Designation: D6824 – 13$^{\varepsilon 1}$

An American National Standard

Standard Test Method for Determining Filterability of Aviation Turbine Fuel[1]

This standard is issued under the fixed designation D6824; 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.

ε[1] NOTE—Editorial changes were made to 6.1.7, 10.1, and the Summary of Changes section in September 2013.

1. Scope*

1.1 This test method covers a procedure for determining the filterability of aviation turbine fuels (for other middle distillate fuels, see Test Method D6426).

NOTE 1—ASTM specification fuels falling within the scope of this test method are Specifications D1655 and D6615 and the military fuels covered in the military specifications listed in 2.2.

1.2 This test method is not applicable to fuels that contain undissolved water.

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

1.4 *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:*[2]

D1655 Specification for Aviation Turbine Fuels
D4057 Practice for Manual Sampling of Petroleum and Petroleum Products
D4176 Test Method for Free Water and Particulate Contamination in Distillate Fuels (Visual Inspection Procedures)
D4177 Practice for Automatic Sampling of Petroleum and Petroleum Products
D4860 Test Method for Free Water and Particulate Contamination in Middle Distillate Fuels (Clear and Bright Numerical Rating)
D5452 Test Method for Particulate Contamination in Aviation Fuels by Laboratory Filtration
D6300 Practice for Determination of Precision and Bias Data for Use in Test Methods for Petroleum Products and Lubricants
D6426 Test Method for Determining Filterability of Middle Distillate Fuel Oils
D6615 Specification for Jet B Wide-Cut Aviation Turbine Fuel

2.2 *Military Standards:*[3]

MIL-DTL-5624 Turbine Fuel, Aviation, Grades JP-4, JP-5, and JP-5/JP-8 ST
MIL-DTL-25524 Turbine Fuel, Aviation, Thermally Stable
MIL-DTL-38219 Turbine Fuels, Low Volatility, JP-7
MIL-DTL-83133 Turbine Fuels, Aviation, Kerosine Types, NATO F-34 (JP-8), NATO F-35, and JP-8+100

3. Terminology

3.1 *Definitions of Terms Specific to This Standard:*

3.1.1 *filterability, n*—a measure of the rapidity with which a standard filter medium is plugged by insoluble matter in fuel and may be described as a function of pressure or volume:

3.1.1.1 *filterability (by pressure), n*—the pressure drop across a filter medium when 300 mL of fuel is passed at a rate of 20 mL/min.

3.1.1.2 *filterability (by volume), n*—the volume of fuel passed when a pressure of 104 kPa (15 psig) is reached.

3.1.1.3 *Discussion*—Filterability by volume is used when less than 300 mL passes the filter at a pressure up to 104 kPa (15 psig).

3.1.1.4 *filterability quality factor (F-QF), n*—a value that defines the filter plugging tendency of a fuel caused by particulates.

3.1.1.5 *Discussion*—The F-QF value is calculated using the volume and pressure attained at the end of the test cycle, according to one of two equations, depending on the outcome of the test. (See Section 10, Calculations.)

4. Summary of Test Method

4.1 A sample is passed at a constant rate (20 mL/min) through a standard porosity filter medium. The pressure drop

[1] This test method is under the jurisdiction of ASTM Committee D02 on Petroleum Products, Liquid Fuels, and Lubricants and is the direct responsibility of Subcommittee D02.J0.01 on Jet Fuel Specifications.

