



AEROSPACE INFORMATION REPORT

AIR4246™**REV. E**

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Superseding AIR4246D

Contaminants for Aircraft Turbine Engine Fuel System Component Testing

RATIONALE

This document discusses descriptions of fluid contamination products that are used for design evaluation and formal component qualification/certification testing of aircraft turbine engine fuel and pneumatic system components. The purpose of this document is to recommend standard descriptions to be used by specification writers.

AIR4246, Revision D has been updated to Revision E to: (1) provide a rationale for the document and clarify the scope, (2) reformat the references section to be compliant with SAE guidelines and delete unnecessary references, (3) clarify the definition of graphite epoxy composite contamination since the definition may be inadequate for certain tests, (4) replace Table D1 in Appendix D of AIR4246D with Table E-1 in Appendix E of the JSSG-2009A specification (including Amendment 1), which now incorporates the contaminants recommended in Table D1 of AIR4246D, (5) clarify that contaminants produced by the sieving method may contain contaminant particles that are significantly larger than the sieve sizes, (6) replace the size distribution of ISO Coarse Test Dust in the tables in Appendix B and Appendix C with the reference to ISO 12103-A4, the governing standard for the ISO Coarse Test Dust, and (7) incorporate editorial changes for clarity.

1. SCOPE

1.1 Introduction

This SAE Aerospace Information Report (AIR) is intended as a guide toward standardization of descriptions and specifications of fluid contamination products.

1.2 Scope and Field of Application

This document discusses descriptions of fluid contamination products. These contaminants are used for design evaluation and formal component qualification/certification testing. Such tests are routinely performed on candidate aircraft engine fuel and pneumatic system components. Typical of these components are fuel pumps, fuel filters, fuel controls, pressurizing valves, flow dividers, selector valves, and combustor nozzles. The purpose of this document is to recommend standard descriptions to be used by specification writers.

This document does not address fluid contaminants that may ingress into fuel from other fluid systems, such as hydraulic or lubrication fluids, or aircraft deicing fluids, all of which have well-defined specifications. It also does not address contaminants encountered in fuel transport and handling, such as FAME (fatty acid methyl ester) or SAP (super absorbent polymer); these contaminants are not typically specified for component qualification/certification testing.

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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 International, 400 Commonwealth Drive, Warrendale, PA 15096-0001, Tel: 877-606-7323 (inside USA and Canada) or +1 724-776-4970 (outside USA), www.sae.org.

SAE J726 Air Cleaner Test Code

2.1.2 ASTM Publications

Available from ASTM International, 100 Barr Harbor Drive, P.O. Box C700, West Conshohocken, PA 19428-2959, Tel: 610-832-9585, www.astm.org.

ASTM D3241 Standard Test Method for Thermal Oxidation Stability of Aviation Turbine Fuels

2.1.3 ISO Publications

Available from International Organization for Standardization, ISO Central Secretariat, 1, ch. de la Voie-Creuse, CP 56, CH-1211 Geneva 20, Switzerland, Tel: +41 22 749 01 11, www.iso.org.

ISO 12103-1 Road Vehicles - Test Dust for Filter Evaluation - Part 1: Arizona Test Dust

2.1.4 U.S. Government Publications

Copies of these documents are available online at <https://quicksearch.dla.mil>.

JSSG-2009 Joint Service Specification Guide Air Vehicles Subsystems

MIL-DTL-5624 Turbine Fuel, Aviation, Grades JP-4 and JP-5

MIL-E-5007¹ Engines, Aircraft, Turbojet and Turbofan, General Specification for

MIL-PRF-87260B Foam Material, Explosion Suppression, Inherently Electrostatically Conductive, For Aircraft Fuel Tanks

2.1.5 Other Publications

Morris, R.E., Hughes, J.M., and Colbert, J.E. (2004). The impact of copper on the liquid-phase oxidation of jet fuel for advanced aircraft. *Energy and Fuels*, 18(2), 490-496.

Hazlett, R.N. (1991). *Thermal oxidation stability of aviation turbine fuels*. ASTM International.

Cueller, J.P. and Russell, J.A. (1985). *Additive depletion and thermal stability degradation of JP-5 fuel shipboard samples* (Report NAPC-PE-141C). Southwest Research Institute (SWRI).

¹ MIL-E-5007 (all revisions) is inactive for new design as of January, 1997.

2.2 Related Publications

The following publications are provided for information purposes only and are not a required part of this SAE Technical Report.

2.2.1 SAE Publications

Available from SAE International, 400 Commonwealth Drive, Warrendale, PA 15096-0001, Tel: 877-606-7323 (inside USA and Canada) or +1 724-776-4970 (outside USA), www.sae.org.

