Designation: D 6426 – 02a

An American National Standard

Standard Test Method for Determining Filterability of Middle Distillate Fuel Oils[1]

This standard is issued under the fixed designation D 6426; 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 test method covers a procedure for determining the filterability of distillate fuel oils within the viscosity range from 1.70 to 6.20 mm^2/s (cSt) at 40°C.

NOTE 1—ASTM specification fuels falling within the scope of this test method are Specification D 396 Grade Nos. 1 and 2, Specification D 975 Grades 1-D, low sulfur 1-D, 2-D, and low sulfur 2-D, and Specification D 2880 Grade Nos. 1-GT and 2-GT.

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

1.3 The values stated in SI units shall be considered standard.

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:*

D 396 Specification for Fuel Oils[2]

D 975 Specification for Diesel Fuel Oils[2]

D 2880 Specification for Gas Turbine Fuel Oils[2]

D 4057 Practice for Manual Sampling of Petroleum and Petroleum Products[3]

D 4176 Test Method for Free Water and Particulate Contamination in Distillate Fuels (Visual Inspection Procedures)[3]

D 4177 Practice for Automatic Sampling of Petroleum and Petroleum Products[3]

D 4860 Test Method for Free Water and Particulate Contamination in Mid-Distillate Fuels (Clear and Bright Numerical Rating)[3]

E 1 Specification for ASTM Thermometers[4]

3. Terminology

3.1 *Definitions of Terms Specific to This Standard:*

3.1.1 For this test method, filterability is a measure of the rapidity with which a standard filter medium is plugged by insoluble matter in fuel and can be described in either of the following two ways:

3.1.1.1 *filterability (by pressure)*—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)*—the volume of fuel passed when 104 kPa (15 psi) is reached. This method of report is used when less than 300 mL passes at that pressure.

3.1.1.3 *filterability quality factor (F-QF)*—a value that defines the filter plugging tendency of a fuel caused by particulate. The value is calculated using the volume and pressure attained at the end of the test cycle. Depending on the outcome of the test, two different equations are applied.

3.1.1.4 *Discussion*—Eq 1 is applied if the total sample was discharged prior to reaching the maximum pressure or Eq 2 if the maximum pressure was reached prior to discharging the entire sample. The equations proportion the results so that a continuous range of 0 – 100 is attained. Eq 1 yields values from 50 to 100, whereas Eq 2 yields values from 0 to 50. Higher values signify less particulate that can plug a filter of a given pore size and porosity.

(1) If the total sample (300 mL) is discharged prior to reaching the maximum pressure (104 kPa or 15 psi), the F-QF is calculated by the following equation:

$$F-QF_{(300\text{ mL at } P(F))} = ((15\, psi - P_{(F)}) / 15\, psi)(50) + (50) \quad (1)$$

where:

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

(2) If the total sample is not discharged prior to reaching the maximum pressure (104 kPa or 15 psi), the F-QF is calculated by the following equation:

$$F-QF_{(V(F)\text{ at 15 psi})} = V_{(F)} / 6 \quad (2)$$

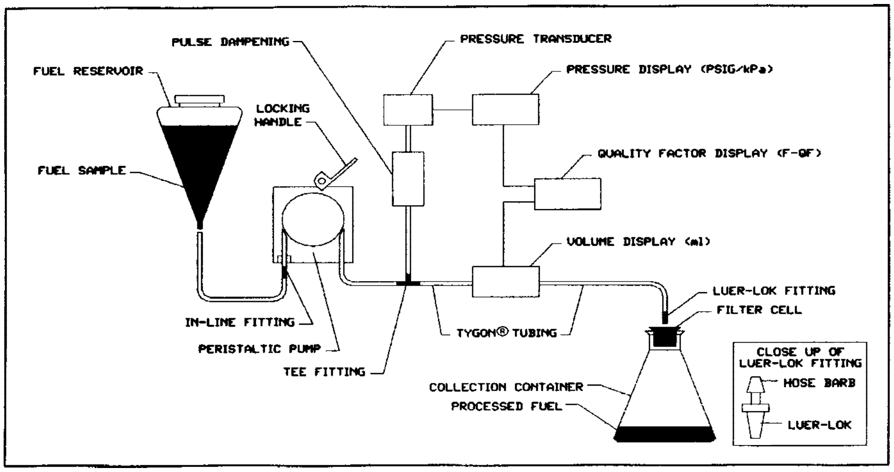
[1] This test method is under the jurisdiction of ASTM Committee D02 on Petroleum Products and Lubricants and is the direct responsibility of Subcommittee D02.14 on Stability and Cleanliness of Liquid Fuels.