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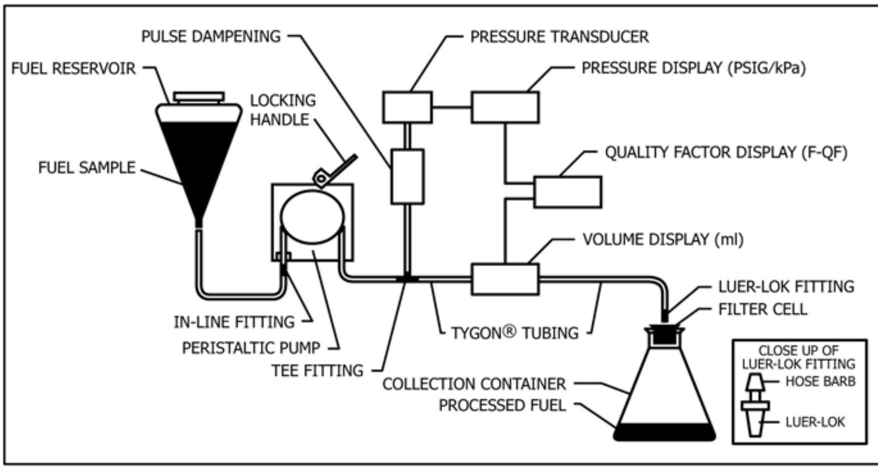
[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

[3] Available from Standardization Documents Order Desk, DODSSP, Bldg. 4, Section D, 700 Robbins Ave., Philadelphia, PA 19111-5098.

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



NOTE 1—Fuel flow from reservoir through pump to container.

FIG. 1 Schematic Diagram of Filterability Apparatus

across the filter and the volume of filtrate are monitored. The test is concluded either when the pressure drop across the filter exceeds 104 kPa (15 psig) or when 300 mL have passed through the filter.

4.2 Results are reported as either the volume that has passed through the filter when a pressure of 104 kPa (15 psig) has been reached or the pressure drop when 300 mL have passed through the filter.

4.3 Verification of the apparatus is required when there is a doubt of a test result, or when the apparatus has not been used for three months or more. It is not necessary to verify apparatus performance prior to each test.

5. Significance and Use

5.1 This test method is intended for use in the laboratory or field in evaluating aviation turbine fuel cleanliness.

5.2 A change in filtration performance after storage, pretreatment, or commingling can be indicative of changes in fuel condition.

5.3 Relative filterability of fuels may vary, depending on filter porosity and structure, and may not always correlate with results from this test method.

5.4 Causes of poor filterability in industrial/refinery filters include fuel degradation products, contaminants picked up during storage or transfer, incompatibility of commingled fuels, or interaction of the fuel with the filter media. Any of these could correlate with orifice or filter system plugging, or both.

6. Apparatus

6.1 *Micro-Filter Analyzer*[4]—The apparatus is shown as a diagram in Fig. 1 and photographically in Fig. 2. It is capable of measuring pressure upstream of the filtering element and the volume of sample passed through the filter at a preset pressure level. The apparatus is comprised of the following parts:

6.1.1 *Peristaltic Pump,* variable speed/flow rate, with feedback speed control, adjusted to provide fuel delivery at a constant rate of 20 ± 1 mL/min, and incorporating a pulse dampening mechanism to produce a smooth flow.

6.1.2 *Pressure Transducer,* capable of measuring gauge pressure in the range from 0 to 104 kPa, in 1.0 kPa increments (0 to 15 psig, in 0.1 psig increments).

6.1.3 *Three Digital Displays,* one for pressure readout capable of interfacing with transducer (see 6.1.2) with display range from 0 to 104 kPa in 1.0 kPa increments (0 to 15 psig in 0.1 psig increments), one for volume readout with display range from 0 to 300 mL in 1 mL increments, and one for filterability quality factor (F-QF).

NOTE 2—The micro-filter analyzer can display the pressure in either kPa or psig units by changing an internal jumper wire.

6.1.4 *Speed Controller,* manual speed adjustment of the peristaltic pump to increase/decrease amount of sample delivered for a given period of time.

6.1.5 *Fuel Reservoir Container,* polytetrafluoroethylene (PTFE), funnel shaped, 500-mL capacity.

6.1.6 *Collection Container,* glass or plastic Erlenmeyer flask, 500-mL capacity.

6.1.7 *Flexible, Inert Tubing,*[5] fuel compatible, nominal 3.1-mm (0.12-in.) inner diameter.

6.1.8 *Plastic In-Line Splice Coupler,* fuel compatible, capable of being inserted into, and making a seal in flexible, inert tubing (see 6.1.7).

