

(R) Contaminants for Aircraft Turbine Engine Fuel System Component Testing

RATIONALE

Five year review/revision: (1) update to include JSSG specification, (2) update to clarify cotton linters specification, (3) additional detail on replacement dusts for Arizona Test Dusts, (4) update to clarify applicability of MIL-E-5007 and MIL-E-8593 specifications, (5) update to include MAP749, (6) Deletion of the detailed discussion on cumulative and differential distribution error accumulation since this is not necessarily valid with the current methods for determining particle size distributions, (7) update to include graphite epoxy contaminant (GEC), (8) update to include explosion suppressent foam (ESF) contaminant, (9) update to include copper contamination, and (10) editorial changes.

1. SCOPE

1.1 Introduction

This SAE Aerospace Information Report (AIR) is intended as a guide toward standardization of 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. 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.

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## 2.1 SAE Publications

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

ARP1827	Measuring Aircraft Gas Turbine Engine Fine Fuel Filter Element Performance
MAP749	Aircraft Turbine Engine Fuel System Component Endurance Test Procedure (Room Temperature Contaminated Fuel)
ARP4014	Aircraft Turbine Engine Pneumatic Component Contaminated Air Endurance Test
AIR4023	Aircraft Turbine Fuel Contamination History and Endurance Test Requirements
J726	Air Cleaner Test Code

## 2.2 U.S. Government Publications

Available from the Document Automation and Production Service (DAPS), Building 4D, 700 Robbins Avenue, Philadelphia, PA 19111-5094, Tel: 215-697-6257, <http://assist.daps.dla.mil/quicksearch/>.

MIL-E-5007 <sup>1</sup>	Engines, Aircraft, Turbojet and Turbofan, General Specification for
MIL-E-8593 <sup>2</sup>	Engines, Aircraft, Turboshift and Turboprop, General Specification for
MIL-PRF-87260B	Foam Material, Explosion Suppression, Inherently Electrostatically Conductive, For Aircraft Fuel Tanks
JSSG-2007	Joint Service Specification Guide Engines, Aircraft, Turbine
JSSG-2009	Joint Service Specification Guide Air Vehicles Subsystems

### 2.2.1 ISO Publications

Available from International Organization for Standardization, 1, rue de Varembe, Case postale 56, CH-1211 Geneva 20, Switzerland, Tel: +41-22-749-01-11, [www.iso.org](http://www.iso.org).

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

## 2.3 Other References

- The Impact of Copper on the Liquid-Phase Oxidation of Jet Fuel for Advanced Aircraft, Robert E. Morris, Janet M. Hughes, and, John E. Colbert, Energy & Fuels, 2004 18 (2), pp. 490-496.
- Hazlett, R. N. Thermal Oxidation Stability of Aviation Turbine Fuels, ASTM: Philadelphia, 1991
- Additive Depletion and Thermal Stability Degradation of JP-5 Fuel Shipboard Samples, J. P. Cueller, Jr., J. A. Russell, Southwest Research Institute (SWRI), Report NAPC-PE-141C, 1985.

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

<sup>2</sup> MIL-E-8593 is inactive for all new design and is no longer used, except for replacement purposes, effective January, 1997.

### 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 counts 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 ( $\mu\text{m}$ )	Percent of Total (by weight)
0-5	39 $\pm$ 2
5-10	18 $\pm$ 3
10-20	16 $\pm$ 3
20-40	18 $\pm$ 3
40-80	9 $\pm$ 3

- b. **Cumulative Scale:** This method involves listing cumulative particle counts 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 PARTICLE SIZE DISTRIBUTION

Particle Size ( $\mu\text{m}$ )	Percent of Total Greater Than Stated Size (by weight)
5	61 $\pm$ 2
10	43 $\pm$ 3
20	27 $\pm$ 3
40	9 $\pm$ 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  $\mu\text{m}$  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 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, and users must take this into consideration in deciding on 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  $\mu\text{m}$ ) 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 (Table A12) and Graphite Epoxy Composite (GEC; Table A13). Table C1 in Appendix C has been developed to cover aircraft employing carbon fiber/graphite composite materials in their construction. A newly defined carbon fiber test contaminant, similar to Table C1, was 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.

### 3.4 ISO Test Dusts

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. Replacement test dusts for the AC Test Dusts, no longer available, have been specified by ISO (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 in this revision to replace the previous standard. 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 AC Test Dusts.