Current edition approved Dec. 10, 2002. Published March 2003. Originally approved in 1999. Last previous edition approved in 2002 as D 6426–02.

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

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

[4] *Annual Book of ASTM Standards*, Vol 14.03.



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

FIG. 1 Schematic Diagram of Filterability Apparatus

where:

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

3.1.1.5 *Discussion*—The final volume *($V_{(F)}$)* is divided by six, since the maximum possible volume is 300 mL. By dividing by six, the values for that test result are proportioned to fit the range from 0 to 50.

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 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 psi) 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 psi) 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 distillate 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:*[5]

NOTE 2—The Micro-Filter can display the pressure in either kPa or psi units by changing an internal jumper wire.

6.1.1 The apparatus is shown diagrammatically 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:

6.1.1.1 *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.

6.1.1.2 *Pressure Transducer*—Pressure transducer capable of measuring gage pressure in the range from 0 to 104 kPa, in 1.0 kPa increments (0 to 15 psi, in 0.1 psi increments).

6.1.1.3 *Three Digital Displays*—One for pressure readout capable of interfacing with transducer (see 6.1.1.2) with display range from 0 to 104 kPa in 1.0 kPa increments (0 to 15 psi in 0.1 psi increments), one for volume readout with display range from 0 to 300 mL in 1 mL increments, and one for F-QF.

6.1.1.4 *Fuel Reservoir Container*—PTFE-fluorocarbon, funnel shaped, 500 mL capacity.

6.1.1.5 *Collection Container*—Glass or plastic Erlenmeyer flask, 500-mL capacity.

6.1.1.6 *Tygon Tubing,*[6] fuel compatible, 3.1-mm (0.12-in.) inner diameter.

6.1.1.7 *Plastic In-line Splice Coupler*, fuel compatible, capable of being inserted into, and making a seal in Tygon tubing (see 6.1.1.6).

[5] 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 34292. If you are aware of alternate suppliers, please provide this information to ASTM International Headquarters. Your comments will receive careful consideration at a meeting of the responsible technical committee, which you may attend.

[6] Tygon tubing was used in the round robin test program to generate the precision and bias. Tygon is available from most laboratory supply houses.

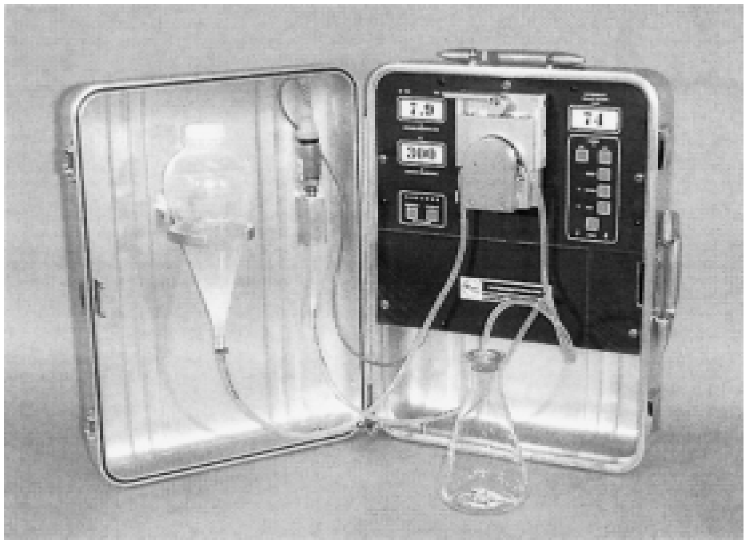


FIG. 2 Micro-Filter Analyzer

6.1.1.8 *Plastic Tee Coupler*, fuel compatible, capable of being inserted into, and making a seal in Tygon tubing (see 6.1.1.6).

6.1.1.9 *Plastic Luer-Loc Coupler*, fuel compatible, one end capable of being inserted into, and making a seal in Tygon tubing (see 6.1.1.6) and the other end into filter unit (see 6.2).