6.1.9 *Plastic Tee Coupler,* fuel compatible, capable of being inserted into, and making a seal in flexible, inert tubing (see 6.1.7).

6.1.10 *Plastic Coupler,* fuel compatible, one end capable of being inserted into, and making a seal in flexible, inert tubing

[4] The sole source of supply of the apparatus (Model 1143 Micro-Filter Analyzer) known to the committee at this time is available from EMCEE Electronics, Inc., 520 Cypress Ave., Venice, FL 34285. If you are aware of alternate suppliers, please provide this information to ASTM Headquarters. Your comments will receive careful consideration at a meeting of the responsible technical committee,[1] which you may attend.

[5] Tygon (trademarked) tubing was used in the round robin test program to generate the precision and bias. Tygon is available from most laboratory supply houses. This is not an endorsement of Tygon.

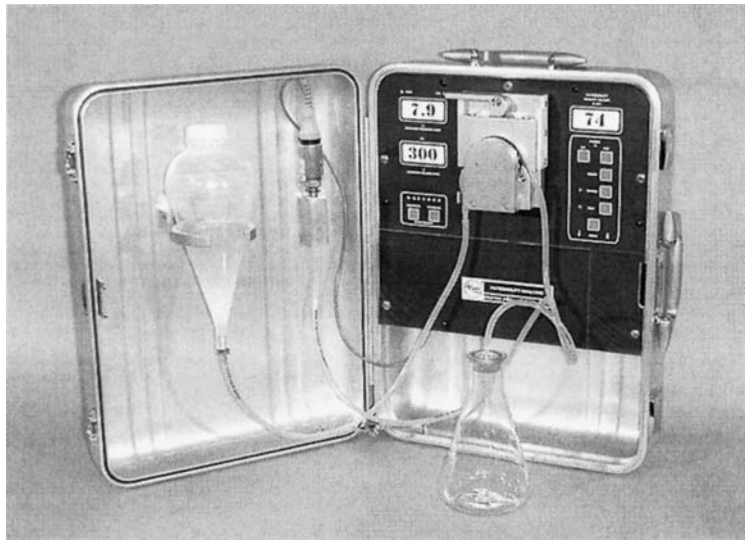


FIG. 2 Micro-Filter Analyzer

(see 6.1.7) and the other end into the filter unit (see 6.2). Luer-Lok (trademarked) couplers have been used successfully.

6.2 *FCell (trademarked)*[6]*Filter Unit*, disposable, precalibrated assembly consisting of a shell and plug containing a 25-mm diameter nylon membrane filter of nominal 0.65-µm pore size, nominal 60 % porosity, with a 158.9-mm^2 effective filtering area. Unit is labeled in green background with black lettering:

D6824, FCell, JET (0.65)

6.3 *Accessories for Apparatus Verification Test:*

6.3.1 *Measuring Cylinder,* 500-mL capacity, with 1-mL graduations.

6.3.2 *Pressure Gauge,* 350-kPa (50-psig) capability, graduations 0.5 kPa (0.1 psig).

6.3.3 *Temperature Measuring Device,* general purpose type, having a range that includes 0 to 60°C and an accuracy of 0.5°C. Liquid-in-glass thermometers, thermocouples, or platinum resistance thermometers that provide the desired accuracy and precision may be used.

7. Sampling

7.1 The fuel sample from which an aliquot is being drawn for the purposes of this test method shall be representative of the lot of fuel. Obtain the sample in accordance with the procedures of Practices D4057 or D4177, and report (see 11.1.1) how and from where it was obtained. The maximum sample size is dictated by the quantity that can be mixed thoroughly (see 9.2). If any undissolved water is visually apparent (as determined by Test Methods D4176 or D4860, or both), discard and replace with a fresh sample.

7.2 After thoroughly mixing, if the original sample container is too large to easily handle, use an epoxy lined can or dark glass bottle as a transfer container to store an aliquot of the test sample. Prior to drawing the aliquot, rinse the transfer container three times with the product to be tested. Draw a representative 1 to 2-L aliquot from the sample container into a transfer container. (**Warning**—Because the situations under which samples are taken vary from laboratory to laboratory and from situation to situation, no firm recommendation for sampling can be given. It is the responsibility of the user of this test method to ensure the aliquot used in the test is representative of the lot of fuel.)

