

AEROSPACE INFORMATION REPORT

AIR4766™/1

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Air Quality for Commercial Aircraft Cabin Particulate Contaminants

FOREWORD

Particulate contamination is one of the factors affecting the air quality in aircraft cabins. The potential sources of particulate contaminants are:

- Ambient air depending on geographical location of the airport or airport activity.
- Engine bleed air: combustion products, semi-volatile and non-volatile materials from aircraft operation.
- Passenger activity: skin flakes, hair, possibly bacteria and viruses, environmental tobacco smoke, food.
- Aircraft material: fabric fibers from seat and carpet.
- Airline operation: insecticides, cleaning, maintenance activities.

High efficiency particulate air filters (HEPA filters) are effective for removing particulates, including tobacco smoke, aerosols, bacteria and viruses.

Particulate contaminant levels in the cabin air are usually low and safe under normal conditions.

However, pathogens (virus, bacteria, spores), allergens (cat fur, molds), semi to non-volatile chemicals, or tobacco smoke, may affect passenger and crew comfort or health.

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1. SCOPE:

This SAE Aerospace Information Report (AIR) covers airborne particulate contaminants that may be present in commercial aircraft cabin air during operation. Discussions cover sources of contaminants, methods of control and design recommendations. Air quality, ventilation requirements and standards are also discussed.

1.1 Purpose:

This document covers design information regarding particulate contaminants in commercial aircraft. This document provides information on Environmental Control System (ECS), particulate contamination (solid and liquid phases), bleed and recirculated air and control methods including ventilation used to design and maintain cabin air environments.

2. REFERENCES:

2.1 Applicable Documents:

The following publications form a part of this document to the extent specified herein. The latest issue of SAE publications shall apply. The applicable issue of other publications shall be the issue in effect on the date of the purchase order. In the event of conflict between the text of this document and references cited herein, the text of this document takes precedence. Nothing in this document, however, supersedes applicable laws and regulations unless a specific exemption has been obtained.

2.1.1 SAE Publications: Available from SAE, 400 Commonwealth Drive, Warrendale, PA 15096-0001.

ARP85	Air Conditioning Systems for Subsonic Airplanes
ARP1270	Aircraft Cabin Pressurization Control Criteria
AIR1609	Aircraft Humidification
ARP4418	Procedure for Sampling and Measurement of Engine Generated Contaminants in Bleed Air Supplies from Aircraft Engines Under Normal Operating Conditions

- 2.1.2 FAA Publications: Available from Federal Aviation Administration, 800 Independence Avenue, SW, Washington, DC 20591.

FAA Advisory Circular AC 25-22, [3/14/00], "Certification of Transport Airplane Mechanical Systems", Initiated by ANM-110

FAA Advisory Circular AC 25-7A, [3/31/98], "Flight Test Guide for Certification of Transport Category Airplanes", Initiated by ANM-110

FAA Order 8110.4B, [April 24, 2000], "Type Certification", Initiated by AIR110

U.S. Code of Federal Regulations, Title 14, Federal Aviation Regulation, Part 25- "Transport Category Airplanes"

U.S. Code of Federal Regulations, Title 14, Part 121- "Transport Category Airplanes"

U.S. Code of Federal Regulations, Title 29, Occupational Safety and Health Administration, §1910.1000- "Air Contaminants"

- 2.1.3 U.S. Government Publications:

U.S. Department of Transportation, DOT-P-15-89-5, [1989], "Airliner Cabin Environment" – Available from U.S. Department of Transportation, 400 7th Street, SW, Washington DC 20590

National Academy of Sciences, ISBN 0-309-08289-7, [2002], "The Airliner Cabin Environment and the Health of Passengers and Crew" - Available from The National Academy of Sciences, 500 Fifth Street, NW, Washington, DC 20001

- 2.1.4 JAA Publications: Available from JAA: www.jaa.nl

JAR 25.831 (ACJ 25.831)

- 2.1.5 EASA Publications: Available from EASA: www.easa.eu.int

EASA Certification Specification - 25

- 2.1.6 Military Standards: Available from DODSSP: <http://assist.daps.mil/online/start>

MIL-STD-282 - 1995 Filter Units, Protective Clothing, Gas-Mask Component and Related Products: Performance-Test Methods

2.1.7 Other Standards:

ASTM D 6399-99 "Standard guide for selecting instruments and methods for measuring air quality in aircraft cabins", ASTM International, West Conshohocken, PA.

ASHRAE 52-1 - 1992 - "Gravimetric and dust-spot procedures for testing air-cleaning devices used in general ventilation for removing particulate matter", American Society of Heating, Refrigerating and Air-Conditioning Engineers, Atlanta, GA.

