Designation: D 4054 – 93 (Reapproved 2003)

An American National Standard

Standard Practice for Evaluating the Compatibility of Additives with Aviation-Turbine Fuels and Aircraft Fuel System Materials[1]

This standard is issued under the fixed designation D 4054; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This practice covers procedures required to determine the compatibility of additives proposed for aviation turbine fuels with both standardized fuels and the materials commonly used in commercial aircraft fuel system construction.

1.2 Satisfactory evidence of compatibility using this practice is required by the ASTM Guidelines for Additive Approval (Research Report D02-1125)[2] for additives specified in Specification D 1655 and also by individual aircraft and engine manufacturers as well as government agencies.

1.3 Compatibility data resulting from these procedures represent only part of the performance information required for additive approval.

1.4 The actual level of acceptance is established by the individual approving groups.

1.5 While efforts are made to maintain the list of fuel system materials to be tested and to keep it current, users of this practice must recognize that these lists are subject to continuing revision to meet the needs of equipment manufacturers.

1.6 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:*

D 156 Test Method for Saybolt Color of Petroleum Products (Saybolt Chromometer Method)[3]

D 1266 Test Method for Sulfur in Petroleum Products (Lamp Method)[3]

D 1655 Specification for Aviation Turbine Fuels[3]

D 2624 Test Methods for Electrical Conductivity of Aviation and Distillate Fuels Containing a Static Dissipator Additive[3]

D 3227 Test Method for (Thiol Mercaptan) Sulfur in Gasoline, Kerosine, Aviation Turbine, and Distillate Fuels (Potentiometric Method)[3]

D 3602 Field Test Method for Water Separation Characteristics of Aviation Turbine Fuels[4]

D 3948 Test Methods for Determining Water Separation Characteristics of Aviation Turbine Fuels by Portable Separometer[5]

D 4308 Test Method for Electrical Conductivity of Liquid Hydrocarbons by Precision Meter[5]

D 4952 Test Method for Qualitative Analysis of Active Sulfur Species in Fuels and Solvents (Doctor Test)[5]

3. Summary of Practice

3.1 These procedures are laboratory techniques for establishing additive compatibility with commercial aviation turbine fuels, with additives previously approved in standard fuels and with the fuel system components used in commercial aircraft, including tank coatings, sealants, and elastomers. Tests are conducted with Jet A/A-1 fuel at four times the maximum additive concentration as recommended by the additive supplier. Immersion tests, with fuel system components only, are conducted in the more severe Reference Test Fluids, TT-S-735, Types III and VII. The time and temperature of immersion tests are representative of aircraft use conditions and immersed components are evaluated after exposure, using industry standard methods. Comparisons are made with representative components exposed to the base fluid with and without additive.

NOTE 1—Data obtained with Jet A/A-1 fuels can be applicable to Jet B fuel or to aviation fuels specified by other organizations, with the agreement of the approving air frame/engine manufacturer.

4. Significance and Use

4.1 Additives are generally used to enhance a fuel property such as oxidation stability or to improve fuel performance by providing corrosion inhibition, protection against icing, metal deactivation, and so forth. However, their use can adversely affect other fuel properties or the ground-handling systems for

[1] This practice is under the jurisdiction of ASTM Committee D02 on Petroleum Products and Lubricants and is the direct responsibility of Subcommittee D02.J0 on Aviation Fuels.

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[2] Supporting data have been filed at ASTM International Headquarters and may be obtained by requesting Research Reports RR:D02-1125 and D02-1137.

[3] *Annual Book of ASTM Standards*, Vol 05.01.

[4] Discontinued. See 1994 *Annual Book of ASTM Standards*, Vol 05.02.

[5] *Annual Book of ASTM Standards*, Vol 05.02.

fuels. Application of the procedures of this practice is intended to disclose these adverse effects.

4.2 Combinations of additives may exhibit antagonistic effects on fuel properties or performance. Compatibility testing with previously approved additives is intended to disclose such antagonistic effects of incompatibilities.

4.3 Fuel system components such as sealants, coatings, and elastomers are normally selected because of their resistance to a Reference Test Fluid, which is designed to be more severe to components than standard fuels. Application of the procedures of this practice is intended to disclose adverse effects of additives beyond the effects of the Reference Test Fluids.

5. Procedure A—Additive Effects on Fuel

5.1 *Base Fuel* required for Procedures A and B must meet the Jet A or Jet A-1 requirements of Specification D 1655 and be clay treated in accordance with the procedure of Test Method D 3948, Appendix X1, "Preparation of Reference Fluid Base." It should exhibit a rating of 98 WSIM after clay treating by Test Methods D 3602 or D 3948. About 75 L (20 gal) of base fuel is required for Procedures A and B. Store the base fuel in clean epoxy-coated metal containers and recheck the WSIM rating after three months of storage.

5.2 Prepare the *test fuel* by blending four times the maximum recommended concentration of the additive into 38 L (10 gal) of base fuel.

NOTE 2—If the maximum solubility level is below this concentration, prepare the test fuel accordingly.

5.3 All ASTM D 1655 specification tests and the following additional tests, should be run on the base fuel and the test fuel:

D 3602 or D 3948 water separation

D 2624 electrical conductivity

D 156 Saybolt color bright and clear-visual inspection

5.4 If tests on test fuel exceed the limits of D 1655, rerun a second test fuel containing only the maximum recommended concentration of additive in accordance with 5.3 and report.

