Designation: D6371 – 17a

# Standard Test Method for Cold Filter Plugging Point of Diesel and Heating Fuels[1]

This standard is issued under the fixed designation D6371; 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 the determination of the cold filter plugging point (CFPP) temperature of diesel and domestic heating fuels using either manual or automated apparatus.

NOTE 1—This test method is technically equivalent to test methods IP 309 and EN 116.

1.2 The manual apparatus and automated apparatus are both suitable for referee purposes.

1.3 This test method is applicable to distillate fuels, including those containing a flow-improving or other additive, intended for use in diesel engines and domestic heating installations.

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 **WARNING**—Mercury has been designated by many regulatory agencies as a hazardous material that can cause central nervous system, kidney, and liver damage. Mercury, or its vapor, may be hazardous to health and corrosive to materials. Caution should be taken when handling mercury and mercury-containing products. See the applicable product Material Safety Data Sheet (MSDS) for details and EPA's website—http://www.epa.gov/mercury/faq.htm—for additional information. Users should be aware that selling mercury and/or mercury containing products in your state or country may be prohibited by law.

1.6 *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.* For specific warning statements, see Section 7.

1.7 *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]

D2500 Test Method for Cloud Point of Petroleum Products and Liquid Fuels

D4057 Practice for Manual Sampling of Petroleum and Petroleum Products

D4177 Practice for Automatic Sampling of Petroleum and Petroleum Products

D5771 Test Method for Cloud Point of Petroleum Products and Liquid Fuels (Optical Detection Stepped Cooling Method)

D5772 Test Method for Cloud Point of Petroleum Products and Liquid Fuels (Linear Cooling Rate Method)

D5773 Test Method for Cloud Point of Petroleum Products and Liquid Fuels (Constant Cooling Rate Method)

D7962 Practice for Determination of Minimum Immersion Depth and Assessment of Temperature Sensor Measurement Drift

E1 Specification for ASTM Liquid-in-Glass Thermometers

E644 Test Methods for Testing Industrial Resistance Thermometers

E2251 Specification for Liquid-in-Glass ASTM Thermometers with Low-Hazard Precision Liquids

E2877 Guide for Digital Contact Thermometers

2.2 *IP Standards:*[3]

IP 309 Diesel and domestic heating fuels—Determination of cold filter plugging point

Specifications for IP Standard Thermometers

2.3 *ISO Standards:*[4]

IP 3310 Test sieves—Technical requirements and testing—Part 1: Metal cloth

[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 D02.07 on Flow Properties.

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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 Energy Institute, 61 New Cavendish St., London, WIG 7AR, U.K., http://www.energyinst.org.uk.

[4] Available from American National Standards Institute (ANSI), 25 W. 43rd St., 4th Floor, New York, NY 10036, http://www.ansi.org.

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

2.4 *European Standards:*[5]
EN 116 Diesel and domestic heating fuels—Determination of cold filter plugging point

## 3. Terminology

3.1 *Definitions:*

3.1.1 *digital contact thermometer (DCT), n*—an electronic device consisting of a digital display and associated temperature sensing probe.

3.1.1.1 *Discussion*—This device consists of a temperature sensor connected to a measuring instrument; this instrument measures the temperature-dependent quantity of the sensor, computes the temperature from the measured quantity, and provides a digital output. This digital output goes to a digital display and/or recording device that may be internal or external to the device. These devices are sometimes referred to as a "digital thermometer."

3.1.1.2 *Discussion*—PET is an acronym for portable electronic thermometers, a subset of digital contact thermometers (DCT).

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *certified reference material, n*—a stable petroleum product with a method-specific nominal CFPP value established by a method-specific interlaboratory study following RR:D02-1007[6] guidelines or ISO Guides 34 and 35.[4]

3.2.2 *cold filter plugging point, n*—highest temperature, expressed in multiples of 1 °C, at which a given volume of fuel fails to pass through a standardized filtration device in a specified time when cooled under the conditions prescribed in this test method.

## 4. Summary of Test Method

4.1 A specimen of the sample is cooled under specified conditions and, at intervals of 1 °C, is drawn into a pipet under a controlled vacuum through a standardized wire mesh filter. The procedure is repeated, as the specimen continues to cool, for each 1 °C below the first test temperature. Testing is continued until the amount of wax crystals that have separated out of solution is sufficient to stop or slow down the flow so that the time taken to fill the pipet exceeds 60 s or the fuel fails to return completely to the test jar before the fuel has cooled by a further 1 °C.

