation from the period that is defined as when the first person enters the aircraft until the last person leaves the aircraft.

The document defines requirements and recommendations in relation to the presence of, and means to prevent exposure to, chemical compounds, including those that could cause adverse effects, taking into account the Precautionary Principle.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

EN 1822-1, *High efficiency air filters (EPA, HEPA and ULPA) — Part 1: Classification, performance testing, marking*

EN ISO 16000-1, *Indoor air — Part 1: General aspects of sampling strategy (ISO 16000-1)*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at http://www.iso.org/obp

— IEC Electropedia: available at http://www.electropedia.org/

3.1
adverse effects
change in morphology, physiology, growth, development or lifespan of an organism which results in impairment of its functional capacity or impairment of its capacity to compensate for additional stress or increased susceptibility to the harmful effects of other environmental influences

[SOURCE: ISO 13073-3:2016, 2.1, modified — The term "adverse effect" was at the singular in the original definition.]

3.2
aerosol
system of solid or liquid particles suspended in gas

[SOURCE: ISO 15900:2009, 2.1]

3.3
air crew
people working on an aircraft in the period that is defined as when the first-person boards the aircraft until the last person leaves the aircraft (pilots and cabin attendants)

3.4
air supply
air introduced into an enclosure by mechanical or natural means

[SOURCE: ISO 16814:2008, 3.41, modified — The term originally defined was "supply air".]

3.5
airline operator
entity authorized by an Air carrier Operator Certificate (AOC) from its national Civil Aviation Authority to operate civil transport aircraft flights for commercial carriage of passengers, cargo or mail

Note 1 to entry: The operator holds responsibility for compliance with Civil Aviation Authorities Regulations on its flights, including when the relevant tasks are performed by sub-contractors.

[SOURCE: ISO 16412:2005, 3.3, modified — The terms originally defined were "operator", "airline" and "carrier".]

3.6
auxiliary Power Unit
APU
gas turbine-powered unit delivering rotating shaft power, compressor air, or both, which is not intended for direct propulsion of an aircraft

[SOURCE: EASA CS Definitions]

3.7
bleed air
air taken from the compressor stages of the aircraft engines or APU, prior to the burning chamber, and from which the hot and compressed air is bled of to the aircraft cabin

3.8
cabin air
air within the section of an aircraft in which passengers and/or crew travel

3.9
cabin material
cabin interior which includes seats, flooring, and casings

3.10
chemical compound
any chemical element or compound on its own or admixed as it occurs in the natural state or as produced, used, or released, including release as waste, by any work activity, whether or not produced intentionally and whether or not placed on the market

[SOURCE: Council Directive 98/24/EC Art. 2(a)]

3.11
contaminants
any material or combination of materials (solid, liquid or gaseous) that can adversely affect the system

[SOURCE: ISO/TR 15640:2011, 3.1, modified — The term "contaminant" was at the singular in the original definition.]

3.12
duct residual contamination
contamination of the ducts by duct material degradation or chemical compounds, which can be deposited in the ducts and reintroduced/re-entrained in the ventilation air

3.13
early warning system
system or a procedure to detect the presence of engine-generated contaminants that may require intervention

3.14
environment control system (ECS)
system of an aircraft which provides air supply, temperature control and cabin pressurization for the crew and passengers

3.15
fresh air
outside air

[SOURCE: EASA CS 25.831]

3.16
fumes
odorous, gaseous compounds which are typically sourced to the cabin/flight deck air supply vents

3.17
hazardous
substance or mixture fulfilling the criteria relating to physical hazards, health hazards or environmental hazards

[SOURCE: Regulation (EC) No 1272/2008 "CLP", Article 3]

3.18
marker compound
chemical compound representing/indicating contamination of the cabin air

3.19
monitoring
collection and assessment of status data for a process or a system

[SOURCE: CEN ISO/TS 17444-2:2017, 3.17]

3.20
outside air
air taken from outside the vehicle

[SOURCE: ISO 19659-1:2017, 3.4.1, modified — The terms originally defined were "fresh air" along with "outside air".]

