SAE The Engineering Society For Advancing Mobility Land Sea Air and Space®
INTERNATIONAL
400 Commonwealth Drive, Warrendale, PA 15096-0001

AEROSPACE INFORMATION REPORT

SAE AIR4246 REV. B

Issued 1990-03
Revised 2002-04

Superseding AIR4246A

Contaminants for Aircraft Turbine Engine Fuel System Component Testing

1. SCOPE:

1.1 Introduction:

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

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.

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.

TO PLACE A DOCUMENT ORDER: (724) 776-4970 FAX: (724) 776-0790 SAE WEB ADDRESS: http://www.sae.org

2.1.1 U.S. Government Publications: Available from DODSSP, Subscription Services Desk, Building 4D, 700 Robbins Avenue, Philadelphia, PA 19111-5094.

MIL-E-5007 Engines, Aircraft, Turbojet and Turbofan, General Specification for

2.1.2 ISO Publications: Available from International Organization for Standardization, Case Postal 56, CH-1211 Geneva 20, Switzerland.

ISO 12103-1 Road vehicles - Test dust for filter evaluation - Part 1: Arizona test dust

2.2 Related Publications:

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

MIL-E-8593	Engines, Aircraft, Turboshaft and Turboprop, General Specification for
MAP749	Aircraft Turbine Engine Fuel System Component Endurance Test (Contaminated Fuel)
ARP1827	Measuring Aircraft Gas Turbine Engine Fine Fuel Filter Element Performance
ARP4014	Aircraft Turbine Engine Pneumatic Component Contaminated Air Endurance Test
AIR4023	Aircraft Turbine Fuel Contamination History and Endurance Test Requirements
JSSG-2007	Joint Service Specification Guide
SAE J726	Air Cleaner Test Code

2.3 Definitions:

There are several ways to describe particle size distributions. Two common methods are normally used. These are "differential range" and 'cumulative scale" methods. What follows is a brief description and some advantages or disadvantages of each type of distribution.

a. Differential Range: This method of expression involves listing several size ranges and the acceptable deviation within each range throughout the desired distribution. 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 Range

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

This expression may be acceptable for many applications, however, it allows a midrange median cumulative variation equal to ± one half the sum of all specified differential deviations. In this example, the 15-µm point (which is the midrange median) the maximum variation could be ±1/2(2+3+3+3+3)%=±7% or 14% possible variation at this point. Total variation at other points would be less, however, differential deviations do accumulative. Insertion of added ranges, without a decrease in deviations, will increase the cumulative variation.

2.3 (Continued):

b. Cumulative Scale: This method involves listing several points 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 - 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

The cumulative distribution method limits the variation to twice the stated deviation at any point. In the example above, the deviation at 20 µm is ±3%, which limits variation at that point to 6%. Additional points within the cumulative curve further define the desired distribution and do not affect maximum variation.

3. DISCUSSION:

Reviewing potential variations in "differential range" and "cumulative scale" methods of particle size expression, it is apparent that "cumulative scale" expressions can limit maximum variation. This does not mean "cumulative scale" should always be used in describing particle size distributions.

Narrow size distributions, described by using two or less differential ranges, do not accumulate variation and are well suited for "differential range" description. See Table 3 for an example.

TABLE 3 - Narrow Size Distribution

Size Range (µm)	Percent Within Specified Range (by weight)
5-10	96-100

Broad particle distributions should be considered carefully to determine the description type and the deviation that properly specify the desired material. In most cases, "cumulative scale" size descriptions are best suited from broad size distributions.

3. (Continued):

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.

The use of carbon fiber composite materials in new aircraft construction may result in fuel system contamination with carbon fiber composite debris.

A standard carbon fiber test contaminant has now been defined and its definition joins the list of other standard contaminants.

Table C1 has been developed to cover aircraft employing carbon fiber composite materials in their construction. Here a quantity of the newly defined carbonfiber test contaminant is added to the conventional contaminant of Table X of MIL-E-5007E. The concentrations of the conventional components are scaled down so that when the carbon fiber contaminant is included, the overall concentration of contaminant is unchanged.

The definition of Arizona test dust used up to Revision A of this document was as for that manufactured by the AC Spark Plug Company. However, this company has ceased production of this test dust and currently manufactured suppliees from elsewhere are to a slightly different standard. Consequently the ISO 12103-1 standard has been adopted in this Revision to replace the previous standard.