AIR4023	Aircraft Turbine Fuel Contamination History and Endurance Test Requirements
ARP1827	Measuring Aircraft Gas Turbine Engine Fine Fuel Filter Element Performance
ARP4014	Aircraft Turbine Engine Pneumatic Component Contaminated Air Endurance Test
MAP749	Aircraft Turbine Engine Fuel System Component Endurance Test Procedure (Room Temperature Contaminated Fuel)

3. CONSIDERATIONS IN SPECIFYING TEST CONTAMINANTS

3.1 Particle Size Distributions

Two common methods are used to describe particle size distributions. These are the “differential range” and “cumulative scale” methods.

- a. Differential range: This method involves expressing particle concentrations for discrete size ranges with an acceptable deviation within each discrete size range. A typical example of a differential range description is shown in Table 1. This distribution has been used to specify SAE J726 Fine Test Dust.

Table 1 - Differential particle size distribution

Particle Size (μm)	Percent of Total (by weight)
0-5	39 ± 2
5-10	18 ± 3
10-20	16 ± 3
20-40	18 ± 3
40-80	9 ± 3

- b. Cumulative scale: This method involves listing cumulative particle concentrations for particles equal to or larger than specified particle sizes along the desired distribution curve and the acceptable deviation at each point. An example is shown in Table 2. This description has been used to specify SAE J726 Fine Test Dust.

Table 2 - Cumulative distribution curve

Particle Size (μm)	Percent of Total Greater Than Stated Size (by weight)
5	61 ± 2
10	43 ± 3
20	27 ± 3
40	9 ± 3
80	0

Cumulative scale descriptions are typically used for broad particle size distributions, such as the silica-based ISO Test Dusts in ISO 12103-1 with size distributions in the 0 to 200 µm size range. Differential range descriptions are typically used when it is necessary to specify a specific size range. As an example, if it is required to determine the specific size range that causes gear wear in a pump, a series of contamination sensitivity tests would be run with various differential size ranges of contaminant to identify the size range corresponding to the maximum contaminant sensitivity.

It should be noted that the accumulation of errors could be very different in differential and cumulative size distributions, depending on how the contaminant was processed to arrive at the distribution. Users must take this into consideration when deciding which distribution mode to specify.

3.2 Specification of Test Contaminants

Descriptions should be carefully considered before making them part of a specification. Prior history and current production capabilities should be investigated when specifying contaminant descriptions. History sets precedence as it is often necessary to compare new aircraft hardware performance with that of the past. Test contaminants should ultimately be designed to simulate actual contaminant products seen in the field. Using modern techniques, field contaminants can usually be duplicated as test contaminants. Surveys of actual in-field contaminants have led to the definition of standard fuel system test contaminants.

For aircraft made of conventional materials (e.g., aluminum), Table X of MIL-E-5007E has been developed. It is worth noting that the large quartz (420 to 1500 µm) is included to cover the aluminum chips generated from the manufacture and repair of aluminum tanks.

3.3 Carbon Fiber Contamination

The use of carbon fiber/graphite composite materials in new aircraft and fuel system designs or in major modifications/repair may result in fuel system contamination with carbon fiber/graphite composite debris. Thus, it should be considered for verification testing of any fuel system. Two types of carbon-based composite contaminants are defined in the list of standard contaminants in Appendix A: carbon fiber rods (see Table A12) and graphite epoxy composite (GEC) (see Table A13). Attention has been drawn from actual experience to the large variability in the graphite epoxy composite contamination size distribution resulting from the detailed composition of the graphite epoxy composite material and the details of the manufacturing process creating the graphite epoxy composite material contamination. Thus, it is recommended that the size distribution and morphology of GEC be obtained from the specification agency (e.g., airframer), and the size distribution in Table A13 only be used as a reference distribution in the absence of more detailed information.

Table C1 in Appendix C has been developed to cover aircraft employing carbon fiber/graphite composite materials in their construction. The carbon fiber rods (see Table A12) and GEC (see Table A13) contaminants were added to the conventional contaminant of Table X of MIL-E-5007E. The concentrations of the conventional contaminant components are scaled down so that when the above contaminants are included, the overall concentration of contaminant is unchanged.

3.4 ISO Test Dusts

The definition of Arizona Test Dust up to Revision A of this document was per that manufactured by the AC Spark Plug Company. Replacement Test Dusts for the AC Test Dusts, no longer available, have been specified by ISO (refer to ISO 12103-1). The corresponding ISO Test Dusts for Arizona Fine and Coarse Test Dusts are, respectively, ISO Fine Test Dust (designated ISO 12103-A2) and ISO Coarse Test Dust (designated ISO 12103-A4). Consequently, the ISO 12103-1 standard has been adopted to replace the previous standard in Revision C of this document. It should be noted that the change to ISO Test Dusts could result in test results that differ from those with the corresponding Arizona Test Dusts. It is necessary for users to take this into account when comparing historic test data with data generated with the ISO Test Dusts and when comparing test results with ISO Test Dusts to historic specification requirements with Arizona Test Dusts.

