Designation: D8385 – 22

Standard Test Method for Dry Filterability of Lubricants and Hydraulic Fluids by Mass Flow Technique[1]

This standard is issued under the fixed designation D8385; 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 determination of the dry filterability of lubricants and hydraulic fluids based upon mass flow rate measurements through a 0.8 µm membrane after ageing (Note 1). The procedure applies to lubricants and hydraulic fluids that are formulated with American Petroleum Institute (API) Group I, II, III, IV, and certain V base stocks. Products formulated with water or base stocks that are heavier than water are out of scope.

NOTE 1—This test method is similar to ISO 13357 but differs from the ISO method in the manner by which filterability is assessed. In ISO 13357, volume flow rates are used to determine filterability. In this test method, mass flow rates are used. Measurements of filterability based on mass flow rates facilitate automation and can be less susceptible to operator error.

NOTE 2—Residual water due to atmospheric conditions or contaminants is in scope for these samples and it is typically low for most in process samples.

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

1.3 *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.*

1.4 *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]

D1193 Specification for Reagent Water

D4057 Practice for Manual Sampling of Petroleum and Petroleum Products

D4175 Terminology Relating to Petroleum Products, Liquid Fuels, and Lubricants

D6300 Practice for Determination of Precision and Bias Data for Use in Test Methods for Petroleum Products, Liquid Fuels, and Lubricants

2.2 *ISO Standards:*[3]

ISO 13357 Petroleum products – Determination of the filterability of lubricating oils – Part 2: Procedure for dry oils

ISO 16889 Hydraulic fluid power – Filters – Multi-pass method for evaluating filtration performance of a filter element

3. Terminology

3.1 *Definitions:*

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

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *filterability, n*—the ability of lubricants and hydraulic fluids to pass through fine filters without plugging them; it is a dimensionless number that is the ratio between two filtration rates.

3.2.2 *Stage I filterability index, n*—the ratio, expressed as a percentage, between 192 g and the mass of oil filtered in the time that 192 g would have theoretically taken, assuming no plugging of the membrane.

3.2.3 *Stage II filterability index, n*—the ratio, expressed as a percentage, between the flow rate near the start of filtration, and the flow rate between 160 g and 240 g of filtered mass.

NOTE 3—Oils having good Stage I filterability would be unlikely to cause filter performance problems in use, unless high efficiency fine filtration is employed in the equipment. Oils with good Stage II filterability would be unlikely to cause filtration problems when high efficiency fine filtration is present. High efficiency filters, within the context of this method, have a Beta Ratio greater than or equal to 75 at 5 µm as defined by ISO 16889. ($\beta_{5\ \mu m} \geq 75$) Thus fluids that have good Stage II filterability

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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 International Organization for Standardization (ISO), ISO Central Secretariat, Chemin de Blandonnet 8, CP 401, 1214 Vernier, Geneva, Switzerland, https://www.iso.org.

are recommended for hydraulic and lubrication systems that have critical cleanliness requirements.

3.3 *Symbols:*

3.3.1 F_I—stage I filterability index, dimensionless

3.3.2 F_{II}—stage II filterability index, dimensionless

3.3.3 M—actual mass of oil filtered at T_m, g

3.3.4 T_8—time corresponding to 8 g of oil filtered, s

3.3.5 T_{40}—time corresponding to 40 g of oil filtered, s

3.3.6 T_{160}—time corresponding to 160 g of oil filtered, s

3.3.7 T_{240}—time corresponding to 240 g of oil filtered, s

3.3.8 T_m—theoretical time for 192 g of oil to filter, s

4. Summary of Test Method

4.1 In this test method the fluid is filtered under specific conditions through a membrane of 0.8 µm mean pore diameter, and the times for the specific filtrate masses are recorded. Filterability indices are calculated from ratios of the mass flow rate near the start of the test, to the flow rate at later stages. The result of the test is the average of three determined values.

5. Significance and Use

5.1 Precision equipment and high pressure hydraulic machinery require filtered lubricants and fluids to prevent damage from the circulation of hard particulate contaminants. Three types of particulate contaminants are present in lubricants and hydraulic fluids: built in contaminants from the machinery assembly process, generated contaminants from equipment wear, and contaminants that enter from external sources.