4. RECOMMENDED DEFINITIONS OF STANDARD CONTAMINANTS:

Appendix A contains recommended descriptions of several contaminants used for current product evaluation in the filtration industry. Some of these descriptions may not have been used previously but should adequately describe particle size distribution of products currently produced by several suppliers. The Arizona test dust definition is changed at Revision B to cater for the non-availability of AC test dusts. The new definition is taken from ISO 12103-1.

5. RECOMMENDED COMPOSITION OF CONTAMINANTS FOR FUEL SYSTEM TESTING:

   Appendix B contains Table X, the fuel contamination requirements from MIL-E-5007E but modified to include the ISO definition of Arizona test dust.

   Appendix C shows a modified version of the above Table X, designated Table C1, deemed suitable for contaminanted 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.

6. HISTORICAL INFORMATION:

   Appendix D shows the original definition of AC produced fine and coarse Arizona test dust which is no longer produced, but may still exist in stock in some companies.

   Appendix E shows the original MIL-E-5007E Table X including AC Arizona test dust.

PREPARED UNDER THE JURISDICTION OF
SAE SUBCOMMITTEE AE-5B, ENGINE RELATED COMPONENTS AND
AIRFRAME MOUNTED PUMPS OF
COMMITTEE AE-5, AEROSPACE FUEL, OIL, AND OXIDIZER SYSTEMS

APPENDIX A

A.1 STANDARDIZED ARIZONA TEST DUST CONTAMINANT - AS SPECIFIED IN ISO 12103-1 (GRADES FINE AND COARSE):

TABLE A1 - Typical Chemical Analysis

Chemical	Mass Fraction %
Silicon expressed as SiO_2	68-76
Aluminium expressed as Al_2O_3	10-15
iron expressed as Fe_2O_3	2-5
Sodium expressed as Na_2O	2-4
Calcium expressed as CaO	2-5
Magnesium expressed as MgO	1-2
Titanium expressed as TiO_2	0.5-1
Potassium expressed as K_2O	0.10
Organics lost from ignition	2-5

TABLE A2 - Particle Size Distribution

Size in Micrometers	Maximum Volume Fraction % Fine Grade (ISO 12103-A2)	Maximum Volume Fraction % Coarse Grade (ISO 12103-A4)
1	2.5 to 3.5	0.6 to 1
2	10.5 to 12.5	2.2 to 3.7
3	18.5 to 22	4.2 to 6
4	25.5 to 29.5	6.2 to 8.2
5	31 to 36	8 to 10.5
7	41 to 46	12 to 14.5
10	50 to 54	17 to 22
20	70 to 74	32 to 36
40	88 to 91	57 to 61
80	99.5 to 100	87.5 to 89.5
120	100	97 to 98
180	-	99.5 to 100
200	-	100

A.2 IRON OXIDE FRACTIONS:

TABLE A3 - 0-Specified Size

Size Range (micrometers)	Acceptable Size Limits
0-5 0-10	Specified fractions shall contain a minimum of 96% within stated size range as measured by volume % 25 to 35% by volume shall be greater than one half of the specified top size

TABLE A4 - Intermediate Grades

Size Range (micrometers)	Acceptable Size Limits
5-10 10-20	Intermediate grade fractions shall contain a minimum of 90% within stated size range as measured by volume %

A.3 COTTON LINTERS:

TABLE A5

Type:	Prime cotton linters ground below Staple #7 (U.S. Department of Agriculture Grading Standards) ground in a Wiley Mill and screened through a 4-mm screen

A.4 GRADED CRUSHED QUARTZ FRACTIONS:

TABLE A6 - From Good Commercial Quality Stock

Graded Size (micrometers)	U.S. Standard Test Sieve No.
150-300	100-50
300-420	50-40
420-1000	40-18
1000-1500	18-14

NOTE: Fractions shall contain a minimum of 96% within stated size range as measured by weight %.

A.5 CRUSHED QUARTZ:

TABLE A7 - Good Commercial Quality

(Micrometers)	% of Total Less Than (by weight)
1000	100
900	98-99
600	93-97
400	82-86
200	46-50
125	18-22
75	3-7

A.6 IRON CHIPS OR FILINGS:

TABLE A8 - 0-Specified Size

Graded Size (micrometers)	U.S. Standard Test Sieve No.
0-150	100

NOTE: 99% minimum by weight within stated size.

TABLE A9 - Intermediate Grades

Particle Size (micrometers)	U.S. Standard Test Sieve No.
150-500	100-35

NOTE: 99% minimum by weight within stated size.