### 3.5 Cotton Linters Standard

The Cotton Linters contaminant is specified in Appendix A, based on the U.S. Department of Agriculture (U.S.D.A.) Standards SRA-AMS 180 and 251. The U.S. Department of Agriculture no longer maintains these standards for the Cotton Linters contaminant. The material is available from vendors who have historically supplied it for fuel testing, and a new standard, when available, will be included in a future revision of this standard. In the interim, existing suppliers should be contacted for specific information.

### 3.6 Explosion Suppressant Foam

Explosion Suppressant Foam (ESF) specified per MIL-PRF-87260B (Foam Material, Explosion Suppression, Inherently Electrostatically Conductive, For Aircraft Fuel Tanks) 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 which 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 Test Method D3241. Thermal Stability, as measured by the 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 paragraph 2.4 that summarize the effects of copper on jet fuel thermal stability. Results from 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 and fuel wetted components have been added to JSSG-2007 tables XXVa, XXVb, and XXVc, and included in Tables C1 & 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. 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 was changed at Revision B of the AIR to cater for the non-availability of AC test dusts. The new definition is taken from ISO 12103-1. As stated above, a new standard for Cotton Linters, when available, will be referenced in a future revision of this standard. In the interim, existing suppliers should be contacted for specific information.

#### 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 ISO Test Dust defined in ISO 12103-1 in place of the original Arizona Test Dust.

Appendix C shows a modified version of the above 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, Table C2.

Appendix D shows the proposed contaminant requirements for the JSSG-2009 specification (Appendix E of the JSSG-2009 specification). The contaminant requirements in Appendix E of the JSSG-2009 specification (at the time of publication of this AIR), have been modified in Appendix D to: (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 JSSG-2009 specification (at the time of this publication).

#### 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 Arizona Test Dust which is no longer produced.

Appendix G shows the original JSSG – 2009, Appendix E contaminant table (at the time of the release of this document), specifying AC Arizona Test Dust (which is 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 that proposed in Appendix D.

#### 6. NOTES

- 6.1 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.

APPENDIX A – DESCRIPTION OF TEST CONTAMINANTS FOR  
TURBINE ENGINE FUEL SYSTEM COMPONENT TESTING

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 <sub>2</sub>	68-76
Aluminium expressed as Al <sub>2</sub> O <sub>3</sub>	10-15
Iron expressed as Fe <sub>2</sub> O <sub>3</sub>	2-5
Sodium expressed as Na <sub>2</sub> O	2-4
Calcium expressed as CaO	2-5
Magnesium expressed as MgO	1-2
Titanium expressed as TiO <sub>2</sub>	0.5-1
Potassium expressed as K <sub>2</sub> O	0.10
Organics lost from ignition	2-5

TABLE A2 - PARTICLE SIZE DISTRIBUTION

Particle Size ( Micrometers )	Maximum Volume Fraction (%) Less Than Indicated Particle Size	Maximum Volume Fraction (%) Less Than Indicated Particle Size Coarse Grade (ISO 12103-A4)
	Fine Grade (ISO 12103-A2)	
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 – SPECIFICATION OF COTTON LINTERS

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
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NOTE: The U.S. Department of Agriculture no longer maintains the Grading Standards. Until a replacement standard is available, existing suppliers should be contacted for specific information.

## 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 RODS 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

5.59 Gpa nominal tensile strength  
Maximum fiber length: 2000 μm

## A.9 GRAPHITE EPOXY COMPOSITE (GEC) CONTAMINANT

TABLE A13 - 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

## A.10 EXPLOSION SUPPRESSANT FOAM (ESF) CONTAMINANT

TABLE A14 - DISTRIBUTION

Explosion suppressant Foam (ESF) contaminant is defined as foam in compliance with MIL-PRF-87260B	1 – 100 micrometers Distribution is random, utilizing method outlined and cut utilizing the methods in section 4.2.4 of MIL-PRF-87260B, excluding a hot wire cutter.
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APPENDIX B – TABLE X CONTAMINATION IN MIL-E-5007,  
MODIFIED FOR ISO COARSE TEST DUST

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 <sub>3</sub> O <sub>4</sub> ) (Black color) (Magnetite)	0 to 5 µm	1.5 gm/1000 gal
Ferric Iron Oxide (Fe <sub>2</sub> O <sub>3</sub> , Hematite)	0 to 5 µm	27.0 gm/1000 gal
Ferric Iron Oxide (Fe <sub>2</sub> O <sub>3</sub> , 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-A4 (ISO Coarse Test Dust)	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 (See footnote to Table A5, Appendix A)	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 <sub>2</sub> O	0.01% by volume entrained

APPENDIX C – PROPOSED FUEL CONTAMINANTS FOR  
CARBON FIBER COMPOSITE MATERIAL AIRCRAFT

TABLE C1 - FUEL CONTAMINANTS FOR EQUIVALENT MISSION TIME  
(FOR CARBON FIBER COMPOSITE MATERIAL AIRCRAFT)

