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Standard Test Method for Particulate Contaminant in Aviation Fuel by Line Sampling[1,2]

This standard is issued under the fixed designation D2276; 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 U.S. Department of Defense.

1. ~~Scope~~ Scope*

1.1 This test method covers the determination of particulate contaminant in aviation turbine fuel using a field monitor.

1.2 There are two test methods described. The basic test method is used to evaluate the level of contamination gravimetrically. The second test method, presented in Appendix X1, describes a color rating technique that is used for rapid qualitative assessment of changes in contamination level without the time delay required for the gravimetric determinations by stringent laboratory procedures.

1.3 There are two Annexes and two Appendixes in this test method.

1.3.1 Annex A1 provides some precautionary information regarding the use of the required reagents.

1.3.2 Annex A2 describes a standard practice for obtaining a sample of the particulates present in a flowing stream of aviation turbine fuel.

1.3.3 Appendix X1 describes a test method for rating the particulate level in an aviation turbine fuel on the basis of the color of a filter membrane after sampling the fuel in the field.

1.3.4 Appendix X2 provides some safety precautions to avoid static discharge resulting from the accumulation of electrical charges in the fuel and on the equipment while following the procedures.

1.4 The values stated in SI units are to be regarded as the standard. The values given in parentheses are for information only.

1.5 *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~~ safety, health, and ~~health~~environmental practices and determine the applicability of regulatory limitations prior to use.*

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[1] This test method is under the jurisdiction of ASTM International Committee D02 on Petroleum Products, Liquid Fuels, and Lubricants and is the direct responsibility of ASTM Subcommittee D02.J0.05 on Fuel Cleanliness. The technically equivalent standard as referenced is under the jurisdiction of the Energy Institute Subcommittee SC-B-11.

This test method has been approved by the sponsoring committees and accepted by the Cooperating Societies in accordance with established procedures.

Current edition approved ~~June 1, 2014~~July 1, 2022. Published ~~July 2014~~September 2022. Originally approved in 1964. Last previous edition approved in ~~2006~~2014 as ~~D2276~~D2276 – 06 (2014).~~–06.~~ DOI: ~~10.1520/D2276-06R14.~~10.1520/D2276-22.

[2] This test method has been developed through the cooperative effort between ASTM and the Energy Institute, London. ASTM and IP standards were approved by ASTM and EI technical committees as being technically equivalent but that does not imply both standards are identical.

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

1.6 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standards:*[3]

D1193 Specification for Reagent Water
D1535 Practice for Specifying Color by the Munsell System
D1655 Specification for Aviation Turbine Fuels
D2244 Practice for Calculation of Color Tolerances and Color Differences from Instrumentally Measured Color Coordinates
D4175 Terminology Relating to Petroleum Products, Liquid Fuels, and Lubricants
D4865 Guide for Generation and Dissipation of Static Electricity in Petroleum Fuel Systems
D5452 Test Method for Particulate Contamination in Aviation Fuels by Laboratory Filtration
D6615 Specification for Jet B Wide-Cut Aviation Turbine Fuel

3. Terminology

3.1 *Definitions:*

3.1.1 For definitions of terms used in this test method, refer to Terminology D4175.

3.2 ~~*Definitions:*~~*Definitions of Terms Specific to This Standard:*

3.2.1 *membrane color, n*—a visual rating of particulate on a filter membrane against ASTM Color Standards.

3.2.2 *membrane filter, n*—a porous article of closely controlled pore size through which a liquid is passed to separate matter in suspension.

3.2.2.1 *Discussion*—
RR:D02-1012[4] contains information on membrane filters that meet the requirements therein.

3.2.3 *monitor, n*—something that reminds or warns.

3.2.3.1 *Discussion*—
A plastic holder for a membrane filter held in a field sampling apparatus.

3.2.4 *particulate, adj*—of or relating to minute separate particles.

3.2.4.1 *Discussion*—
Solids generally composed of oxides, silicates, and fuel insoluble salts.

3.2.5 *volatile fuels, n*—relatively wide boiling range volatile distillate.

3.2.5.1 *Discussion*—
These are identified as Jet B in Specification D6615 or the military grade known as JP-4.

~~3.2 *Definitions of Terms Specific to This Standard:*~~

~~3.2.1 *volatile fuels, n*—relatively wide boiling range volatile distillate.~~

~~3.2.1.1 *Discussion*—~~
~~These are identified as Jet B in Specification D6615 or the military grade known as JP-4.~~

4. Summary of Test Method

4.1 A known volume of fuel is filtered through a preweighed test membrane filter in a field monitor and the increase in membrane filter mass determined after washing and drying. The change in mass of a control membrane filter located immediately below the test membrane filter is also determined. The objective of using a control membrane is to assess whether the fuel itself influences the weight of a membrane. The particulate contaminant is determined from the increase in mass of the test membrane filter relative to the control membrane filter.