A.7 ALUMINUM CHIPS OR FILINGS:

TABLE A10 - 0-Specified Size

Particle Size (micrometers)	U.S. Standard Test Sieve No.
0-150	100

NOTE: 99% minimum by weight within stated size.

TABLE A11 - Intermediate Grades

Particle Size (micrometers)	U.S. Standard Test Sieve No.
150-500	100-35

NOTE: 99% minimum by weight within stated size.

A.8 CARBON FIBER COMPOSITE CONTAMINANT:

TABLE A12 - Population Distribution

Paricle Size (micrometers)	% (Population)
0-25	43 ± 5
25-50	25 ± 5
50-75	13 ± 5
75-125	12 ± 5
>125	7 ± 5

APPENDIX B

TABLE B1 - MIL-E-5007E Table X - Fuel Contaminants for Equivalent Mission Time Modified for ISO Specified Arizona Test Dust

Contaminant	Particle Size	Quantity
Ferroso-Ferric Iron Oxide (Fe_3O_4) (Black color) (Magnetite)	0 to 5 µm	1.5 gm/1000 gal
Ferric Iron Oxide (Fe_2O_3, Hematite)	0 to 5 µm	27.0 gm/1000 gal
Ferric Iron Oxide (Fe_2O_3, Hematite)	5 to 10 µm	1.5 gm/1000 gal
Crushed Quartz	1000 to 1500 µm	0.25 gm/1000 gal
Crushed quartz	420 to 1000 µm	1.75 gm/1000 gal
Crushed Quartz	300 to 420 µm	1.0 gm/1000 gal
Crushed Quartz	150 to 300 µm	1.0 gm/1000 gal
Prepared dirt conforming to ISO 12103-1 (Arizona test dust - coarse)	Mixture as follows 0 to 5 µm (9.25%) 5 to 10 µm (10.25%) 10 to 20 µm (14.5%) 20 to 40 µm (25%) 40 to 80 µm (29.5%) 80 to 200 µm (11.5%)	8.0 gm/1000 gal
Cotton linters	Staple below 7 USDA Grading Standards SRA-AMS 180 and 251	0.1 gm/1000 gal
Crude Naphthenic Acid		0.03% by volume
Salt water prepared by dissolving salt in distilled water or other water containing not more than 200 ppm of total solids	4 parts by weight NaCl 96 parts by weight H_2O	0.01% by volume entrained

APPENDIX C

TABLE C1 - Fuel Contaminants for Equivalent Mission Time
(For Carbon Fiber Composite Material Aircraft)

Contaminant	Particle Size	Quantity
Ferroso-Ferric Iron Oxide (Fe_3O_4) (Black color) (Magnetite)	0 to 5 µm	1.43 gm/1000 gal
Ferric Iron Oxide (Fe_2O_3, Hematite)	0 to 5 µm	25.66 gm/1000 gal
Ferric Iron Oxide (Fe_2O_3, Hematite)	5 to 10 µm	1.43 gm/1000 gal
Crushed Quartz	1000 to 1500 µm	0.24 gm/1000 gal
Crushed Quartz	420 to 1000 µm	1.66 gm/1000 gal
Crushed Quartz	300 to 420 µm	0.95 gm/1000 gal
Crushed Quartz	150 to 300 µm	0.95 gm/1000 gal
Prepared dirt conforming to ISO 12103-1 (Arizona test dust - coarse)	Mixture as follows 0 to 5 µm (9.25%) 5 to 10 µm (10.25%) 10 to 20 µm (14.5%) 20 to 40 µm (25%) 40 to 80 µm (29.5%) 80 to 200 µm (11.5%)	7.60 gm/1000 gal
Cotton linters	Staple below 7 USDA Grading Standards SRA-AMS 180 and 251	0.1 gm/1000 gal
Crude Naphthenic Acid		0.03% by volume
Salt water prepared by dissolving salt in distilled water or other water containing not more than 200 ppm of total solids	4 parts by weight NaCl 96 parts by weight H_2O	0.01% by volume entrained

TABLE C1 - Fuel Contaminants for Equivalent Mission Time
(For Carbon Fiber Composite Material Aircraft) (Continued)

Contaminant	Particle Size	Quantity
Carbon fiber rods of tensile strength 5.59 GPa nominal	5 µm nom dia 0 to 2000 µm in length Population distribution: 0 to 25 µm (43% ± 5%) 25 to 50 µm (25% ± 5%) 50 to 75 µm (13% ± 5%) 75 to 125 µm (12% ± 5%) >125 µm (7% ± 5%) Maximum fiber length 2000 µm	2.05 gm/1000 US gal