Note 1 to entry: In this document, the vehicle is the aircraft.

3.21
particulate matter
solid and liquid matter of a sufficiently small size to be suspended in gas

[SOURCE: ISO 19867-1:2018, 3.46]

3.22
precautionary Principle
PP
approach to risk management whereby if there is the possibility that a given policy or action might cause harm to the public or the environment and if there is still no scientific consensus on the issue, the policy or action in question should not be pursued

[SOURCE: European Union law]

3.23
risk analysis
systematic use of available information to identify hazards and to estimate the risk

[SOURCE: ISO/IEC Guide 51:1999, 3.10]

3.24
sensor
electronic device that senses a physical condition or chemical compound and delivers an electronic signal proportional to the observed characteristic

[SOURCE: ISO/IEC TR 29181-9:2017, 3.14]

3.25
sooting
particulate matter produced and deposited during or after combustion

[SOURCE: EN ISO 472:2013, 2.1278, modified — The term originally defined was "soot".]

3.26
transient power settings
short-term engine power setting characterized by unstable temperature and/or pressure

EXAMPLE Examples include engine start, take-off, and top-of-descent, changes in engine regime including changing the power setting from idle to take off power and back.

3.27
ultra-fine particles
ultra-fine particles (UFP) or ultrafine dust are the most commonly used definitions of airborne particles with a diameter between 1 and 100 nanometres (nm)

[SOURCE: ISO 2007]

4 Cabin air quality – chemical compounds

4.1 Presence of chemical compounds in cabin air

The presence of chemical compounds in cabin air is measured in many studies, providing a large base set of chemical compounds. A comprehensive list of chemical compounds detected in cabin air and/or air supply is included in Annex B, Table B.2 "List of supplementary chemical compounds found in cabin and supply air".

The quality of the cabin air in aircraft can be reflected by chemical marker compounds. Identification of these chemical marker compounds takes into account the different sources of contamination, measurability and reported presence in cabin air.

4.2 Sources of airborne contaminants

Chemical agents sources consist of but are not limited to:

— Engine oil;

— Hydraulic fluid;

— Engine Exhaust;

— Fuel(unburned);

— De-icing Fluid;

— Occupants;

— Cabin material;

— Bleed system and air conditioning equipment material;

— Duct residual contamination.

An overview of chemical compounds that are introduced via different sources into the cabin via outside air is given in Annex F, Table F.1. Chemical compounds that originate from inside the cabin and can contaminate the cabin air are listed in Annex F, Table F.2.

4.3 Sources of engine oil leakage in the bleed air system

Pressurized compressor air is used to seal the engine bearing chambers and is responsive to variations in engine operating conditions. All dynamic seals are designed to leak, with the leakage amount depending on many factors including seal design, balance, lubricating regime, operating conditions, compartment condition, wear life and distortion. It is accepted that oils seals commonly utilized will leak a very small amount of oil vapour in normal service. Labyrinth seals operate with a clearance, while mechanical face seals operate with a lubricated face, with both types of seals designed to limit sealed product migration and therefore limiting emissions, rather than preventing them. Oil passing over the seals in the area of the compressor has a path to enter the cabin air supply, if the leakage or emissions occur prior to the compressor bleed air off-take port. Further information can be found in Annex G.

4.4 Fume event

The presence of fumes and/or aerosols, sourced to the air supply vents, when aircraft occupants are present can indicate the presence of some type of contaminant in the supply air (e.g. oil, hydraulic fluid, de-icing fluid, etc.) that has been heated in either the engine(s) or the APU, or electrical fire.

4.5 Marker compounds

Based on these data, a subset of marker compounds that can be present in cabin air is identified and listed. The marker compounds cover all contaminant sources as mentioned above. Based on expert judgement and support from experts and stakeholders, marker compounds are selected. An overview of the selected marker compounds is shown in Annex B, Table B.1 "Chemical Marker Compounds". The marker compounds are deemed to be useful markers for relevant sources of air contamination in the aircraft environment.

Table B.2 lists "reliability ratings" (A through C) for each marker compound, intended to assist the user in determining which combination of compounds to monitor for each source of contamination.