[3] 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.

[4] Supporting data (and a list of suppliers who have provided data indicating their membranes, field monitors, and field monitor castings) have been filed at ASTM International Headquarters and may be obtained by requesting Research Report RR:D02-1012. Contact ASTM Customer Service at service@astm.org.

4.2 This test method employs a field monitor to filter a sample of fuel that is taken in the field by the sampling procedure detailed in Annex A2.

4.3 For situations where it is not possible to take a field monitor sample, procedures are given in Test Method D5452 for the determination of particulate contaminant in a fuel sample by laboratory filtration.

4.4 Appendix X1 describes a method for color-rating used filter membranes.

5. Significance and Use

5.1 This test method provides a gravimetric measurement of the particulate matter present in a sample of aviation turbine fuel by line sampling. The objective is to minimize these contaminants to avoid filter plugging and other operational problems. Although tolerable levels of particulate contaminants have not yet been established for all points in fuel distribution systems, the total contaminant measurement is normally of most interest. The Appendix X1 color rating method is useful for fuel system monitoring purposes. No quantitative relationship exists between gravimetric and color rating test results.

6. Apparatus

6.1 *Analytical Balance,* single- or double-pan, the precision standard deviation of which must be 0.07 mg or better.

6.2 *Oven,* of the static type (without fan-assisted air circulation), controllable to ~~90~~90 °C ± ~~5°C.~~5 °C.

6.3 *Petri Dishes,* approximately 125 mm in diameter with removable glass supports for membrane filters.

6.4 *Forceps,* flat-bladed with unserrated, non-pointed tips.

6.5 *Vacuum System.*

6.6 *Test Membrane Filters,* [4,5] plain, ~~37-mm~~37 mm diameter, nominal pore size 0.8 µm (see Note 1).

6.7 *Control Membrane Filters,* [4,5] ~~37-mm~~37 mm diameter, nominal pore size 0.8 µm. (Gridded control membrane filters may be used for purpose of identification.)

NOTE 1—Matched weight membrane filters,[5] ~~37-mm~~37 mm diameter, nominal pore size 0.8 µm, may be used as test and control membrane filters if so desired. Use of matched-weight membrane filters precludes the necessity for carrying out subsequently the procedures detailed in Section 8.

6.8 *Dispenser for Flushing Fluid,* ~~0.45-µm~~0.45 µm membrane filters to be provided in the delivery line (see Fig. 1). Alternatively, flushing fluid that has been pre-filtered through a 0.45 µm membrane before delivery to the dispenser flask is acceptable.

6.9 *Field Monitors,* [5] complete with protective plugs and ~~34-mm~~34 mm support pads.

6.10 *Air Ionizer,* for the balance case (see Note 2 and Note 3).

NOTE 2—When using a solid-pan balance, the air ionizer may be omitted provided that, when weighing a membrane filter, it is placed on the pan so that no part protrudes over the edge of the pan.

NOTE 3—Air ionizers should be replaced within 1 year of manufacture.

6.11 *Multimeter/VOM,* used for determining whether electrical continuity is 10 Ω or less between 2 points.

[5] All available membrane filters are not suitable for this application. Apparatus considered for this application shall be checked by the user for suitability in accordance with the requirements of RR:D02-1012, 1994 revision.

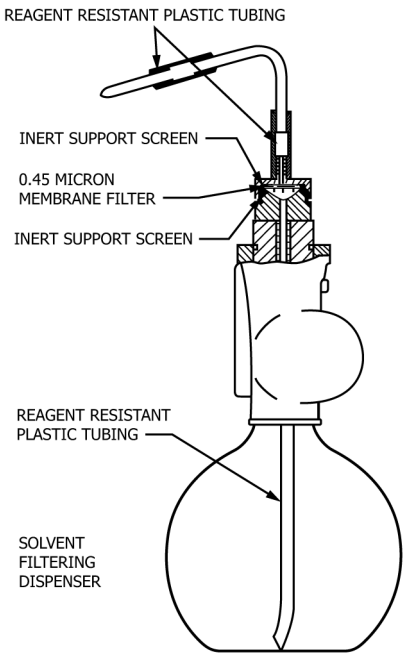

FIG. 1 Apparatus for Filtering and Dispensing Flushing Fluid

6.12 *Field Monitor Flushing Apparatus,* of the type shown in Fig. 2. It consists of a receiving flask large enough to contain the flushing fluid and shall be equipped with a side arm to connect to the vacuum system. Reagent resistant tubing shall be arranged to allow passage of a grounding wire. An assembly of reagent grade resistant tubing and bung fitted with a glass tube shall be assembled as shown in Fig. 2 to attach to a field monitor.

