INTERNATIONAL

Designation: D8386 – 21

Standard Test Method for Determining Enhanced Filter Blocking Tendency (EFBT)[1]

This standard is issued under the fixed designation D8386; 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.

INTRODUCTION

This test method is based on Test Method D2068 and uses a filter media which is more sensitive to blocking by contaminants in fuels than the filter specified in Test Method D2068 Procedure A and B. The result of this test method is dependent on the mandated filter material, as well as the procedural steps of this method. If a specification requires a specific Dxxxx procedure, do not substitute a different procedure or filter without agreement from the specifier.

1. Scope

1.1 This test method covers a procedure for the determination of the Enhanced Filter Blocking Tendency (EFBT) and the filterability of middle distillate fuel oils. This test is applicable to fuels within the viscosity range of 1.3 mm^2/s to 6.0 mm^2/s at 40 °C.

NOTE 1—ASTM specification fuels falling within the scope of this test method are: Specification D396 Grades No 1 and 2; Specification D975 Grades No. 1-D S15 and S500, and No. 2-D S15 and S500; Specification D2880 Grades No. 1-GT and No. 2-GT.

1.2 This test method has interim repeatability only. For more information, see Section 12.

1.3 This test method is not applicable to fuels that contain free (undissolved) water (see 7.3).

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

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

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:*[2]

D396 Specification for Fuel Oils
D975 Specification for Diesel Fuel
D2068 Test Method for Determining Filter Blocking Tendency
D2880 Specification for Gas Turbine Fuel Oils
D4057 Practice for Manual Sampling of Petroleum and Petroleum Products
D4175 Terminology Relating to Petroleum Products, Liquid Fuels, and Lubricants
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)
D6300 Practice for Determination of Precision and Bias Data for Use in Test Methods for Petroleum Products, Liquid Fuels, and Lubricants

2.2 *ASTM Manuals:*[3]

ASTM MNL 1

2.3 *ASTM Adjuncts:*

D2PP, Determination of Precision and Bias Data for Use in Test Methods for Petroleum Products[4]

[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 D02.14 on Stability, Cleanliness and Compatibility of Liquid Fuels.

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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] MNL 1, *Manual on Significance of Tests for Petroleum Products, 9th Edition*, ASTM International, West Conshohocken, 2018.

[4] This adjunct has been withdrawn and is no longer available.

3. Terminology

3.1 For definitions of terms used in this standard, see Terminology D4175.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *enhanced filter blocking tendency (EFBT), n—of fuels described in 1.1*, a calculated dimensionless value that defines the tendency of contaminants in the fuel to plug or block the filter media specified in this test procedure.

3.2.1.1 *Discussion*—The value is calculated using the pressure across the filter or the volume of fuel filtered at the end of the test. Depending on the outcome of the test, one of two equations is applied. See Section 10, Calculation. See 5.6 for the interpretation of results.

3.2.2 *filterability, n—of fuels described in 1.1*, is the relationship between the volume of sample filtered and the measured pressure increase across the filter.

3.2.2.1 *Discussion*—The filterability of the fuel can be assessed by recording the pressure when a specific volume of fuel has flowed through the filter or recording the volume when a specific pressure across the filter has been achieved. This assessment may be assisted by plotting a volume versus pressure graph. See Appendix X1.

4. Summary of Test Method

4.1 A test portion of the fuel to be analyzed is passed at a constant rate of flow (20 mL/min) through a specified filter medium. The pressure difference across the filter, and the volume of fuel passing the filter, are monitored until the pressure reaches 105 kPa, or the volume of fuel passing the filter medium reaches 300 mL. The pressure (see 3.2.2) and flow are then used to calculate the enhanced filter blocking tendency, where a low number indicates clean fuel (see 5.6).

5. Significance and Use

5.1 This test method is intended for use in evaluating the cleanliness of middle distillate fuels for quality control purposes.

5.2 The filter media specified in this procedure is suitable for the materials in the scope.

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

5.4 The filterability of fuels varies depending on filter porosity and structure. Therefore, results from this test method might not correlate with full-scale filtration; however, results from this test might help identify fuels that can reduce filter life.

5.5 Causes of poor filterability in industrial/refinery filters include fuel degradation products, contaminants (including water) picked up during storage or transfer, effects due to temperature or composition for diesel, 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.