8. Preparation of Apparatus

8.1 Locate the apparatus on a level surface in an area where the temperature is between 15 and 25°C (59 and 77°F).

8.2 Open the case, and assemble the apparatus as shown in Fig. 2. If the flexible, inert tubing (see 6.1.7) is not attached, as shown, carry out 8.2.1 to 8.2.2.

8.2.1 Attach one end of the flexible, inert tubing to the fuel reservoir container (6.1.5) and insert the plastic in-line splice coupler (6.1.8) into the other end.

8.2.2 Insert the plastic in-line coupler into another piece of flexible, inert tubing, thread the tubing in the peristaltic pump (see 6.1.1), as shown in Fig. 3, and clamp it in place by moving the lever arm counterclockwise.

NOTE 3—The splice fitting prevents the tubing from being pulled into the pump during operation. This also allows easy replacement of the portion of the tubing that is depressed by the pump rollers. To extend the life of the flexible, inert tubing, when not in use, leave the clamp open or remove the tubing from the pump.

8.2.3 Insert one end of the horizontal section of the plastic tee coupler (6.1.9) into the tubing that is clamped in the pump, and attach two other sections of tubing to the other parts of the tee.

8.2.4 Connect the tubing that is connected to the perpendicular part of the tee to the pressure transducer. Insert the hose

[6] A registered trademark of EMCEE Electronics, Inc., 520 Cypress Ave., Venice, FL 34285.

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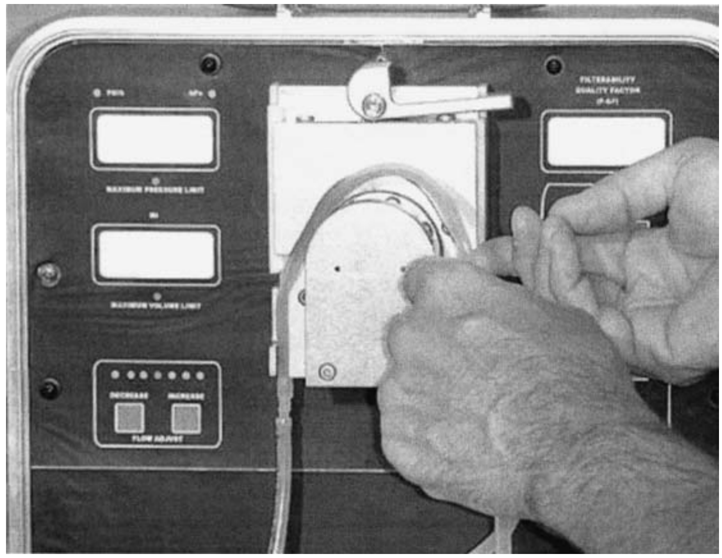


FIG. 3 Threading the Tubing in the Pump

barbered portion of the plastic coupler (6.1.10) into the other section of tubing that is connected to the in-line part of the tee.

8.3 Attach the power pack to the connector on the top of the case, and connect the power pack to an ac power source. Turn the instrument on by depressing the ON switch, causing both the POWER and MODE A lights to illuminate.

8.4 Have a labeled FCell filter (see 6.2) ready for use.

8.5 *Verification of Apparatus*—As required in accordance with 4.3, verify apparatus performance by checking that the flow rate and the pressure transducer are within tolerance.

8.5.1 Check the flow rate by performing a purge cycle to eliminate any air from the system. Subsequently, perform a test using a fuel sample without a filter, collecting the sample in a graduate (see 6.3.1). Compare the volume collected with amount displayed. The amount displayed shall be approximately 300 mL, and the amount collected shall be 285 to 315 mL. Adjust the pump speed control (6.1.4), as required.