6.13 *Ground/Bond Wire,* Nos. 10 through 19, ~~(0.912~~(0.912 mm to 2.59 mm) bare stranded flexible stainless steel or copper installed in the flask and grounded as shown in Fig. 2.

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.[6] Other grades may be used, provided it is first ascertained that the reagent is of sufficiently high purity to permit its use without lessening the accuracy of the determination.

7.2 *Purity of Water*—Unless otherwise indicated references to water shall be understood to mean reagent water as defined by Type III of Specification D1193.

7.3 *Isopropyl Alcohol,* reagent grade. (**Warning**—Flammable. See A1.1.)

7.4 *Liquid Detergent,* water-soluble.

7.5 *Flushing Fluids:*

7.5.1 *Petroleum Spirit (also known as petroleum ether or IP Petroleum Spirit 40/60)* (**Warning**—Extremely flammable. Harmful if inhaled. Vapors are easily ignited by electrostatic discharges, causing flash fire. See A1.2.), having boiling range from ~~35~~35 °C to ~~60°C.~~60 °C.

[6] ~~*Reagent Chemicals, American Chemical Society Specifications,*~~*ACS Reagent Chemicals, Specifications and Procedures for Reagents and Standard-Grade Reference Materials,* American Chemical Society, Washington, DC. For suggestions on the testing of reagents not listed by the American Chemical Society, see *Analar 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.

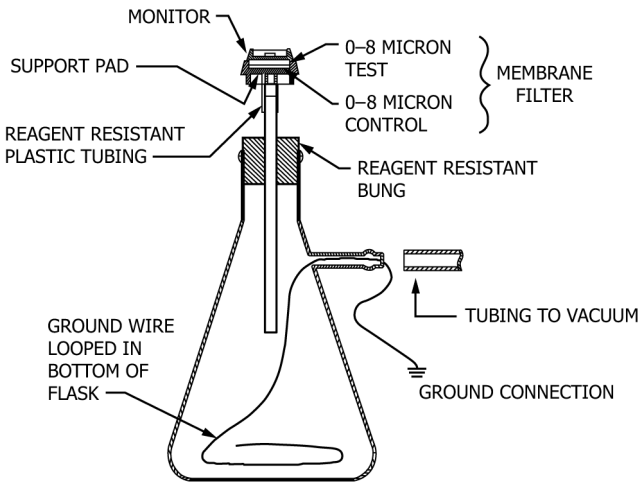

FIG. 2 Field Monitor Flushing Apparatus

8. Preparation of Test and Control Membrane Filters and Field Monitors Prior to Sampling

8.1 Two ~~37-mm~~37 mm membrane filters of nominal pore size ~~0.8 µm~~ 0.8 µm are required: a test and a control membrane filter. Matched-weight membrane filters may be used if so desired (see Note 1). If matched-weight membrane filters are used, it is unnecessary to carry out the procedures detailed in this section because they have been carried out previously by the membrane filter supplier. The two membrane filters used for each individual test should be identified by marking the petri dishes used as containers. Glassware used in preparation of membrane filters shall be cleaned as described in Section 10.

8.1.1 Using forceps, place the test and control membrane filters side by side in a clean petri dish. To facilitate handling the membrane filters should rest on clean glass support rods in the petri dish.

8.1.2 Place the petri dish with its lid slightly ajar, in an oven at ~~90~~90 °C ± ~~5°C~~5 °C and leave it for 30 min.

8.1.3 Remove the petri dish from the oven and place it near the balance. The petri dish cover should be ajar but still protecting the membrane filters from contamination from the atmosphere. Allow 30 min for the membrane filters to come to equilibrium with the ambient air temperature and humidity.

8.1.4 Remove the control membrane filter from the petri dish with forceps, handling by the edge only, and place it centrally on the weighing pan. Weigh it and return it to the petri dish.

8.1.5 Repeat 8.1.4 for the test membrane filter. Record the membrane filter masses.

8.1.6 Take a clean field monitor, mark for identification, rinse with filtered flushing fluid, and insert a clean support pad.

8.1.7 Using clean forceps, place the weighed control membrane filter centrally on the support pad in the field monitor and place the weighed test membrane filter on top of the control membrane filter. Assemble the two parts of the field monitor, ensuring that the membrane filters are firmly clamped inside and the protective plugs are in position.

8.1.8 Record the monitor identification.

9. Sampling and Testing Procedure

9.1 When possible, 3.785 L (1 gal) to 5 L (1.321 gal) of fuel should be passed through the monitor during field sampling. The sample volume actually employed shall be reported. (**Warning**—Jet A, combustible. Vapor harmful. See A1.3.) (**Warning**—Jet B, extremely flammable. Harmful if inhaled. Vapors may cause flash fire. See A1.4.)

