



# Standard Test Method for Determining Filterability of Aviation Turbine Fuel<sup>1</sup>

This standard is issued under the fixed designation D 6824; 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 reappraisal. A superscript epsilon ( $\epsilon$ ) indicates an editorial change since the last revision or reappraisal.

## 1. Scope

1.1 This test method covers a procedure for determining the filterability of aviation turbine fuels.

NOTE 1—ASTM specification fuels falling within the scope of this test method are Specifications D 1655 and D 6615 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:

- D 1655 Specification for Aviation Turbine Fuels<sup>2</sup>
- D 4057 Practice for Manual Sampling of Petroleum and Petroleum Products<sup>3</sup>
- D 4176 Test Method for Free Water and Particulate Contamination in Distillate Fuels (Visual Inspection Procedures)<sup>3</sup>
- D 4177 Practice for Automatic Sampling of Petroleum and Petroleum Products<sup>3</sup>
- D 4860 Test Method for Free Water and Particulate Contamination in Mid-Distillate Fuels (Clear and Bright Numerical Rating)<sup>3</sup>
- D 5452 Test Method for Particulate Contamination in Aviation Fuels by Laboratory Filtration<sup>4</sup>
- D 6426 Test Method for Determining Filterability of Distillate Fuel Oils<sup>5</sup>

D 6615 Specification for Jet B Wide-Cut Aviation Turbine Fuel<sup>5</sup>

E 1 Specification for ASTM Thermometers<sup>6</sup>

### 2.2 Military Standards:<sup>7</sup>

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

### 2.3 ASTM Adjuncts:

ADJD6300 D2PP, Version 4.43, Determination of Precision and Bias Data for Use in Test Methods for Petroleum Products<sup>8</sup>

## 3. Terminology

### 3.1 Definitions of Terms Specific to This Standard:

3.1.1 *filterability*—a measure of the rapidity with which a standard filter medium is plugged by insoluble matter in fuel and can be described in the following 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, 104 kPa (15 psi).

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 to 100 is attained. Eq 1 yields values

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<sup>2</sup> *Annual Book of ASTM Standards*, Vol 05.01.

<sup>3</sup> *Annual Book of ASTM Standards*, Vol 05.02.

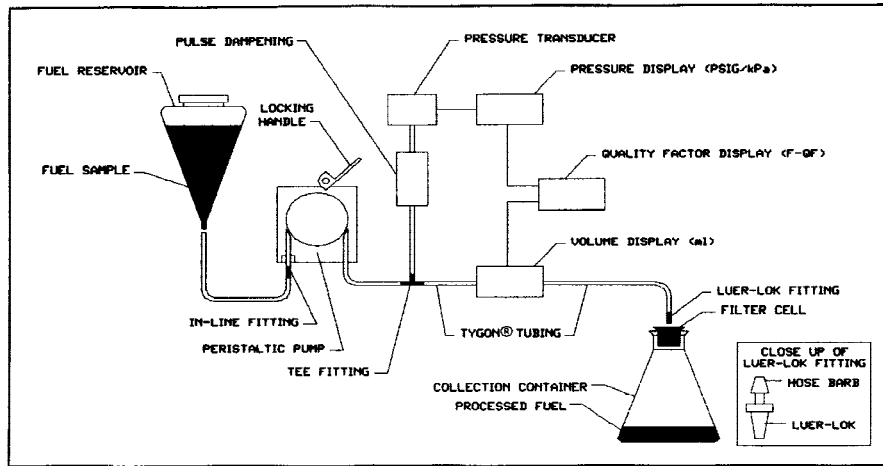
<sup>4</sup> *Annual Book of ASTM Standards*, Vol 05.03.

<sup>5</sup> *Annual Book of ASTM Standards*, Vol 05.04.

<sup>6</sup> *Annual Book of ASTM Standards*, Vol 14.03.

<sup>7</sup> Available from Standardization Documents Order Desk, DODSSP, Bldg. 4, Section D, 700 Robbins Ave., Philadelphia, PA 19111-5098.

<sup>8</sup> Available from ASTM International Headquarters. Order Adjunct No. ADJD6300.



NOTE—Fuel flow from reservoir through pump to container.