8.5.1.1 If the proper flow rate cannot be attained by adjusting the pump speed control, perform the following operation:

(1) Release the tubing in the peristaltic pump,

(2) Using both hands, grasp each end of the tubing that is engaged by the pump rollers,

(3) Hold and alternately pull on each end to stretch the tubing,

(4) Clamp the tubing in place, and

(5) Repeat 8.5.1.

8.5.2 Check the pressure by inserting a pressure gauge (see 6.3.2) at the end of the flexible, inert tubing where the filter would be installed. Perform a test using air only, and compare the readings when approximately 104 kPa (15 psig) is displayed. If the readings vary more than ±7 kPa (1.0 psig), return the apparatus to the manufacturer.

9. Procedure

9.1 Measure the temperature (see 6.3.3) of the fuel in the transfer container (see 7.2) and, if necessary, adjust to 15 to 25°C.

9.2 Shake the sample or transfer container (see 7.2) vigorously for approximately 2 min.

9.3 Rinse the fuel reservoir container (see 6.1.5) with some of the product to be tested.

9.4 Place 450 ± 5 mL of the sample into the fuel reservoir (see 6.1.5). Check that the temperature is still within the range from 15 to 25°C. Record the actual temperature. If any undissolved water is visually apparent in the fuel at this time, as determined by Test Methods D4176 or D4860, or both, the test shall be abandoned and the presence of water shall be reported.

9.5 Place the end of the flexible, inert tubing with the plastic coupler (see 6.1.10) into the collection container (see 6.1.6).

9.6 Press and release the PURGE pushbutton. Approximately 40 mL will be drawn from the fuel reservoir through the flexible, inert tubing and discharged into the collection container, thus purging the air and any residual fuel from the system. The fuel flow will automatically cease at the end of the purge cycle (2 min).

9.7 After the purge cycle, insert the plastic coupler affixed to the flexible, inert tubing into a precalibrated FCell filter (see 6.2) and place the filter into the mouth of the collection container.

9.8 Press and release the TEST pushbutton. The peristaltic pump activates, drawing the fuel from the fuel reservoir and extruding it through the filter into the collection flask.

9.9 During the filtration period, the pressure is constantly displayed along with the amount of sample processed. The test will automatically stop when one of the following occurs:

9.9.1 The entire sample (300 mL) is discharged prior to reaching 104 kPa (15 psig). The total volume, $V_{(V=300\ mL)}$, the final pressure, $P_{(FP<15\ psig\ at\ 300\ mL)}$, and F-QF will be displayed.

9.9.2 The entire sample (300 mL) has not been discharged, and the maximum allowable pressure, 104 kPa (15 psig), has been reached. The volume, $V_{(V\ at\ 15\ psig)}$, discharged at 104 kPa (15 psig), the final pressure, $P_{(FP=15\ psig)}$, and the F-QF will be displayed.

9.10 After completion of the test, prior to disconnecting the FCell filter from the flexible, inert tubing, release the lever on the pump to depressurize the system.

9.11 Disconnect the FCell filter from the flexible, inert tubing, and discard the unit. Insert the flexible, inert tubing into the collection container (6.1.6), and drain all of the residual fuel from the fuel reservoir container (6.1.5) and flexible, inert tubing, including the section connected to the pressure transducer.

10. Calculations

10.1 Eq 1 (or Eq 2) is applied if the total sample was discharged prior to reaching the maximum pressure. Eq 3 is applied if the maximum pressure was reached prior to discharging the entire sample. The equations proportion the results so that a continuous range of 0 to 100 is attained. Eq 1 (and Eq 2) yields values from 50 to 100, whereas Eq 3 yields values from 0 to 50. Higher values signify fewer particulates that can plug a filter of a given pore size and porosity.

10.1.1 *Filterability by Pressure*—If the total sample, 300 mL, is discharged prior to reaching the maximum pressure, 104 kPa (15 psig), the F-QF is calculated by the following equation:

$$F - QF_{[300\ mL\ at\ P(F)]} = 50\left[\left(104\ kPa - P_{(F)}\right)/104\ kPa\right] + 50 \quad (1)$$

where:

$P_{(F)}$ = final pressure in kPa when the total sample, 300 mL, was discharged.

or

$$F - QF_{[300\ mL\ at\ P(F)]} = 50\left[\left(15\ psig - P_{(F)}\right)/15\ psig\right] + 50 \quad (2)$$

where:

$P_{(F)}$ = final pressure in psig when the total sample, 300 mL, was discharged.