9.2 See Annex A2 for specific details of sampling practices that shall be followed.

10. Preparation of Flushing Apparatus

10.1 Fig. 2 shows the recommended configuration of the flushing apparatus. Alternative apparatus may be used, provided that it achieves the same end.

10.1.1 Wash the petri dishes and supports with warm water containing detergent. Then rinse with warm water and finally with distilled water.

10.1.2 Rinse thoroughly with filtered isopropyl alcohol.

10.1.3 Rinse thoroughly with filtered flushing fluid.

10.1.4 Drain for a few seconds, and then air or oven dry.

10.2 Ensure that all glass and plastic tubing attached to the solvent filtering dispenser is clean by flushing thoroughly with filtered flushing fluid.

11. Flushing and Weighing Procedure

11.1 Upon receipt of the field monitor in the laboratory, assemble the apparatus shown in Fig. 2 with the field monitor in place on the stopper of the vacuum flask.

NOTE 4—Take care to ensure that monitors are tightly closed and preferably clamped. Spring paper clips have been found suitable for this purpose.

11.2 Place the tip of the delivery spout of the solvent filtering dispenser in direct contact with the monitor inlet hole. Introduce filtered flushing fluid.

11.3 Apply vacuum to the flask and allow approximately 250 mL of filtered flushing fluid to pass from the flushing fluid dispenser through the monitor and into the vacuum flask.

11.4 Remove the flushing fluid dispenser and slowly release the vacuum.

11.5 Remove the monitor from the stopper of the vacuum flask and carefully dismantle it in an upright position.

11.6 Carefully remove the test and control membrane filters, and place side by side on clean glass supports in a clean, covered petri dish.

NOTE 5—The test and control membrane filters can be removed from the monitor by pushing upwards against the support pad through the outlet orifice with a thin dowel.

11.7 Dry and reweigh the membrane filters as described in 8.1.2 – 8.1.5, taking care not to disturb the contaminant on the surface of the test membrane filter.

12. Calculation and Report

12.1 Subtract the initial mass of the test membrane filter, W_1, from the final mass, W_2.

12.2 Subtract the initial mass of the control membrane filter, W_3, from the final mass, W_4.

12.3 Divide the correct mass of contaminant $(W_2 - W_1) - (W_4 - W_3)$ by the volume of sample filtered and report the result as total contaminant, expressed in milligrams per litre.

NOTE 6—If matched-weight membrane filters have been used for the test (see Note 1), then $W_1 = W_3$ and the corrected mass of contaminant in 12.3 becomes $W_2 - W_4$.

TABLE 1 Statistical Information for Particulate Contaminant

Average Result, mg/L	0.0	0.1	0.2	0.3	0.5	0.7	1.0	1.5	2.0
Repeatability	0.07	0.09	0.11	0.12	0.16	0.19	0.25	0.33	0.42
Reproducibility	0.18	0.22	0.27	0.31	0.40	0.49	0.62	0.84	1.07

12.4 Report the result to the nearest 0.01 mg/L, and also the sample volume used in the test.

13. Precision and Bias[7]

13.1 The precision of this test method is not known to have been obtained in accordance with currently accepted guidelines in Committee D02 RR:D02-1007.

13.2 These precision data have been obtained by statistical examination of test results using ~~5-L~~5 L samples and were first published in 1966.

13.3 *Repeatability*—The difference between successive results obtained by the same operator with the same apparatus under constant operating conditions on identical test material would, in the long run, in the normal and correct operation of the test method, exceed the following values in only one case in twenty:

Range	Repeatability
~~0.0 to 2.0 mg/L~~	~~0.175x + 0.070~~
0.0 mg/L to 2.0 mg/L	0.175x + 0.070

where x is the average value of two results.

13.4 *Reproducibility*—The difference between two single and independent results obtained by different operators working in different laboratories on identical test material would, in the long run, exceed the following values in only one case in twenty:

Range	Reproducibility
~~0.0 to 2.0 mg/L~~	~~0.444x + 0.178~~
0.0 mg/L to 2.0 mg/L	0.444x + 0.178

where x is the average value of two results.

13.5 Typical values are given in Table 1.

NOTE 7—Reproducibility values were determined through cooperative testing by different operators using separate apparatus working at the same location using identical test material. This procedure was adopted as it is highly improbable, if not impossible, to ensure the obtaining of "identical test material" when testing at different locations.

13.6 *Bias*—The procedure given for the determination of particulate contaminant in aviation turbine fuels has no bias since this property can only be defined in terms of this test method.

14. Keywords

14.1 aviation fuel; color rating; field monitor; gravimetric contaminant; membrane color; membrane filter; particulate

[7] Supporting data have been filed at ASTM International Headquarters and may be obtained by requesting Research Report RR:D02-1197. Contact ASTM Customer Service at service@astm.org.