FIG. 1 Schematic Diagram of Filterability Apparatus

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 (15 psi), the F-QF is calculated by the following equation:

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

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 (15 psi), the F-QF is calculated by the following equation:

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

where:

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

3.1.1.5 Discussion—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.

#### 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 aviation turbine fuel cleanliness.

5.2 A change in filtration performance after storage, pre-treatment, 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*<sup>9</sup>—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  $20 \pm 1$  mL/min, and incorporating a pulse dampening mechanism to produce a smooth flow.

6.1.2 *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).

6.1.3 *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 psi in

<sup>9</sup> 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 Headquarters. Your comments will receive careful consideration at a meeting of the responsible technical committee,<sup>1</sup> which you may attend.

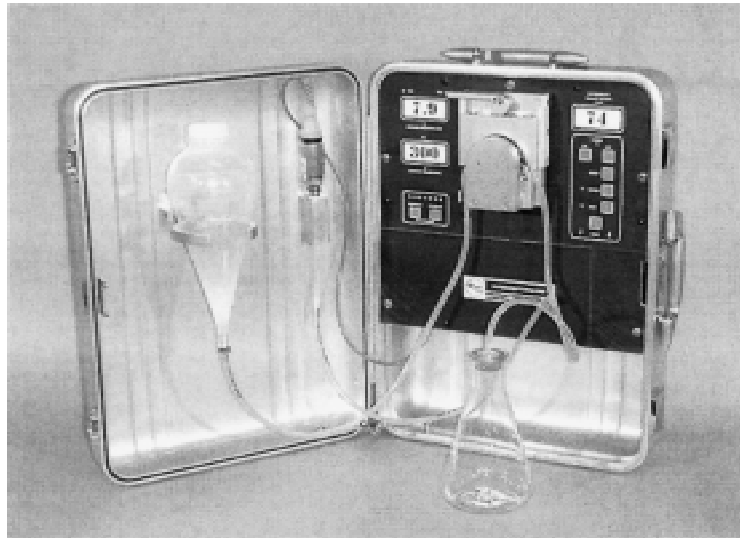


FIG. 2 Micro-Filter Analyzer

0.1 psi 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 psi 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 *Tygon Tubing*,<sup>10</sup> fuel compatible, 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 Tygon tubing (see 6.1.7).

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

6.1.10 *Plastic Luer-Loc Coupler*, fuel compatible, one end capable of being inserted into, and making a seal in Tygon tubing (see 6.1.7) and the other end into the filter unit (see 6.2).

6.2 *FCell*<sup>11</sup> *Filter Unit*, disposable, precalibrated assembly consisting of a shell and plug containing a 25-mm diameter nylon membrane filter of nominal 0.65- $\mu$  pore size, nominal 60 % porosity, with a 158.9-mm<sup>2</sup> 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*, general purpose type, having a range of 0 to 60°C (see Specification E 1). Temperature measuring devices that cover the temperature range of interest, such as an ASTM 1C thermometer, or liquid-in-glass thermometers, thermocouples, or platinum resistance thermometers that provide equivalent or better accuracy and precision than ASTM 1C thermometers 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 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 9.2). If any undissolved water is visually apparent (as determined by Test Methods D 4176 or D 4860, 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 Tygon tubing (see 6.1.7) is not attached, as shown, carry out 8.2.1 to 8.2.2.

<sup>10</sup> Tygon 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.

<sup>11</sup> A registered trademark of EMCEE Electronics, Inc., 520 Cypress Ave., Venice, FL 34292.

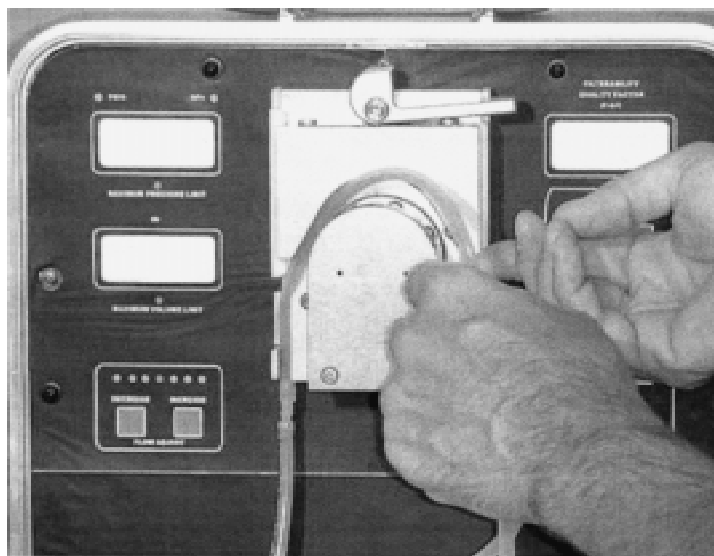


FIG. 3 Threading the Tubing in the Pump

8.2.1 Attach one end of the Tygon 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 Tygon 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 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 (6.1.9) 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 barbed portion of the Luer-Loc 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.