ASHRAE 52-2 - 1999 - "Method of testing general ventilation air-cleaning devices for removal efficiency by particle size", American Society of Heating, Refrigerating and Air-Conditioning Engineers, Atlanta, GA.

ASHRAE-62 - 1999 - "Ventilation for acceptable indoor air quality", American Society of Heating, Refrigerating and Air-Conditioning Engineers, Atlanta, GA.

ASHRAE Fundamentals, 1997, American Society of Heating, Refrigerating and Air-Conditioning Engineers, Atlanta, GA.

MIL-STD-282 - 1995 - "Filter units, protective clothing, gas-mask components and related products: performance-test methods".

EN 779 - 1993 - "Particulate air filters for general ventilation - Determination of the filtration performance" CEN European committee for standardization, Brussel.

EN 1822 - 1998 - "High efficiency air filters (HEPA and ULPA): Part 1: Classification, performance testing, marking, Part 2: Aerosol production, measuring equipment, particle counting statistics, Part 3: Testing flat sheet media, Part 4: Determining leakage of filter element (scan method), Part 5: Determining the efficiency of filter element".

EUROVENT 4/9 - 1997 - "Method of testing air filters used in general ventilation for determination of fractional efficiency", Eurovent/Cecomaf, Paris.

BS 3928 - 1969 - "Sodium flame test for air filters", British Standards Institution, London.

NFX 44 012 - 1982 - "Cleaning equipment for air and other gases - Method of testing air filters used in general ventilation", AFNOR, Paris.

2.1.8 Other Publications:

AIHA 1989, "Odor Thresholds for Chemicals with Established Occupational Health Standards", American Industrial Hygiene Association, Fairfax, VA.

AFP 161-26 (TB MED 265), "Threshold Limit Values of Airborne Contaminants", Departments of the Air Force and Army.

ASHRAE STD 62-1989, "Ventilation for Acceptable Air Quality", Published by the American Society of Heating, Refrigerating, and Air Conditioning Engineers, Inc. Atlanta, GA.

ASHRAE Handbook. 1993. Fundamentals. American Society of Heating, Refrigerating and Air-Conditioning Engineers, Atlanta, GA.

ASHRAE HANDBOOK, 2000, HVAC Systems and equipment, Industrial Gas Cleaning and air pollution control ISBN 1-883413-80-X.

Davies, C.N. Air Filtration. Academic Press. 1973.

Environmental Protection Agency (EPA) National Ambient Air Quality Standards.

Filters and Filtration Handbook, Elsevier Advanced Technology, 1991.

Geomet: 1989. Airliner Cabin Environment: contaminant measurements, health risks, and mitigation options, US DoT, Report n° DOT-P-15-89-5.

Janssen, J.E. 1989. Ventilation for Acceptable Indoor Air Quality. ASHRAE Journal 31(10):40-48.

Kayser C. 1953. Aviation toxicology. New York, Toronto, The Blakiston Company, 126 pp.

Leaderer, B.P. and Cain, W.S. 1983. Air Quality in Buildings During Smoking and Nonsmoking Occupancy. ASHRAE Transactions 89(2B):601-613.

Occupational Safety and Health Administration (OSHA) Code of Federal Regulations, Title 29, Subpart Z-Toxic and Hazardous Substances.

National Research Council, "The Airliner Cabin Environment", Nat'l Academy Press, 1986.

ACGIH. 1989. Guidelines for the Assessment of Bioaerosols in the Indoor Environment. American Conference of Governmental Industrial Hygienists, Cincinnati, OH.

2.1.8 (Continued):

Morey, P.R. 1994. Suggested Guidance on Prevention of Microbial Contamination for the Next Revision of ASHRAE Standard 62. Indoor Air Quality '94. ASHRAE. Atlanta, GA.

Nagda, N.L. et al. 1992. Measurement of Cabin Air Quality Aboard Commercial Airlines. Atmos. Environ. 12:2203-2210.

Sofrance, Technical Report, 1999 "Contamination analysis on avionic bay air".

Sulzman, F.M. and Genin, A.M. 1994. Space Biology and Medicine Vol. II: Life Support and Habitability. Joint U.S./Russian Publication AIAA, Wash. D.C., Nauka Press, Moscow.

Threshold Limit Values for Chemical Substances In Workroom Air Adopted by the American Conference of Governmental Industrial Hygienists.- 1973 -, American Conference of Governmental Industrial Hygienists.

Pedelty, J.F. 1995. Ventilation and Indoor Air Quality: Factors That Affect the Results. Presented at the 1995 ASHRAE Winter Meeting, Jan. 28 - Feb. 1 1995. Chicago, IL.