The approach is not intended to define the toxicity of the cabin air.

4.6 Environmental Control System (ECS)

Airborne chemical agents can be introduced to the cabin and flight deck by way of the aircraft air supply. Most commercial passenger aircraft are equipped with a bleed air ventilation system while some use a bleed free ventilation system. Further details on these two types of Environmental Control Systems (ECS) are provided in Annex A.

5 Requirements for cabin air quality

5.1 General

Exposure to supply air contaminants (e.g. engine oil, hydraulic fluid, de-icing fluid, and exhaust fumes) can be prevented/minimized through the application of the design, maintenance and operation measures listed in Annex E.

The lists of chemical compounds in Annex B are derived from the chemical compound sources originating from aircraft engines or APU bleed air, cabin air and outside air as identified in 4.1. originating from aircraft engines or APU bleed air, cabin air and outside air. The pathway for the chemical compounds to enter the cabin and flight deck is through bleed, air conditioning, pressurization and ventilation systems. Chemical compounds can also be emitted via diffusion by cabin interior or generated by passengers, food and beverages, ventilation systems and open aircraft doors. The table of chemical marker compounds in Annex B are deemed to be the most reliable markers as evidence of contamination in the aircraft environment. It is acknowledged that there could be alternative methods to indicate the presence of a specific source (for example: by identification of a pattern recognition (see Clause 6, and in Table B.2).

The intention of the requirements is to:

a) minimize contamination of the air supply by facilitating pilot and maintenance intervention;

b) measure the levels of each chemical marker compounds as specified in Annex B during aircraft operation, by ventilation source and by phase of flight including transients;

c) acilitate the development of an "onboard monitoring system" that gives, at the earliest possible time, an indication of an abnormal condition or change in the cabin air quality. This allows the operator to take appropriate timely operational and/or maintenance measures to enhance flight safety and protect health of crew and passengers;

d) adopt design, operational, and maintenance measures which will prevent fume events and potentially reduce exposure to background supply air contamination during normal operations.

The intention is not to define acceptability/suitability, health, comfort, safety, or airworthiness of the quality of the cabin air.

The intention is to identify the cause and source of a possible contamination of cabin air and to derive measures to address them.

5.2 Requirements for the Precautionary Principle and hierarchy of controls

5.2.1 Precautionary Principle

The operator shall apply the Precautionary Principle in relation to the prevention of exposure to chemical compounds including those that could cause adverse effects. Further inform on the Precautionary Principle can be found in Annex C.

Airline operators shall identify the risks to pilots, crew and passenger health and mitigate from this potential risk source joining the air supply of the aircraft.

5.2.2 Hierarchy of controls

5.2.2.1 General

The operator shall apply the hierarchy of controls for the prevention of contaminants and the protection of crew members:

— avoid risks

— evaluate risks that cannot be avoided

— combat risks at the source

— adapting to technical progress

— replacing the dangerous by the non-dangerous or the less dangerous

— developing a coherent overall prevention policy which covers technology, organization of work, working conditions, and the influence of factors related to the working environment

— giving collective protective measures priority over individual protective measures

— giving appropriate instructions to the workers

— eliminate or minimize hazardous chemical exposures by the design and organization of system.

NOTE 1 Best Available Technology (BAT) has been used successfully as a means to mitigate against chemical exposures.

NOTE 2 Examples of elimination at source and technical progress could be the inclusion of a bleed free architecture, and/or oil free bearing systems.

5.2.2.2 Elimination — Design – Air supply system design

The breathing air supply system shall have design features to eliminate hazards to occupants from internally (inside) and external to the aircraft.

The breathing air supply system design shall prevent/minimize hazards to occupants from contamination generated internally (inside) and external to the aircraft.

Air supply systems shall meet airworthiness requirements which eliminate the potential for degraded or impaired crew performance or incapacitation due to oil and other aircraft fluids contamination of the air supply by applying an SMS that reflects the full range of operating conditions.

Air supply systems shall be designed to facilitate regular maintenance of the system by cleaning or replacement of parts.