6. Procedure B—Additive Compatibility with Other Additives

6.1 Prepare duplicate test blends by mixing 100 mL of base fuel containing four times the maximum recommended concentration of the candidate additive to 100 mL of base fuel containing, in turn, each of the previously approved additives (other than oxidation inhibitors) at four times their maximum recommended concentrations. The resultant blend contains two times the maximum recommended concentration of each additive.

NOTE 3—Approved additives are listed in Specification D 1655 but Procedure B may also be applied to additives approved for aviation fuels by other organizations.

6.2 Divide each of the mixtures described in 6.1 into two clear, tall glass containers (100 mL each). Put the duplicate samples into dark, cold storage at − 17.8°C (0°F) for 24 h. Inspect immediately after removal from cold storage, for indications of precipitation, cloudiness, darkening, or other visual evidence of incompatibility.

6.3 Warm the samples inspected from cold storage, shake to remix any separated components, and hold at 38°C (100°F) for 24 h. Inspect them again for visual evidence of incompatibility immediately after cooling to room temperature. Keep fuel samples in dark storage during conditioning and between inspections.

NOTE 4—Photographs are a useful record of results of compatibility testing.

7. Procedure C—Additive Compatibility with Fuel System Components

7.1 Formulate the jet reference liquid required for conducting fluid immersion tests as follows:

Jet Reference Fluid, TT-S-735, Type III	
Toluene (TT-T-548)	30 Volumes
*Iso*octane (TT-S-735, Type I or ASTM Reference Grade)	70 Volumes
Jet Reference Fluid, TT-S 735, Type VII	
Toluene (TT-T-548)	30 volumes
Cyclohexane (D 3055 or technical grade)	60 volumes
*Iso*octane (TT-S-735, Type I or ASTM Reference Grade)	10 volumes
Ditertiary butyl disulfide[A]	1 volume
Tertiary butyl mercaptan	0.015 ± 0.0015 weight % of other four components

[A] The ditertiary dibutyl disulfide shall be doctor sweet in accordance with the Doctor Test in Test Method D 4952.

7.1.1 When tested for mercaptan and total sulfur in accordance with Test Methods D 3227 and D 1266, respectively, the reference fluid shall have the following properties:

$$\text{Mercaptan sulfur content, } 0.0050 \pm 0.0005 \text{ weight \%} \quad (1)$$

$$\text{Total sulfur content, } 0.400 \pm 0.005 \text{ weight \%} \quad (2)$$

Store the fluid out of contact with light in containers that are inert to the fluid ingredients. (Welded aluminum, nongalvanized welded steel, or glass containers are suitable.) If not used within 90 days after blending, retest the fluid for mercaptan and total sulfur content.

7.2 Prepare *reference test fluids* by blending four times the maximum recommended concentration of the additive into the specified Jet Reference Fluid.

7.3 Fuel system materials subject to immersion tests in *Jet Reference Fluid* and in *Reference Test Fluid* are listed in Table 1.

7.4 Detailed testing procedures for each class of fuel system components appear in Research Report D02-1137[2] on file at ASTM Headquarters. When conducted by an approved laboratory,[6] these testing procedures provide data acceptable to aircraft manufacturers or other approving agencies.

7.5 In general, each fuel system material is subject to special application and curing techniques and then each test specimen is immersed in both the specified Jet Reference Fluid and Reference Test Fluid containing additive for varying times at specified temperatures. These details as well as the techniques for inspecting specimens for failure are described in Research Report D02-1137.[2]

[6] An approved laboratory is Boeing Technology Services, Box 3707, Seattle, WA 98124.

TABLE 1 Aircraft Fuel System Components[A]

(*a*)	*Integral Fuel Tank Sealants*:
	Polysulfide, manganese cured, MIL-S-8802 (PR 1440 and Pro Seal 890)
	Polysulfide, chromate cured, MIL-S-8802 (PR1422)
(*b*)	*Integral Fuel Tank Coatings*:
	Amine cured epoxy[B]
	Polyurethane, MIL-C-27725, Type II (PR1560M)
	Buna ′A′//′N′, MIL-S-4383 (EC776SR)
(*c*)	*Integral Fuel Tank Substrates (Metals)*:
	Aluminum 7075-T6 bare, QQ-A-250/12
	7075-T6 chromic acid anodized per MIL-A-8625
	7075-T6 alodined per MIL-C-5541, Class 1A (Alodine 1200 or Iridite 14)
	Titanium (6AL-4V) AMS 4967/MIL-T-9046, Type III, Comp C.
	Steel (4130), cadmium plated per QQ-P-416, Class 2, Type II
(*d*)	*Elastomers*:
	Nitrile, Buna ′N′, MIL-R-6855, Class I, Grade 70
	Fluorosilicone, MIL-R-25988, Class I, Grade 60
	Fluorocarbon, MIL-R-83248, Type II, Class 1, Grade 75
(*e*)	*Bladder Cells*:
	Polyurethane, Vithane, Goodyear BTC-69 (compound No. 80C29)
	Polyurethane, Vithane, Goodyear BTC-86 (compound No. 82C39)

[A] This list of materials to be tested has not been revised since 1981; an up-to-date list is being developed.

[B] Suitable materials are identified in RR:D02-1137.[2]

8. Report

8.1 Laboratory results from Procedures A, B, and C should be compiled and reported as evidence of additive compatibility.

9. Keywords

9.1 additives; aviation fuel additives; compatibility; fuel system