



Standard Test Method for Water Reaction of Aviation Fuels¹

This standard is issued under the fixed designation D1094; 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.

This standard has been approved for use by agencies of the Department of Defense.

1. Scope*

1.1 This test method covers the determination of the presence of water-miscible components in aviation gasoline and turbine fuels, and the effect of these components on volume change and on the fuel-water interface.

1.2 The values stated in SI units are to be regarded as standard. No other units of measurement are included in this standard.

1.3 *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.* This standard involves the use of hazardous chemicals identified in Section 7. Before using this standard, refer to suppliers' safety labels, Material Safety Data Sheets and other technical literature.

2. Referenced Documents

2.1 ASTM Standards:²

D381 Test Method for Gum Content in Fuels by Jet Evaporation

D611 Test Methods for Aniline Point and Mixed Aniline Point of Petroleum Products and Hydrocarbon Solvents

D1836 Specification for Commercial Hexanes

D2699 Test Method for Research Octane Number of Spark-Ignition Engine Fuel

D2700 Test Method for Motor Octane Number of Spark-Ignition Engine Fuel

D3948 Test Method for Determining Water Separation Characteristics of Aviation Turbine Fuels by Portable Separometer

¹ This test method is under the jurisdiction of ASTM Committee D02 on Petroleum Products and Lubricants and is the direct responsibility of Subcommittee D02.J0.05 on Fuel Cleanliness.

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² For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

2.2 Energy Institute Standard:³

IP Standard Test Methods Vol 2, Appendix B, Specification for Petroleum Spirits

3. Terminology

3.1 Definitions of Terms Specific to This Standard:

3.1.1 *film, n*—thin, translucent layer that does not adhere to the wall of the glass cylinder.

3.1.2 *lace, n*—fibers thicker than hairlike shred or of which more than 10 % are interlocking, or both.

3.1.3 *loose lace or slight scum, or both (Table 2, Rating 3), n*—an assessment that the fuel/buffer solution interface is covered with more than 10 % but less than 50 % of lace or scum that does not extend into either of the two layers.

3.1.4 *scum, n*—layer thicker than film or that adheres to the wall of the glass cylinder, or both.

3.1.5 *shred, n*—hairlike fibers of which less than 10 % are interlocking.

3.1.6 *shred, lace or film at interface (Table 2, Rating 2), n*—an assessment that fuel/buffer solution interface contains more than 50 % clear bubbles or some but less than 10 % shred, lace, film or both.

3.1.7 *tight lace or heavy scum, or both (Table 2, Rating 4), n*—an assessment that the fuel/buffer solution interface is covered with more than 50 % of lace or scum, or both, that extends into either of the two layers or forms an emulsion, or both.

3.1.8 *water reaction interface conditions rating, n*—a qualitative assessment of the tendency of a mixture of water and aviation turbine fuel to form interface films or precipitates.

3.1.9 *water reaction separation rating, n*—a qualitative assessment of the tendency of insufficiently cleaned glassware to produce emulsions or precipitates, or both, in separated fuel and water layers.

3.1.10 *water reaction volume change, n*—a qualitative indication of the presence in aviation gasoline of water-soluble components.

³ Available from Energy Institute, 61 New Cavendish St., London, WIG 7AR, U.K., <http://www.energyinst.org.uk>.

*A Summary of Changes section appears at the end of this standard.

4. Summary of Test Method

4.1 A sample of the fuel is shaken, using a standardized technique, at room temperature with a phosphate buffer solution in scrupulously cleaned glassware. The cleanliness of the glass cylinder is tested. The change in volume of the aqueous layer and the appearance of the interface are taken as the water reaction of the fuel.

5. Significance and Use

5.1 When applied to aviation gasoline, water reaction volume change using the technique reveals the presence of water-soluble components such as alcohols. When applied to aviation turbine fuels, water reaction interface rating using the technique is not reliable in revealing the presence of surfactants which disarm filter-separators quickly and allow free water and particulates to pass; but can reveal the presence of other types of contaminants. Other tests, such as Test Method **D3948**, are capable of detecting surfactants in aviation fuels.

6. Apparatus

6.1 *Graduated Glass Cylinder*, glass-stoppered, 100 mL, with 1-mL graduations. The distance between the 100-mL mark and the top of the shoulder of the cylinder must be within the range from 50 to 60 mm.

7. Reagents

7.1 *Purity of Reagents*—Reagent grade chemicals shall be used in all tests. Unless otherwise indicated, it is intended that all reagents shall conform to the specifications of the Committee on Analytical Reagents of the American Chemical Society, where such specifications are available.⁴ Other grades may be used, provided it is first ascertained that the reagent is of sufficient purity to permit its use without lessening the accuracy of the determination.

7.2 *Purity of Water*—Unless otherwise indicated, reference to water shall be understood to mean distilled water, or water of equivalent purity.

7.3 *Acetone*—(**Warning**—Flammable. Health hazard.)

7.4 *Glass-Cleaning Solution*—Saturate concentrated sulfuric acid (H_2SO_4 , sp gr 1.84) with potassium dichromate ($\text{K}_2\text{Cr}_2\text{O}_7$) or sodium dichromate ($\text{Na}_2\text{Cr}_2\text{O}_7$). (**Warning**—Corrosive. Health hazard. Oxidizing agent.)

7.5 *n-Hexane*—Conforming to Specification **D1836** or *n*-heptane conforming to material used in Test Methods **D611**, **D381**, **D2699**, and **D2700** or petroleum spirit 60/80 conforming to IP Appendix B Specification, or equivalent. (**Warning**—Flammable. Health hazard.)