5.6 The results of the EFBT test can range from 1 for a fuel with very good filterability, to over 30 for a fuel with poor filterability. The selection of a single EFBT number to define a pass or fail criteria is not possible, as this will be dependent on the fuel type and application specifics. The correlation between filter life and EFBT number is, therefore, dependent on many variables stemming from the design and use of the engine. Some factors like pressures and particle size removal required come from the fuel system design while others are a result of the duty cycle and environment where the engine is deployed. As an example, a large displacement HPCR (High-Pressure Common Rail) engine in continuous operation may have cleanliness needs much greater than that of a medium or light-duty engine in occasional use. In each case, the expected EFBT value may be different. An EFBT value of <1.4 for the fuel before it reaches the fuel system in the first example of HPCR engines may be suitable, while an EFBT <2.0 may be suitable in the medium/light-duty engines. In a small study, the EFBT test was shown to be more sensitive to constituents in the fuel than the Test Method D2068 method (Appendix X1).

6. Apparatus

6.1 *General*—The apparatus is described in A1.1 and shown in Fig. A1.1.

6.2 *Filter Media and Assemblies:*

NOTE 2—Effective filtration areas were determined by measuring the diameter of the sediment collected in the center of the filter media.

6.2.1 *Filter Housing,* stainless steel, nominal 13 mm diameter with a Luer fitting at the top where it connects with the filtration apparatus as shown in Fig. 1.

6.2.2 *Filter Media*[5], the media is 2.1 µm ± 0.15 µm nominal pore diameter, nominal 13.0 mm diameter and with an effective filtration area of 55.4 mm^2 to 63.6 mm^2. The filter media has been treated with a resin to bring the permeability to 13.2 $l/m^2/s$ ± 1.5 $l/m^2/s$.

6.3 *Measuring Cylinder,* 25 mL, glass or other suitable transparent material, with graduations every 0.5 mL, for verifying the flow rate.

6.4 *Measuring Cylinder,* 500 mL, glass or other suitable transparent material, with graduations every 5 mL, for verifying the flow rate, and for measuring the volume of fuel in the fuel receiver if required.

6.5 *Stopwatch,* capable of measuring to the nearest 0.2 s, required for verifying the flow rate and preparing the sample.

6.6 *Thermometer,* electronic or liquid-in-glass type thermometers with a range of at least 15 °C to 25 °C and accuracy of ±0.5 °C or better are suitable.

6.7 *Forceps,* spade-ended.

6.8 *Open-Ended Spanner Wrenches,* plastic or metal.

[5] The sole source of supply of the Cummins Nanonet® Quantitative Media and entire apparatus known to the committee at this time is Stanhope-Seta, London Street, Chertsey, KT16 8AP, United Kingdom (part numbers 91620 and 91600 respectively). If you are aware of alternative suppliers, please provide this information to ASTM International Headquarters. Your comments will receive careful consideration at a meeting of the responsible technical committee,[1] which you may attend.