Contaminant	Particle Size	Quantity
Ferroso-Ferric Iron Oxide (Fe <sub>3</sub> O <sub>4</sub> ) (Black color) (Magnetite)	0 to 5 µm	1.43 gm/1000 gal
Ferric Iron Oxide (Fe <sub>2</sub> O <sub>3</sub> , Hematite)	0 to 5 µm	25.66 gm/1000 gal
Ferric Iron Oxide (Fe <sub>2</sub> O <sub>3</sub> , 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-A4 (ISO Coarse Test Dust)	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 (See footnote to Table A5, Appendix A)	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 <sub>2</sub> O	0.01% by volume entrained
Graphite Epoxy Composite (GEC)	0 – 45 (23%) Microns 45 – 150 (26%) 150 – 300 (8%) 300 – 425 (32%) 425 – 710 (11%)	1.3 gm/1000 US gal
Carbon fiber rods of tensile strength 5.59 GPa nominal	5 µm nom diameter, 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
Copper*	Dissolved	250 ppb minimum

\* Recommended for aircraft required to operate from aboard naval aircraft carriers

TABLE C2 - FUEL CONTAMINANTS FOR CONTINUOUS OPERATION  
(BASED ON MIL-E-5007E TABLE X)

Contaminant	Particle Size	Quantity
Ferroso-Ferric Iron Oxide ( $\text{Fe}_3\text{O}_4$ ) (Black color) (Magnetite)	0 to 5 $\mu\text{m}$	1.0 gm/1000 gal
Ferric Iron Oxide ( $\text{Fe}_2\text{O}_3$ , Hematite)	0 to 5 $\mu\text{m}$	5.0 gm/1000 gal
Ferric Iron Oxide ( $\text{Fe}_2\text{O}_3$ , Hematite)	5 to 10 $\mu\text{m}$	1.0 gm/1000 gal
Prepared dirt conforming to ISO 12103-A4 (ISO Coarse Test Dust)	Mixture as follows 0 to 5 $\mu\text{m}$ (9.25%) 5 to 10 $\mu\text{m}$ (10.25%) 10 to 20 $\mu\text{m}$ (14.5%) 20 to 40 $\mu\text{m}$ (25%) 40 to 80 $\mu\text{m}$ (29.5%) 80 to 200 $\mu\text{m}$ (11.5%)	2.0 gm/1000 gal
Cotton linters (See footnote to Table A5, Appendix A)	Staple below 7 USDA Grading Standards SRA- AMS 180 and 251	0.02 gm/1000 gal
Copper *	Dissolved	250 ppb minimum

\* Recommended for aircraft required to operate from aboard naval aircraft carriers

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## APPENDIX D – PROPOSED CONTAMINANT FOR JSSG-2009, APPENDIX E

TABLE D1 – PROPOSED CONTAMINANT MIXTURE IN JSSG-2009, APPENDIX E

Contaminant	Contaminant Mixture	
	Particle Size (Microns)*	Quantity (gms per 1000 liters)
Iron Oxide	0 - 5	19
	5 - 10	1.0
Sharp Silica Sand	150 - 300	0.7
	300 - 420	0.7
Prepared dirt conforming to ISO 12103-A4 (ISO Coarse Test Dust)	Mixture as follows	5.3
	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%)	
Cotton linters (See footnote in Table A5, Appendix A)	80 to 200 µm (11.5%)	0.07
	Staple below 7 U.S. Dept of Agriculture Grading Standards	
Iron Chips	150 - 500	10
Aluminum Chips	150 - 500	10
Graphite Epoxy Composite	0 - 45 (23%)	5.2
	45 - 150 (26%)	
	150 - 300 ( 8%)	
	300 - 425 (32%)	
	425 - 710 (11%)	
** Explosion suppressant Foam (ESF) particles. ESF contaminant is defined as foam in compliance with MIL-PRF-87260B	1 - 100 Distribution is random utilizing method outlined and cut utilizing the methods in section 4.2.4 of MIL-PRF-87260B, excluding a hot wire cutter.	0.75

\* NOTE: The contamination used for testing is graded by the sieve method with the exception of ISO Coarse Test Dust, where the particle size distribution is by volume and was determined with a Coulter Counter. In the sieve method, particles considerably larger than 500 microns size could pass through the sieve. Particles in the 700 to 800 micron range have been found in certified test contamination samples.

\*\* for air vehicle with fuel tank explosion suppression foam installed in the tanks, or which has aerial refueling capability.