10.1.2 *Filterability by Volume*—If the total sample is not discharged prior to reaching the maximum pressure, 104 kPa (15 psig), the F-QF is calculated by Eq 3. The final volume ($V_{(F)}$) is divided by 6, since the maximum possible volume is 300 mL. By dividing by 6, the values for that test result are proportioned to fit the range from 0 to 50.

$$F - QF_{[V(F)]} = V_{(F)}/6 \quad (3)$$

where:

$V_{(F)}$ = final volume in mL when the maximum pressure was reached.

11. Report

11.1 Report the following information:

11.1.1 The source and how the sample was obtained, as required in 7.1.

11.1.2 The filterability-quality factor (F-QF), the final pressure ($P_{(F)}$), and the final volume ($V_{(F)}$) in the form, ($P_{(F)}$) in kPa (psig), ($V_{(F)}$) (mL); and the temperature as recorded in 9.4.

11.1.3 If applicable, that free (undissolved) water was present and filtration was not performed.

11.1.4 Reference this test method.

12. Precision and Bias[7]

12.1 *Precision*—The precision for the filterability quality factor (F-QF) of this test method for field samples of commercial and military jet fuels was determined by statistical analysis of test results obtained by a cooperative test program conducted at a common test site.

NOTE 4—These results were calculated by applying ASTM D2PP Statistical Analysis computer program (now known as Practice D6300) to the data obtained from a November 2000 laboratory cooperative test program. The repeatability and reproducibility values were calculated from the results obtained at the same location on two consecutive days, by eight different operator/instrument pairs performing replicate tests on nine identical samples. Results, particularly for reproducibility, obtained at different times and locations may, therefore, not be comparable according to these calculations, since they may contain errors due to sampling and environmental factors. In practice, two results obtained at different laboratories (locations) would be acceptable if their difference did not exceed the published reproducibility. In the event that the difference did exceed the reproducibility, there would be no means of testing whether the results were acceptable.

12.1.1 *Repeatability*—The difference between successive measured F-QF values obtained by the same operator with the same apparatus under constant operating conditions on identical test material at the same fuel temperature would, in the long run, in the normal and correct operation of the test method, exceed the values in Table 1, graphically shown in Fig. 4, only in one case in twenty.