6.2 *FCell Filter Unit*[7]—Disposable, precalibrated assembly consisting of a shell and plug containing a 25-mm diameter nylon membrane filter of nominal 5.0-µm pore size, nominal 60 % porosity, with a 158.9-mm^2 effective filtering area.

6.3 *Accessories for Apparatus Verification Test*:

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

6.3.2 *Pressure Gage*, 350-kPa (50-psi) capability, graduations 0.5 kPa (0.1 psi).

6.3.3 *Thermometer*, having a range of 0 to 60°C. Temperature measuring devices that cover the temperature range of interest, such as the ASTM 1C thermometer, or liquid-in-glass thermometers, thermocouples, or platinum resistance thermometers that provide equivalent or better 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 must be representative of the lot of fuel. Obtain the sample in accordance with the procedures of Practice D 4057 or D 4177, and report (see 10.1) how and from where it was obtained. The maximum sample size is dictated by the quantity that can be mixed thoroughly (see 9.3). If any undissolved water is visually apparent (as determined by Test Method D 4176 or D 4860, or both), discard and replace with a fresh sample.

7.2 After thoroughly mixing, if the sample container such as a drum is too large to readily 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 Tygon tubing (see 6.1.1.6) is not attached as shown, carry out 8.2.1 to 8.2.2.

8.2.1 Attach one end of the Tygon tubing to the fuel reservoir container (6.1.1.4) and insert the plastic in-line splice coupler (6.1.1.7) into the other end.

8.2.2 Insert the plastic in-line coupler into another piece of Tygon tubing, thread the tubing in the peristaltic pump (see 6.1.1.1), 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 Tygon 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 (6.1.1.8) 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 barbered portion of the Luer-Loc coupler (6.1.1.9) into the other section of tubing that is connected to the in-line part of the tee.

[7] A registered trademark of EMCEE Electronics, Inc., 520 Cypress Ave., Venice, FL 34292.

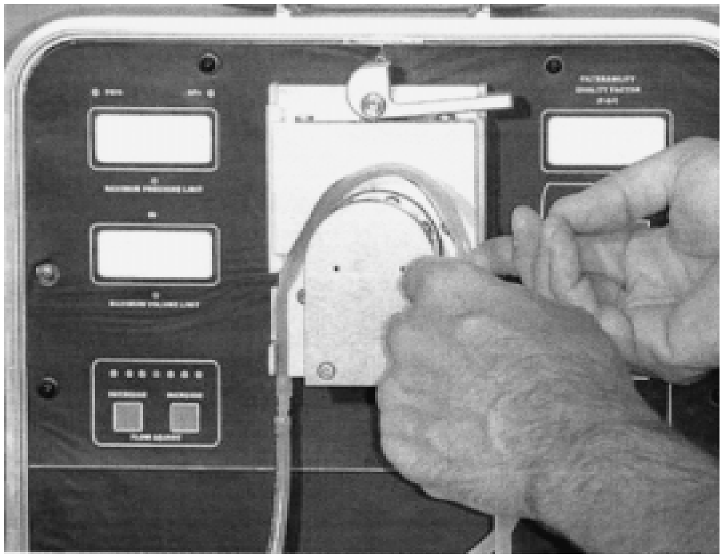


FIG. 3 Threading the Tubing in the Pump

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 per 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, as required.

8.5.2 Check the pressure by inserting a pressure gage (see 6.3.2) at the end of the Tygon tubing where the filter would be installed. Perform a test using air only, and compare the readings when approximately 104 kPa (15 psi) is displayed. If the readings vary more than ± 7 kPa (1.0 psi), 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 Rinse the fuel reservoir container (see 6.1.1.4) with some of the product to be tested.

9.3 Shake the transfer container (see 7.2) vigorously for approximately 2 min.

9.4 Place 450 ± 5 mL of the sample into the fuel reservoir (see 6.1.1.4). 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 Method D 4176 or D 4860, or both, the test shall be abandoned and the presence of water shall be reported.

9.5 Place the end of the Tygon tubing with the Luer-Loc coupler (see 6.1.1.9) into the collection container (see 6.1.1.5).

9.6 Press and release the PURGE pushbutton. Approximately 40 mL will be drawn from the fuel reservoir through the Tygon 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 Luer-Loc coupler affixed to the Tygon 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, 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 psi). The total volume $V_{(V=300\ \mathrm{mL})}$, the final pressure, $P_{(FP<15\ \mathrm{psi}\ @\ 300\ \mathrm{mL})}$, 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 psi) has been reached. The volume, $V_{(V\ \mathrm{at}\ 15\ \mathrm{psi})}$, discharged at 104 kPa (15 psi), the final pressure, $P_{(FP=25\ \mathrm{psi})}$, and the F-QF will be displayed.