8.5.2 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  $\pm 7$  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 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  $450 \pm 5$  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 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 6.1.10) 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 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 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:

**TABLE 1 Precision of Aviation Turbine Fuels (0.65  $\mu$  Filter)**

| Maximum Allowable Difference<br>Between Two F-QF Values |               |                 | Maximum Allowable Difference<br>Between Two F-QF Values |               |                 |
|---|---------------|-----------------|---|---------------|-----------------|
| Average of<br>Two F-QF Values                           | Repeatability | Reproducibility | Average of<br>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               |

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

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

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

## 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, and filtration not performed; otherwise, report according to 10.1.3.

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

## 11. Precision and Bias <sup>12</sup>

11.1 *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. The precision for a similar procedure for measuring filterability of diesel fuels has been determined (Test Method D 6426), and gasoline is being determined.

NOTE 4—These results were calculated by applying ASTM D2PP Statistical Analysis computer program (now known as ADJD6300) 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.

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 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.

11.2 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 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.

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. Data were also obtained with the same samples using Appendix A of MIL-DTL-5624 and Test Method D 5452 and are available in the research report.<sup>12</sup>

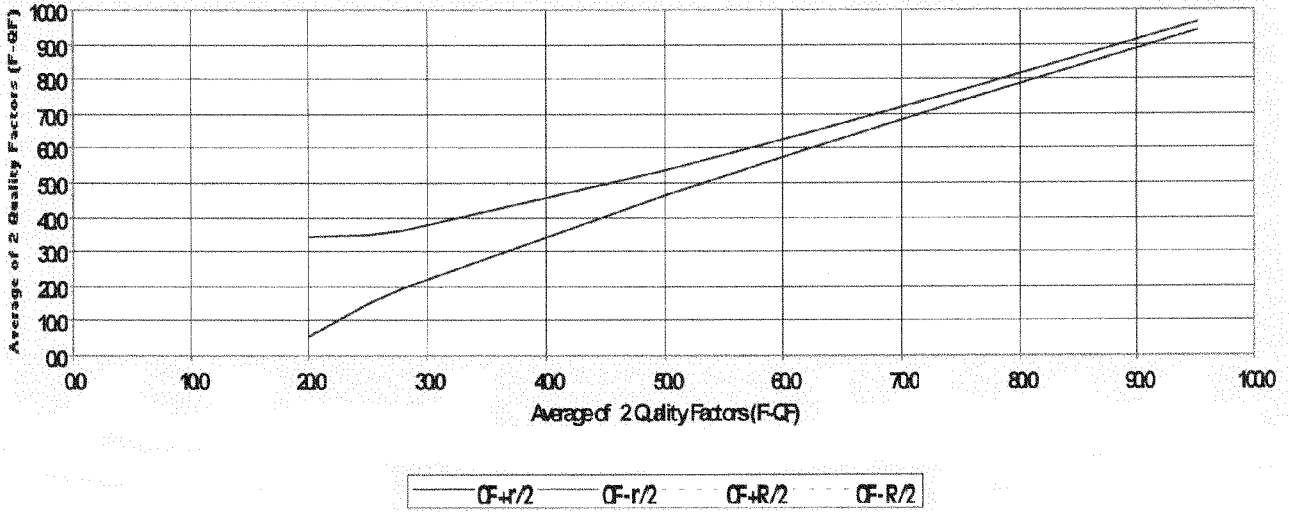
## 12. Keywords

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

<sup>12</sup> Supporting data have been filed at ASTM International Headquarters and may be obtained by requesting Research Reports RR: D02-1530 and D02-1542.

Precision for Emcee Model - 1143 Jet Fuel @ .65 micron Filter Pore Size  
(Repeatability (r) & Reproducibility (R))

Round Robin Program  
November 2000



NOTE—Dotted lines are covered by solid lines; r and R are practically the same.

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

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