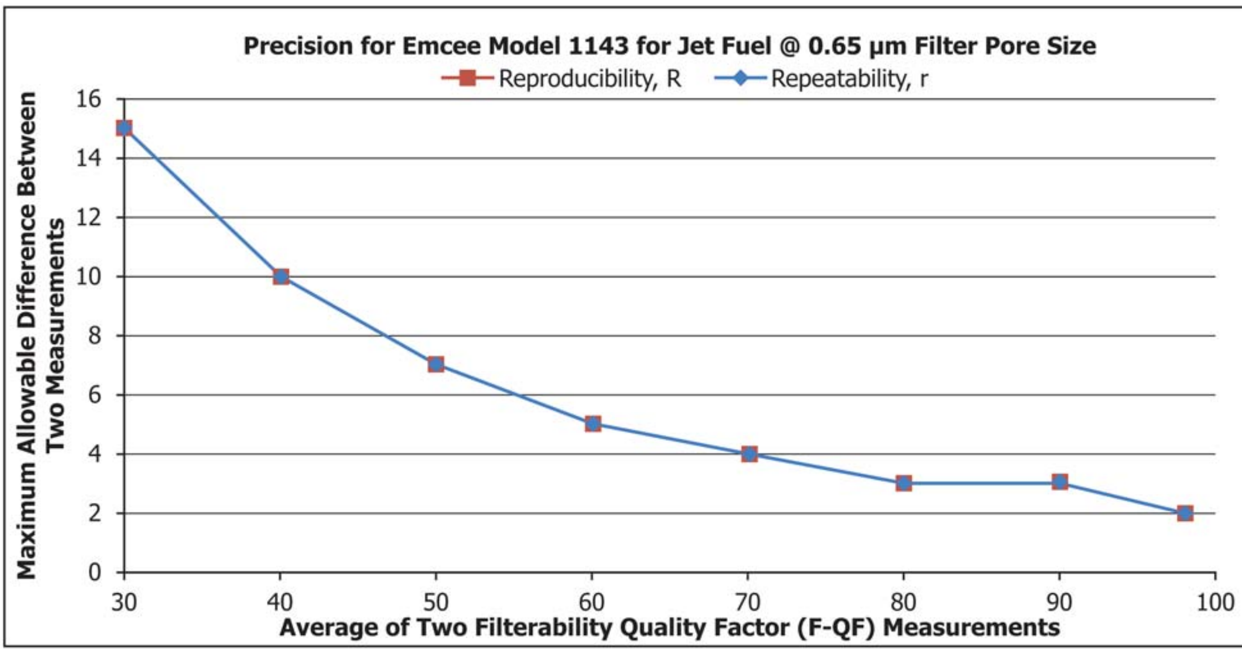
12.1.2 *Reproducibility*—The difference between two single and independent measurements of filterability quality factor (F-QF) values obtained by different operators using different apparatus under constant operating conditions on identical test material at the same fuel temperature would, in the long run, in the normal and correct operation of the test method, exceed the values in Table 1, graphically shown in Fig. 4, only in one case in twenty.

12.2 In 1999, a filterability test program using diesel fuel was carried out to investigate reproducibility of results when samples are shipped between laboratories. While repeatability values were similar to those in Table 1, it was concluded that adequate reproducibility values were not obtained due to changes in the physical characteristics of samples during

[7] Supporting data have been filed at ASTM International Headquarters and may be obtained by requesting Research Reports RR:D02-1530 and D02–1542.

TABLE 1 Precision of Aviation Turbine Fuels (0.65 μ Filter)

Average of Two F-QF Values	Maximum Allowable Difference Between Two F-QF Values: Repeatability	Reproducibility	Average of Two F-QF Values	Maximum Allowable Difference Between Two F-QF Values: Repeatability	Reproducibility
30	15	15	70	4	4
40	10	10	80	3	3
50	7	7	90	3	3
60	5	5	98	2	2



NOTE 1—Since repeatability and reproducibility are the same, the lines for each overlay; consequently, only one line is shown.

FIG. 4 Precision for Jet Fuel at 0.65 µm Filter Pore Size (Repeatability (r) and Reproducibility (R))

shipment, storage, and aging. The latter was considered to have the most effect since the different laboratories randomly tested the samples over a three-month period. Conducting a single site round robin program that produced adequate reproducibility results substantiated this conclusion. In the event of dispute or concern regarding the F-QF of the shipped sample, it is recommended that operators come to the bulk fuel storage site to measure F-QF on bulk fuel or on freshly obtained samples according to cited procedures. This ensures that a sample identical to the bulk supply is tested by either or both parties and the precision data shown in Table 1 and Fig. 4, shall apply.

12.3 *Bias*—The procedure in this test method has no bias because the value of F-QF is defined only in terms of this test method. Data were also obtained with the same samples using Appendix A of MIL-DTL-5624 and Test Method D5452 and are available in the research report.[7]

13. Keywords

13.1 aviation turbine fuels; distillate fuels; filterability; fuel cleanliness; fuel filterability; gas oils

SUMMARY OF CHANGES

Subcommittee D02.J0 has identified the location of selected changes to this standard since the last issue (D6824 – 07) that may impact the use of this standard.

(1) Reference to Specification E1 and mercury-in-glass liquid thermometers has been deleted.
(2) Section 3, Terminology, has been totally revised.
(3) A new Section 10 on Calculations has been added, using material formerly in Terminology.
(4) Section 11, Report, was renumbered and revised.