5.2 The ability of lubricants and hydraulic fluids to retain their filterability is critical for efficient and reliable machine performance. Normally, the pressure differential across a filter will increase gradually as the filter accumulates dirt, sludge, and wear debris. In order to prevent the filter from collapsing, bypass valves in the filter assembly open when the differential pressure gets too high. If a filter becomes blocked by precipitating additives or other contaminants, the bypass valve will open. This can lead to an equipment shutdown or circulation of damaging particles throughout the machine.

6. Apparatus

6.1 *Beaker,* 500 mL or other size suitable for collecting the filtrate.

NOTE 4—A 300 mL graduated cylinder may also be used but overflows can occur with low density oils.

6.2 *Bottles,* 500 mL narrow mouth glass laboratory media bottles with a screw on cap. Neck inner diameter, 3 cm ± 0.2 cm, bottle width 8.7 cm ± 0.4 cm, height without cap 17.6 cm ± 0.2 cm.

NOTE 5—The shape of the bottle has been found to affect wet filterability results. The effect of the bottle shape in dry filterability is unknown.

6.3 *Filtration apparatus,* constructed of stainless steel, consisting of a lidded funnel of at least 350 mL capacity, and a funnel base with filter support, such that a membrane filter (6.5) can be clamped between the sealing surfaces of the funnel and the base by means of a metal clamp or other suitable air-tight closure.

6.4 *Forceps,* spade ended.

6.5 *Membrane filters,* of mixed cellulose esters, diameter 47 mm and mean pore size of 0.8 µm.

NOTE 6—Membranes of an equivalent specification to Millipore filter membranes, catalogue number AAWP 047 have been found satisfactory.

6.6 *Oven,* controlled at 70 °C ± 2.0 °C.

6.7 *Petri dishes,* glass type.

6.8 *Pressure gauge,* dial or digital type, capable of reading the required delivery pressures (see 11.7) ±5 kPa.

6.9 *Top loading balance,* with dynamic measurement mode. Capable of continuously recording 0.1 g mass at 0.1 s increments.

7. Reagents and Materials

7.1 *Purity of Reagents*—Reagent grade chemicals shall be used in all tests. Unless otherwise indicated, it is intended that all reagents shall conform to the specifications of the Committee on Analytical Reagents of the American Chemical Society, where such specifications are available.[4] Other grades may be used, provided it is first ascertained that the reagent is of sufficiently high purity to permit its use without lessening the accuracy of the determination.

7.2 *Compressed air or nitrogen,* complete with regulator system capable of supplying air or nitrogen at nominal pressures between 50 kPa and 200 kPa. The air or nitrogen shall be dry and filtered.

7.3 *Aliphatic solvent,* reagent grade heptanes or 2,2,4-trimethylpentane are suitable.

7.4 *Water,* conforming to Type 3 of Specification D1193 for Reagent Water.

8. Hazards

8.1 Safety glasses and solvent impermeable gloves must be worn during the experiments.

9. Sampling, Test Specimens, and Test Units

9.1 Unless otherwise specified, samples shall be taken by the method specified in D4057.

9.2 Equilibrate the test oils out of direct sunlight at a temperature of 15 °C to 25 °C for a minimum of 24 hours.

10. Preparation of Apparatus

10.1 Rinse the apparatus with aliphatic solvent (7.3) to remove traces of oil from previous tests.

[4] *ACS Reagent Chemicals, Specifications and Procedures for Reagents and Standard-Grade Reference Materials*, American Chemical Society, Washington, DC. For suggestions on the testing of reagents not listed by the American Chemical Society, see *Analar Standards for Laboratory Chemicals*, BDH Ltd., Poole, Dorset, U.K., and the *United States Pharmacopeia and National Formulary*, U.S. Pharmacopeial Convention, Inc. (USPC), Rockville, MD.