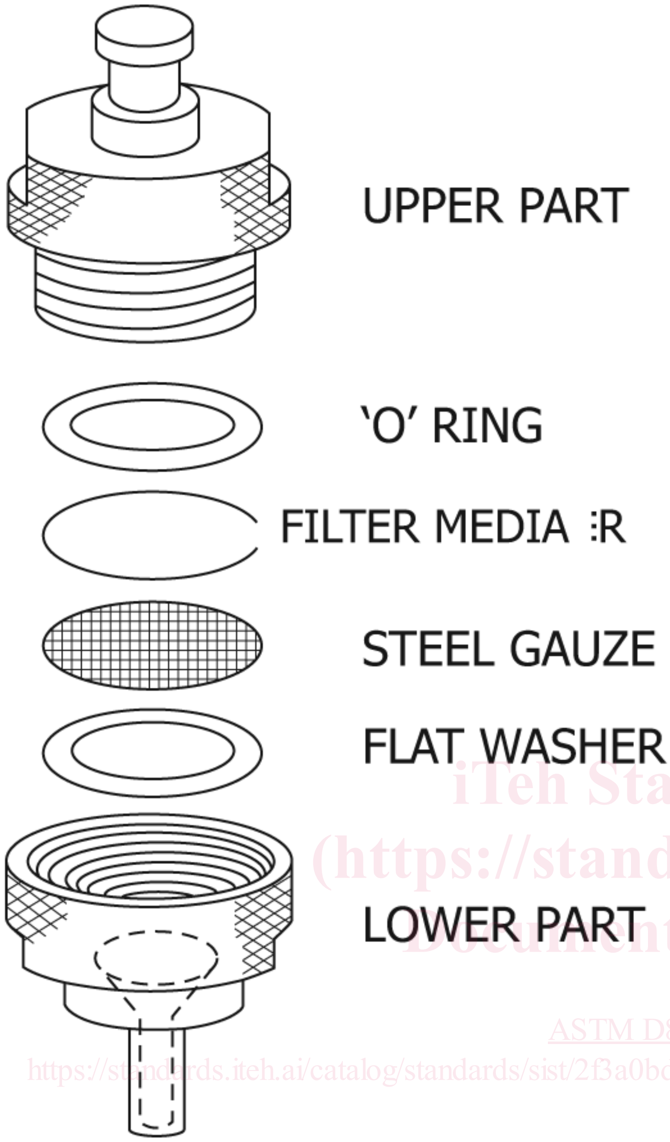

FIG. 1 Assembly

6.9 *Anti-splash Tubing,* nylon or silicone rubber, approximately 4 mm inner diameter to reduce splashing of the sample in the fuel receiver beaker.

7. Sampling

7.1 Unless otherwise specified, samples shall be obtained in accordance with Practices D4057, D4177, MNL 1, 9th Edition, Chapter 8, or other comparable sampling practices.

7.1.1 Containers shall have been previously flushed three times with the product to be sampled.

7.2 Obtain at least 400 mL of a representative aliquot of the sample to be tested in an epoxy-lined can or dark glass bottle.

7.3 If any undissolved water is visually apparent (as determined by Test Method D4176 or D4860), discard and replace with a fresh sample.

8. Preparation of Apparatus

8.1 *Verification:*

8.1.1 *Pressure and Temperature*—Follow the manufacturer's instructions for verifying that the pressure and temperature readings are in accordance with the tolerances given in A1.1.3 and 6.6, respectively. Verify the pressure reading, at ambient atmospheric pressure (0 kPa) and at approximately 100 kPa, at least every six months or if the apparatus has not been used for the previous three months. Verify the temperature reading is correct, at ambient temperature, at least every twelve months. If the readings do not meet the specified tolerances in A1.1.3 and 6.6, calibrate the sensors (8.2.1).

8.1.2 *Flow Rate*—Follow the manufacturer's instructions for verifying that the flow rate is 20 mL/min ± 1 mL/min through a filter assembly. The flow rate is verified by measuring the volume pumped during a 15 min period, at least once a month, using a suitable measuring cylinder (6.4). If the measured volume is between 285 mL and 315 mL the flow rate is correct. More frequent checks on the flow rate may be made by measuring the volume during a 1 min period using a 25 mL measuring cylinder (6.3). If the measured volume is not between 19 mL and 21 mL, calibrate the pump (8.2.2).

8.2 *Calibration:*

8.2.1 *Pressure and Temperature*—Follow the manufacturer's instructions to calibrate the pressure at atmospheric pressure (0 kPa) and approximately 100 kPa, and temperature-measuring device at ambient temperature.

8.2.2 *Flow Rate*—Follow the manufacturer's instructions to set and lock the mechanical flow adjustment control on the pump to give a flow rate of 20 mL/min ± 1 mL/min.

8.2.2.1 A filter assembly shall be fitted when the flow rate is calibrated.

8.3 *Apparatus Assembly*—Assemble the apparatus as shown in Fig. A1.1, without the filter unit connected.

8.4 *Filter Assembly*—Assemble the filter as shown in Fig. 1 using a new filter medium handled with the forceps (6.7), taking care not to damage the filter medium. Place the media with the grooved side facing the backing metal screen or is the clean side. The open-ended spanner wrenches (6.8) may be used to assist in assembling or disassembling the housing. Attach a suitable length (typically 80 mm to 90 mm) of anti-splash tubing (6.9) to the outlet of the filter assembly.

NOTE 3—It is most important that the filter unit components are assembled in the exact configuration shown in Fig. 1.

NOTE 4—Over- or under-tightening of the Filter A assembly can lead to erroneous results.

8.5 Rinse the fuel reservoir beaker with some of the product to be tested, and discard.

8.6 Remove the adaptor.

9. Procedure

9.1 *General*—Unless otherwise specified, the test specimen shall be prepared as described in 9.1.1 – 9.1.6.

9.1.1 Measure the temperature (6.6) of the fuel in the container and adjust to 15 °C to 25 °C if necessary.

9.1.2 Shake the fuel container vigorously for 120 s ± 5 s, and then immediately proceed to the next step to prevent settling of contaminants.

9.1.3 Place at least 400 mL of the sample into the fuel reservoir beaker and check that the temperature (6.6) is still within the range of 15 °C to 25 °C. Record the actual temperature. If any undissolved water is apparent in the fuel at this stage, abandon the test and report the presence of water.