7.6 *Phosphate Buffer Solution (pH 7)*—Dissolve 1.15 g of potassium monohydrogen phosphate, anhydrous (K_2HPO_4) and 0.47 g of potassium dihydrogen phosphate, anhydrous (KH_2PO_4) in 100 mL of water. Larger volumes of the phosphate buffer solution may be prepared provided the concentra-

tion of K_2HPO_4 and KH_2PO_4 in the water solution is equivalent to that described above. As an alternative, the laboratory may use a commercially prepared solution.

8. Preparation of Apparatus

8.1 Clean the graduated cylinder thoroughly before carrying out this test. Only cylinders that are adequately cleaned can be used.

8.1.1 Remove traces of oil from the graduated cylinder and stopper by flushing with hot tap water, brushing if necessary. Alternately, remove all traces of oil from the graduated cylinder and stopper, using either *n*-hexane or *n*-heptane or the IP petroleum solvent 60/80. Rinse with acetone followed by tap water.

8.1.2 Following the washing described in 8.1.1, immerse the cylinder and stopper in either (1) a non-ionic detergent cleaning solution, or (2) glass cleaning solution described in 7.4. The type of non-ionic detergent and conditions for its use need to be established in each laboratory. The criterion for satisfactory cleaning shall be a matching of the quality of that obtained with chromic acid cleaning solution. Non-ionic detergent cleaning avoids the potential hazards and inconveniences related to handling corrosive chromic acid solutions. The latter remains as the reference cleaning practice and as such may function as an alternate to the preferred procedure—cleaning with non-ionic detergent solutions. Following cleaning with non-ionic detergent or glass cleaning solution, rinse with tap water, then distilled water, and finally rinse with phosphate buffer solution and drain.

8.1.3 Inadequately cleaned glassware used in this test can give misleading indications of fuel contaminants. Use only cylinders that are adequately cleaned. Cylinders that drain cleanly are adequately cleaned. Alternatively, a separation rating (see Table 1) of 2 or less is indicative of adequately cleaned glassware.

9. Preparation of Samples

9.1 It is desirable to take a sample of at least 100 mL to perform this test. A clean container is required.

9.2 Under no circumstances shall the sample be prefiltered after collection. Filtration media can remove surfactants, the detection of which is one of the purposes of this test method. If the test fuel sample is contaminated with particulate matter, allow it to settle before testing.

NOTE 1—Test method results are known to be sensitive to trace contamination from sampling containers.

TABLE 1 Separation

Rating	Appearance
(1)	Complete absence of all emulsions and/or precipitates within either layer or upon the fuel layer.
(2)	Same as (1), except small air bubbles or small water droplets in the fuel layer.
(3)	Emulsions and/or precipitates within either layer or upon the fuel layer, and/or droplets in the water layer or adhering to the cylinder walls, excluding the walls above the fuel layer.

⁴ *Reagent Chemicals, American Chemical Society Specifications*, American Chemical Society, Washington, DC. For Suggestions on the testing of reagents not listed by the American Chemical Society, see *Annual Standards for Laboratory Chemicals*, BDH Ltd., Poole, Dorset, U.K., and the *United States Pharmacopeia and National Formulary*, U.S. Pharmacopeial Convention, Inc. (USPC), Rockville, MD.

10. Procedure

10.1 Measure 20 mL of phosphate buffer solution at room temperature into the cylinder and record the volume to the nearest 0.5 mL. Add 80 mL, at room temperature, of the fuel to be tested and stopper the cylinder.

10.2 Shake the cylinder for $2 \text{ min} \pm 5 \text{ s}$, two to three strokes per second using 5 to 10-in. (12 to 25-cm) strokes. (**Warning**—Take care to avoid a swirling motion during shaking of the cylinder since swirling action tends to break any emulsion that might be formed.)

10.3 Immediately place the cylinder on a vibration-free surface and allow the contents to settle undisturbed for 5 min.

10.4 Without picking up the cylinder, record the following, viewing in diffused light:

10.4.1 The change in volume of the aqueous layer to the nearest 0.5 mL.

10.4.2 The condition of the interface in accordance with **Table 2**.

10.4.3 The degree of separation of the two phases in accordance with **Table 1**.

10.4.4 Disregard any slight cloudiness in the fuel layer that is no longer visible when viewed against a white background.

11. Report

11.1 The report shall include the following:

11.1.1 Change in volume of the aqueous layer to the nearest 0.5 mL.

11.1.2 Rating of the condition of the interface (see **Table 2**).

11.1.3 Rating of the degree of separation (see **Table 1**).

12. Precision and Bias

12.1 *Precision*—The change in volume of the aqueous layer is a measure of water reaction of aviation gasoline and is a qualitative indication of water-miscible components and is not subject to a statement of precision.

12.1.1 It is not practical to specify the precision of the interface rating as a measure of the water reaction of aviation turbine fuels because results of the ratings described in **Table 2** are purely qualitative. **Table 2** assigns a number to descriptions of interface appearance as a convenient guide to qualitative ratings.

12.2 *Bias*—The procedure in this test for water reaction of aviation fuels has no bias because the value of volume change and interface rating is defined only in terms of the test method.

13. Keywords

13.1 aviation gasoline; aviation turbine fuel; fuel water interface surfactants; water reaction; water-soluble additives

TABLE 2 Interface Conditions^A

Rating	Appearance
1	Clear and clean
1b	Clear bubbles covering not more than an estimated 50 % of the interface and no shreds, lace, or film at the interface
2	Shred, lace, or film at interface
3	Loose lace or slight scum, or both
4	Tight lace or heavy scum, or both

^A Section 3 contains definitions of terms used in this table.

SUMMARY OF CHANGES

Subcommittee D02.J0 has identified the location of selected changes to this standard since the last issue (D1094–00(2005)) that may impact the use of this standard.

(I) Revised **5.1**.

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