3.5 Cotton Linters Standard

The cotton linters contaminant specification was based on the U.S. Department of Agriculture (USDA) Standards SRA-AMS 180 and 251. The USDA no longer maintains these standards for the cotton linters contaminant. The material is available from vendors who have historically supplied it for fuel testing. The description of the cotton linters contaminant has been modified, in consultation with a primary vendor, to be suitable for use in specifications. Existing suppliers may be contacted for additional information.

3.6 Explosion Suppressant Foam

Explosion suppressant foam (ESF) specified per MIL-PRF-87260B is being used in both transport and tactical aircraft to address safety hazards associated with static, power, and lightning electrical discharge inside of fuel systems. This foam represents a unique contamination threat to bearings, hinges, pilot holes, and other small flow passages that is not simulated by any of the historical contaminants.

3.7 Copper Contamination

Copper contamination in aviation fuel has been an area of concern for over 40 years. The presence of dissolved copper, even at trace concentrations of 35 ppb (parts per billion), has been shown to degrade an aviation fuel's thermal stability as determined by the ASTM D3241 Test Method. Thermal stability, as measured by ASTM D3241, is a MIL-DTL-5624 specification requirement for JP-5 fuel. Numerous studies have been performed over the past 40 years showing the deleterious effects of trace chemical elements, including copper, on aviation fuel thermal stability. Several technical references are included in 2.1.5 that summarize the effects of copper on jet fuel thermal stability. Results from U.S. Navy shipboard JP-5 fuel sample testing show an average dissolved copper concentration of 250 ppb. Requirements to adequately verify the effect of dissolved copper in engine fuel systems for aircraft operating from aboard marine vessels where copper plumbing may be present in aircraft refueling systems are included in Tables C1 and C2 of Appendix C.

4. RECOMMENDED DEFINITIONS OF STANDARD CONTAMINANTS

Appendix A contains recommended descriptions of several contaminants used for current product evaluation in the industry. The Arizona Test Dust definition was changed at Revision C of this AIR to cater to the nonavailability of AC Test Dusts. The new definition is taken from ISO 12103-1. Some of the contaminant descriptions in Appendix A may not have been used previously but should adequately describe particle size distributions of products currently produced by several suppliers.

It should be noted that contaminants that are graded for size by the sieving method - typically larger size contaminants such as aluminum and iron chips and crushed quartz (also referred to as sharp silica sand) - may have particles that are larger than the upper size limits since the holes in the sieves may permit long, narrow particles to pass through in the appropriate attitude. The JSSG-2009 (with Amendment 1) specification (Appendix E, Table E-1) has included a footnote to this effect, stating that contamination specified at 500 μm , upper size limit, may include some contaminant particles as large as 700 to 800 μm (see Appendix D).

5. RECOMMENDED COMPOSITION OF CONTAMINANTS FOR FUEL SYSTEM TESTING

Appendices B and C show modifications to MIL-E-5007E, Table X contamination; the volumetric unit of gallons (gal) is U.S. gallons. Appendix B contains Table X, the fuel contamination requirements from MIL-E-5007E, but modified to include ISO Test Dust, defined in ISO 12103-1, in place of the original Arizona Test Dust.

Appendix C shows a modified version of Table X, designated Table C1, deemed suitable for contaminated fuel testing of fuel systems fitted to aircraft employing carbon fiber composite materials in the construction of their fuel tanks. Appendix C also shows a test contaminant suitable for continuous operation testing (see Table C2).

Appendix D shows the contaminant requirements for the JSSG-2009A (with Amendment 1) specification (Appendix E, Table E-1). The contaminant requirements: (1) include ISO Test Dust defined in ISO 12103-1 in place of the original Arizona Test Dust, (2) include the size distributions of graphite epoxy contaminant (GEC) and explosion suppressant foam (ESF) contaminant, and (3) reduce the concentration of ESF specified in the original JSSG-2009 specification. It should be noted that the cotton linters contamination is specified in terms of the defunct USDA standards. As discussed in 3.5, the definition included in Table A5 is appropriate for defining cotton linters contamination.

6. HISTORICAL INFORMATION

Appendix E shows the original definition of AC produced Fine and Coarse Arizona Test Dusts, which are no longer produced.

Appendix F shows the original MIL-E-5007E Table X, including AC produced Arizona Test Dust, which is no longer produced; the volumetric unit of gallons (gal) is U.S. gallons.

Appendix G shows the original JSSG-2009, Appendix E (Table E-1) contaminant specifying AC produced Arizona Test Dust (no longer produced) and including graphite epoxy composite (GEC) and explosion suppressant foam (ESF) contaminants but without their size distributions. Note also that the concentration of ESF is higher than in JSSG-2009A (with Amendment 1), Appendix E (Table E-1).

7. NOTES

7.1 Revision Indicator

A change bar (|) located in the left margin is for the convenience of the user in locating areas where technical revisions, not editorial changes, have been made to the previous issue of this document. An (R) symbol to the left of the document title indicates a complete revision of the document, including technical revisions. Change bars and (R) are not used in original publications, nor in documents that contain editorial changes only.

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