9.1.4 Place the pump suction pipe fully down into the reservoir beaker, 5 mm from the bottom of the beaker and start the pump. Flush the system through with the sample by allowing approximately 20 mL of the sample to flow into the receiver beaker. Stop the pump and discard any fuel from the fuel receiver beaker.

9.1.5 Test fuels having an extremely high blocking tendency can cause pressure reading to rise so rapidly at the beginning of the test that the initial pressure requirement cannot be met. If this is found to be the case after checking the pump and filter units, the requirement may be ignored, and this fact reported in the form described in 11.2.

9.1.6 Samples subjected to specific pretreatment, that may be specified in other test methods or procedures, shall follow the prescribed instructions, particularly the temperature requirements, sample mixing, and flushing of the system. The precision of this test method may not apply in such circumstances.

9.2 *Procedure:*

9.2.1 Attach the filter assembly (8.4) to the Luer fitting on the system.

9.2.2 Re-start the pump and after 20 s, record the pressure gauge reading, which should be within the range 7 kPa to 40 kPa. If the pressure gauge reading is not within the correct range, stop the pump and check the apparatus for faults.

NOTE 5—A pressure reading of greater than 21 kPa can indicate an incorrect installation of the filter media.

9.2.3 Observe the pressure gauge reading as pumping continues. If the pressure rises to 105 kPa, stop the pump immediately. Measure and record the volume of the fuel in the receiver beaker, rounding off the figure to the nearest 10 mL.

9.2.4 When 300 mL of the sample has been pumped without the pressure rising to 105 kPa, record the pressure reading at the end of the test to the nearest 5 kPa, and discontinue the test.

9.2.5 Disassemble the filter unit and inspect the filter medium. The patch of sediment (if visible) in the center shall be 8.4 mm to 9.0 mm in diameter. Repeat the test if this condition is not met.

9.2.6 If for specification compliance purposes, the test is stopped manually after a specific volume of fuel other than 300 mL has been pumped through the filter, record, and report the pressure and volume.

9.2.7 If, during any test, the pressure rises to 105 kPa or if a sample is known to be severely contaminated with particulates, then follow the manufacturer's instructions to clean the pulse damper assembly before commencing the next test. An example of a suitable procedure is described in Appendix X3.

9.2.8 Some test materials are known to occasionally show a decline in pressure during the test. This can be a function of the material/filter media but could be indicative of a test apparatus leak. If an unexpected pressure drop is noticed, check that the Luer-lock filter connections are not leaking and follow the manufacturer's instructions for performing leak tests.

10. Calculation

10.1 The apparatus automatically calculates the EFBT according to the equations shown below in Eq 1 and 2.

10.1.1 Calculate the enhanced filter blocking tendency (EFBT) using one of the equations below. Eq 1 applies when 300 mL of fuel has passed the filter medium at a pressure below 105 kPa, and Eq 2 applies when the test has been discontinued when the pressure reached 105 kPa.

$$EFBT = \sqrt{1 + \left(\frac{P}{105}\right)^2} \tag{1}$$

$$EFBT = \sqrt{1 + \left(\frac{300}{v}\right)^2} \tag{2}$$

where:

P = pressure reading at the end of the test obtained for 300 mL of fuel to pass the filter, in kilopascals, and

v = volume of fuel in milliliters, passed prior to the pressure rising to 105 kPa.

11. Report

11.1 If free (undissolved) water is observed (see 9.1.3), report as "Free (undissolved) water present, test not carried out."

11.2 If the test is stopped manually when a specified volume of fuel has been pumped, the report: volume pumped and final pressure.

11.3 For all completed tests, report the following.

11.3.1 A reference to this standard.

11.3.2 The type and complete identification of the product tested.

11.3.3 The results of the test (EFBT) to the nearest 0.01.

11.3.4 The volume of fuel pumped, in mL, rounded to the nearest 10 mL.

11.3.5 The pressure at the end of the test, in kPa, rounded to the nearest 5 kPa.

11.3.6 The sample temperature (see 9.1.1), in °C.

11.3.7 Any deviation, by agreement or otherwise, from the procedure specified; and

11.3.8 The date of the test.

11.4 If the condition of 9.1.5 applies, report "high initial pressure" appended to the EFBT result.

12. Precision and Bias[6]

12.1 This test method has interim repeatability precision only. An inter-laboratory study of this test method will be conducted, and a complete precision statement is expected to be available by 2026.