4.2 The indicated temperature at which the last filtration was commenced is recorded as the CFPP.

## 5. Significance and Use

5.1 The CFPP of a fuel is suitable for estimating the lowest temperature at which a fuel will give trouble-free flow in certain fuel systems.

5.2 In the case of diesel fuel used in European light duty trucks, the results are usually close to the temperature of failure in service except when the fuel system contains, for example, a paper filter installed in a location exposed to the weather or if the filter plugging temperature is more than 12 °C below the cloud point value in accordance with Test Method D2500, D5771, D5772, or D5773. Domestic heating installations are usually less critical and often operate satisfactorily at temperatures somewhat lower than those indicated by the test results.

5.3 The difference in results obtained from the sample *as received* and after heat treatment at 45 °C for 30 min can be used to investigate complaints of unsatisfactory performance under low temperature conditions.

## 6. Apparatus

6.1 *Manual Apparatus:*

6.1.1 The apparatus, as detailed in 6.1.2 – 6.1.13, shall be arranged as shown in Fig. 1.

6.1.2 *Test Jar,* cylindrical, of clear glass, flat bottomed, with an internal diameter of 31.5 mm ± 0.5 mm, a wall thickness of 1.25 mm ± 0.25 mm and a height of 120 mm ± 5 mm. The jar shall have a permanent mark at the 45 mL ± 1 mL level.

NOTE 2—Test jars of the required dimensions may be obtained by selection from jars conforming to Test Method D2500, which specifies a wider diameter tolerance.

6.1.3 *Jacket,* brass, watertight, cylindrical, flat bottomed, to be used as an air bath. It shall have an inside diameter of 45 mm ± 0.25 mm, outside diameter of 48 mm ± 0.25 mm, and a height of 115 mm ± 3 mm (see Fig. 2).

6.1.4 *Insulating Ring,* made from oil-resistant plastics or other suitable material, to be placed in the bottom of the jacket (see 6.1.3) to provide insulation for the bottom of the test jar. It shall fit closely inside the jacket and have a thickness of 6 mm + 0.3 mm - 0.0 mm.

6.1.5 *Spacers* (two), approximately 5 mm thick, made of oil-resistant plastics or other suitable material, to be placed as shown in Fig. 1 around the test jar (see 6.1.2) to provide insulation for the test jar from the sides of the jacket. The spacers shall fit closely to the test jar and closely inside the jacket. The use of incomplete rings, each with a 2 mm circumferential gap, will accommodate variations in test jar diameter. The spacers and insulating ring may be made as a single part as shown in Fig. 3.

6.1.6 *Supporting Ring,* of oil resistant plastics or other suitable non-metallic, non-absorbent, oil-resistant material, used to suspend the jacket (see 6.1.3) in a stable and upright position in the cooling bath and to provide a concentric location for the stopper (see 6.1.7). A design is shown in Fig. 4 for guidance, but this design may be modified to suit the cooling bath.

6.1.7 *Stopper,* of oil-resistant plastics or other suitable nonmetallic, nonabsorbent, oil-resistant material, to fit the test jar and the support ring as shown in Fig. 5. It shall have three holes to accommodate the pipet (see 6.1.8) and the thermometer (see 6.1.9) and to allow venting of the system. If necessary, when using the high-range thermometer (see 6.1.9), the upper part of the stopper shall have an indentation to permit the thermometer (see 6.1.9) to be read down to a temperature of –30 °C. A pointer shall be fitted to the upper surface of the stopper to facilitate location of the thermometer in relation to

[5] Available from European Committee for Standardization (CEN), 36 rue de Stassart, B-1050, Brussels, Belgium, http://www.cenorm.be.

[6] Supporting data have been filed at ASTM International Headquarters and may be obtained by requesting Research Report RR:D02-1007. Contact ASTM Customer Service at service@astm.org.

the bottom of the test jar. A spring wire clip shall be used to retain the thermometer in the correct position.