9.10 At the completion of the test, unclamp the Tygon tubing from the pump to relieve the back pressure; disconnect the FCell filter; place the end of the Tygon tubing that was attached to the FCell filter into the collection container (6.1.1.6). Drain all of the remaining fuel from the fuel reservoir container (6.1.1.5) and from all of the tubing including the section connected to the pressure transducer into the collection container.

10. Report

10.1 Report the following information:

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

10.1.2 The temperature recorded in 9.4 and, if applicable, *undissolved water present, filtration not performed;* otherwise, report per 10.1.3.

10.1.3 The final pressure ($P_{(F)}$) and volume ($V_{(F)}$) in the form $P_{(F)}$(kPa)/$V_{(F)}$(mL) or $P_{(F)}$(psi)/$V_{(F)}$(mL), and F-QF.

11. Precision and Bias [8]

11.1 *Precision*—The precision for the F-QF of this test method for field samples of diesel, home heating, and blended bio-diesel fuels was determined by statistical analysis of test results obtained by a cooperative test program conducted at a common test site. The precision of this procedure in this test method for measuring filterability of aviation turbine fuels and gasoline is being determined.

NOTE 4—These results were calculated by applying ASTM D2PP statistical analysis computer program[9] to the data obtained from a May 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 six different operator/instrument pairs performing replicate tests on twelve 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. This precision analysis may not apply to samples having viscosities other than those that were used in the round robin program.

11.1.1 *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.

11.1.2 *Reproducibility*—The difference between two single and independent measurements of 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.

TABLE 1 Precision for Diesel, Home Heating, and Blended Bio-diesel Fuels (5.0 μ Filter)

	Maximum Allowable Difference Between Two F-QF Values	
Two F-QF Values, avg	Repeatability	Reproducibility
10	10	12
20	11	14
30	12	15
40	13	16
50	14	18
60	15	19
70	16	21
80	17	22
90	19	24
100	20	25

11.2 In 1999, a test program 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 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. 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.

11.3 *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.

12. Keywords

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

[8] Supporting data have been filed at ASTM International Headquarters and may be obtained by requesting Research Report RR: D02–1540.

[9] Available from ASTM International Headquarters.

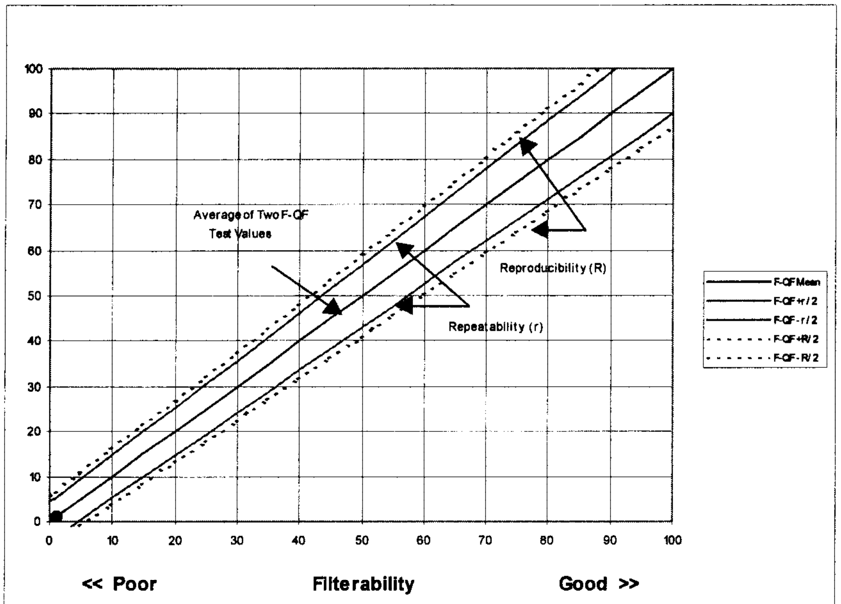


FIG. 4 Precision of Filterability Quality Factor (F-QF) Repeatability (*r*) and Reproducibility (*R*)