12.2 The precision of this test method was determined by the statistical evaluation of an interim repeatability study,

[6] Supporting data have been filed at ASTM International Headquarters and may be obtained by requesting Research Report RR:D02-2017. Contact ASTM Customer Service at service@astm.org.

which met the requirements of Practice D6300. A single laboratory measured eight samples twelve times under repeatability conditions. The samples, which included US retail diesel grade, the diesel meeting Specifications D975 No. 2-S15 and Fuel Standard (Automotive Diesel) Determination 2001 from North American and Australian sources. The interim precision statement for this test method, as determined following Practice D6300, is stated as follows (12.3).

12.3 *Interim Repeatability (r)*—The difference between two independent results obtained by the same operator in a given laboratory applying the same test method with the same apparatus under constant operating conditions on identical test material within short intervals of time would exceed the following value with an approximate probability of 5 % (one case in 20 in the long run) in the normal and correct operation of the test method (see RR:D02-2017[6] for more information).

12.3.1 For commercial fuels obtained and tested as-is:

TABLE 1 Tabulated Interim Repeatability

Average EFBT	Standard Deviation	Interim Repeatability (r)
1.05	0.01	0.03
1.95	0.08	0.26
3.14	0.18	0.60

12.3.2 For laboratory designed fuel, pre-filtered fuel adulterated with PTI 0-5 test dust, the interim repeatability function is:

$$r = 0.1652(X + 7.36)FBT \quad (3)$$

where:

X = average of two results.

13. Keywords

13.1 automotive diesel; filter blocking tendency (EFBT); filterability; gas oil; marine diesel; middle distillates

ANNEX

(Mandatory Information)

A1. APPARATUS DETAILS

A1.1 *General*—The apparatus, as shown diagrammatically in Fig. A1.1, is available as a complete unit comprising pressure and temperature measurement, automated calculation of enhanced filter blocking tendency and a graphical representation of filterability.

A1.1.1 *Piston Pump,* capable of delivering fuel at a constant rate of 20 mL/min ± 1 mL/min and incorporating a mechanical means of adjusting and calibrating the flow. The flow adjustment shall have a locking mechanism.

A1.1.2 *Pulse Damper,* a mechanism to produce a smooth flow of fuel to the filter unit.

A1.1.3 *Pressure Gauge,* calibrated, and graduated covering the range 0 kPa to 105 kPa gauge pressure, with an accuracy of ±1 kPa.

A1.1.4 *Over-Pressure Sensor,* fitted to automated apparatus between the pump and the damper to stop the pump if the pressure exceeds 200 kPa.

A1.1.5 *Pressure Relief Valve,* located on the front of the arm holding the filter assembly. Used to relieve the pressure if the filter becomes blocked and during verification and calibration of the pressure sensor in the automated apparatus.

A1.1.6 *Fuel Beakers,* made of glass, or other suitable transparent materials, with a capacity of at least 400 mL with 10 mL graduations.

NOTE A1.1—Fuel reservoir beakers made of plastic-type materials can cause particulates to adhere to the walls of the beaker due to static effects and can affect the result.

A1.1.7 *Printer,* optional with automated apparatus to record results and graphically represent the pressure/flow characteristics (see Appendix X2).

A1.1.8 Fuel input and output assemblies shall be directly grounded (earthed) to avoid the build-up of static electricity.

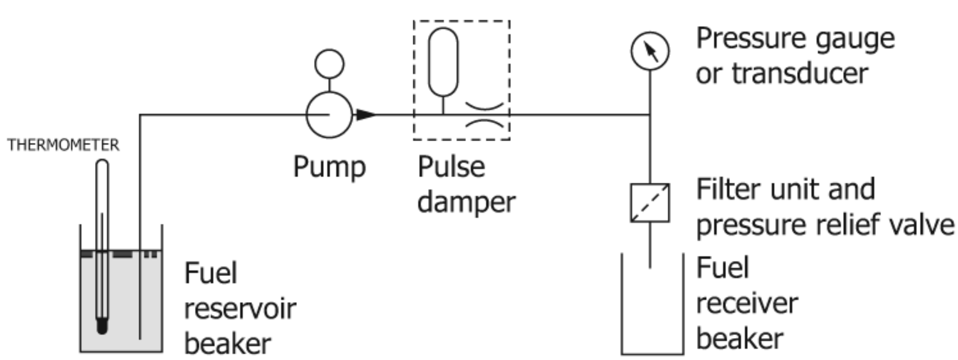

FIG. A1.1 Flow Diagram of Filtration Test Apparatus