Wever, A. 1984. Environmental Tobacco Smoke Exposure: Acute Effects - Acceptance Level - Protective Measures. Proceedings of the 3rd International Conference on Indoor Air Quality and Climate. Stockholm, Sweden.

Wheeler, A.E. 1993. Better Filtration: A Prescription for Healthier Building. Indoor Air Quality '93. ASHRAE. Atlanta, GA.

WHO, 1998, Tuberculosis and air travel. Rep 13/98.

It should be noted that regulations and standards are periodically updated and the designer should review the latest amendments. Current standards for exposure to particles are illustrated in TABLE 1. This listing is not necessarily comprehensive, however, other standards that are promulgated and reviewed by cognizant authorities may be considered.

2.2 Definitions:

AEROSOLS: A suspension in a gaseous medium of solid particles, liquid particles or solid and liquid particles having a negligible falling velocity (ISO 1995).

AIR FILTER: Component that retains contaminants present in air.

AUTOMATIC PARTICLE COUNTING: Measurement of solid particle contamination in fluid by automatic means.

CLOGGING: Reduction of filter porosity due to accumulation of pollutant.

CONTAMINANT: Any material or combination of materials (solid, liquid or gaseous) which adversely affect system.

CONTAMINATION: Introduction or presence of contaminants.

DUST HOLDING CAPACITY: Amount of contaminant that can be retained by the filter up to the point at which a given differential pressure across the filter is reached.

DISPOSABLE FILTER ELEMENT: Filter element that is intended to be discarded.

EFFECTIVE FILTRATION AREA: Total area of the porous medium exposed to flow rate in a filter element.

FILTER: Component that retains contaminants from a fluid.

FILTER CLOGGING INDICATOR: Device that indicates clogging of a filter.

FILTER EFFICIENCY: Ability of a filter, expressed as a percentage, to retain contaminant under specified conditions.

FRACTIONAL EFFICIENCY: Filter efficiency expressed as a percentage for a defined size of particle.

PENETRATION: Percentage of particles of a defined size passing through the filter.

FILTER ELEMENT: Element that ensures the retention of contaminant.

FLOW: Fluid motion generated by pressure difference.

FLOW RATE: Volume of fluid crossing the transverse plane of a flow path per unit of time.

FLUID CONTAMINANT MIGRATION: Contaminant particles that are displaced after having been retained.

2.2 (Continued):

FUME: Aerosol of solid particles generated by condensation from the gaseous state, generally after volatilization from melted substances and often accompanied by chemical reactions such as oxidation (ISO 1994). By extension, also the gases charged by particles resulting from a chemical process (WHO 1980, ISO 1995).

LAMINAR FLOW: Flow field characterized by the sliding of fluid layers in an orderly way.

MIST: Suspension of droplets in a gas.

NUISANCE PARTICULATE: All inert dusts, whether mineral, inorganic, or organic, not listed specifically by substance name which can be inhaled.

PARTICULATE CONTAMINANT: any liquid or solid material.

PARTICLE: Small discrete mass of solid or liquid matter, or in combination.

PARTICLE SIZE DISTRIBUTION: Tabular or graphical representation of the number and distribution of fluid contaminant particles according to particle size ranges.

PRESSURE DROP: Pressure reduction due to resistance to flow.

RECIRCULATED AIR: Air drawn out of cabin compartments and re-admitted into the aircraft cabin.

TIME WEIGHTED AVERAGE: The average amount of a substance one can be exposed to over a defined period of time.

VENTILATION AIR: Total amount of air including outside and recirculated air.

2.3 Acronyms:

AC: Advisory Circular (FAA/JAA)

ACCTD: Air Cleaner Coarse Test Dust

ACFTD: Air Cleaner Fine Test Dust

ACGIH: American Conference of Governmental and Industrial Hygienists

ACM: Air Cycle Machine

ACS: Air Conditioning System

AIR: Aerospace Information Report

APU: Auxiliary Power Unit

ARP: Aerospace Recommended Practice

ASHRAE: American Society for Heating, Refrigerating and Air Conditioning Engineers

AsMA: Aerospace Medical Association

ASTM: American Society for Testing and Materials

CFR: Code of Federal Regulation

ECS: Environmental Control System

EPA: Environmental Protection Agency

ETS: Environmental Tobacco Smoke

FAA: Federal Aviation Administration (USA)

HEPA Filter: High Efficiency Particulate Air Filter

ISO: International Organization for Standardization

JAA: Joint Aviation Authorities (Europe)

JAR: Joint Aviation Requirement