10.2 Soak in laboratory detergent solution overnight, or scrub thoroughly with hot laboratory detergent solution.

10.3 Rinse with hot tap water, followed by cold tap water.

10.4 Rinse with distilled water (7.4).

10.5 Rinse with propan-2-ol.

10.6 Rinse with aliphatic solvent (7.3) and allow to dry.

11. Procedure

11.1 Carry out the test in triplicate.

11.2 Wash the filter apparatus with solvent between each test.

11.3 Place a membrane filter (6.5) in a loosely covered Petri dish (6.7) and heat it in the oven (6.6) at 70 °C for 10 min. Handle the filter membrane by the edge only, using forceps (6.4), during this and all subsequent operations.

11.4 Place the filter membrane (6.5) on the filter support with the original orientation top side up.

11.5 Assemble the filtration apparatus (6.3).

11.6 Place a beaker (6.1) below the filter outlet and tare the balance (6.9).

11.7 With the ball valve closed, adjust the compressed air or nitrogen pressure gauge (6.8) to the specified level, according to the viscosity of the oil. The required pressures, ±5 kPa, are:

ISO viscosity grades (VG) less than 32	50 kPa
ISO viscosity grades (VG) of 32 and 46	100 kPa
ISO viscosity grades (VG) of 68 and 100	200 kPa

11.8 Start the balance data acquisition system for dynamic weighing.

11.9 Verify that time and mass measurements are being collected.

11.10 Shake the test fluid by inverting the sample container sharply 30 times in 60 s ± 10 s. Each inversion shall be completed by a distinct snap.

11.11 Weigh 265 g ± 1 g of sample into the 500 mL glass bottle (6.2).

11.12 Immediately pour the entire sample into the filter funnel, seal the lid and attach the compressed air or nitrogen hose.

11.13 Open the ball valve and verify that the correct pressure is maintained.

11.14 Mass flow rate measurements begin when the first drop of oil is registered on the analytical balance.

11.15 Verify that time and weight measurements are being collected.

11.16 Discontinue the test if the time to T_M or T_{240} exceeds 7200 s (2 hours).

11.17 After the time to the highest required mass (T_{240}) has been recorded, close the ball valve and compressed air supply valve, depressurize the apparatus, remove the air supply line and stop the dynamic weighing system.

11.18 Visually inspect the membrane filter for homogeneity of coloration. Repeat the determination if the color of the membrane filter is visually significantly uneven.

12. Calculation or Interpretation of Results

12.1 Process the dynamic mass values using a moving average low-pass filter with a cutoff frequency between 1.5 Hz and 2 Hz.

NOTE 7—Moving average lengths for different sample rate frequencies are provided below:

Sample Rate, Hz	Length, N	Cutoff Frequency, Hz
10	3	1.57
20	5	1.81
30	8	1.67
40	10	1.78

12.2 Record the time in seconds corresponding to an average filtrate mass ≥ 8.0 g, 40.0 g, 160.0 g, and 240.0 g (T_8, T_{40}, T_{160}, and T_{240}).

12.3 Calculate T_M using the following equation:

$$T_m = 6(T_{40} - T_8) + T_8 \quad (1)$$

12.4 Determine the filtrate mass (M) at T_M based upon the tabulated balance outputs.

12.5 Calculate the Stage I filterability (F_I) using the following equation:

$$F_I = \frac{M - 8}{192} \times 100 \quad (2)$$

12.6 Calculate the Stage II filterability (F_{II}) from the equation:

$$F_{II} = \frac{2.5(T_{40} - T_8)}{T_{240} - T_{160}} \times 100 \quad (3)$$

13. Report

13.1 Calculate the mean Stage 1 and Stage II filterability indices for the three replicate tests.

13.2 If the mean value is ≥50, report the mean filterability index.

13.3 If the mean value is >100, report the filterability index as 100.

13.4 If the mean value is <50, report the filterability index as "Fail."

13.5 If the test was discontinued because the time to the highest required mass (either T_M or T_{240}) exceeded 7200 s (2 hours), report the result as "Unfilterable."

14. Precision and Bias

14.1 This test method has an interim repeatability precision only. An inter-laboratory study of this test method will be conducted and completed by 2026.

14.2 The interim repeatability precision statement for filterability index values ≥50 (13.2) was determined from five samples tested nine times each in the same laboratory under the repeatability requirements of Practice D6300. The Stage I repeatability standard deviation was determined to be 4.6. The Stage II repeatability standard deviation was determined to be 8.2. The difference between successive determined values,