6.1.8 *Pipet with Filter Unit:*

6.1.8.1 *Pipet,* of clear glass with a calibration mark corresponding to a contained volume of 20 mL ± 0.2 mL at a point 149 mm ± 0.5 mm from the bottom of the pipet (see Fig. 6). It shall be connected to the filter unit (see 6.1.8.2).

6.1.8.2 *Filter Unit* (see Fig. 7), containing the following elements:

*(1) Brass Body*, with a threaded cavity that houses the wire mesh holder. The cavity shall be fitted with an O-ring of oil-resistant plastics. The internal diameter of the central tube shall be 4 mm ± 0.1 mm.

*(2) Brass Screw Cap*, to connect the upper part of the body of the filter unit (see 6.1.8.2) to the lower part of the pipet (see 6.1.8.1) to ensure a leak-free joint. An example of satisfactory connection is shown in Fig. 7.

*(3) Disc*, 15 mm ± 0.1 mm diameter, of plain weave stainless steel wire mesh gauze with a nominal aperture size of 45 µm. The nominal diameter of the wire shall be 32 µm, and the tolerance for the size of an individual aperture shall be as follows:

No aperture size shall exceed the nominal size by more than 22 µm.

The average aperture size shall be within ± 3.1 µm of the nominal size.

Not more than 6 % of the apertures shall be above the nominal size by more than 13 µm.

*(4) Filter Holder of Brass*, in which the disc of wire mesh gauze (see 6.1.8.2 (*3*)) is firmly clamped by a retaining ring pressed into the filter holder. The diameter of the exposed part of the gauze shall be 12 mm + 0.1 mm – 0.0 mm (see Fig. 8).

*(5) Brass Cylinder*, threaded on the outside, that can be screwed into the cavity of the body (see 6.1.8.2 (*1*)) to clamp the filter holder (see 6.1.8.2 (*4*)) against the O-ring (6.1.8.2 (*1*)), The lower end shall have four slots to allow the specimen to flow into the filter unit.

NOTE 3—The requirements for the wire mesh are taken from IP 3310, to which reference may be made for methods for testing the gauze.

6.1.9 *Temperature Measuring Device*—Either a liquid-in-glass thermometer as described in 6.1.9.1 or a digital contact thermometer (DCT) meeting the requirements described in 6.1.9.2.

6.1.9.1 *Liquid-in-glass Thermometers,* having ranges shown below and conforming to the requirements prescribed in Specifications E1 or E2251, or Specifications for IP Standard Thermometers.

| Thermometer | Temperature Range | Thermometer Number | |
|---|---|---|---|
| | | ASTM | IP |
| High-range for CFPP down to –30 °C | –38 °C to +50 °C | 5C, S5C | 1C |
| Low-range from CFPP below –30 °C | –80 °C to +20 °C | 6C | 2C |
| Cooling bath | –80 °C to +20 °C | 6C | 2C |

6.1.9.2 Digital contact thermometer requirements:

| Parameter | Requirement |
|---|---|
| DCT | Guide E2877 Class F or better |
| Nominal Temperature Range[A] | –38 °C to +50 °C for CFPP down to –30 °C<br>–80 °C to +20 °C for CFPP below –30 °C<br>–80 °C to +20 °C for cooling bath |
| Display Resolution | 0.1 °C, minimum |
| Accuracy[B] | ±500 mK (±0.5 °C) for combined probe and sensor |
| Sensor Type | Platinum Resistance Thermometer (PRT) |
| Sensor Sheath[C] | 4.2 mm OD maximum |
| Sensor Length[D] | Less than 10 mm |
| Immersion Depth[E] | Less than 40 mm per Practice D7962. |
| Measurement Drift[E] | Less than 500 mK (0.5 °C) per year. |
| Response Time[E] | Less than or equal to 4 s per Footnote F[F] |
| Calibration Error | Less than 500 mK (0.5 °C) over the range of intended use. |
| Calibration Range | Consistent with temperature range of use |
| Calibration Data | Four data points evenly distributed over the calibration range that is consistent with the range of use. The calibration data is to be included in calibration report. |
| Calibration Report | From a calibration laboratory with demonstrated competency in temperature calibration which is traceable to a national calibration laboratory or metrology standards body. |

[A]The nominal temperature range may be different than the values shown provided the calibration and accuracy criteria are met.
[B]Accuracy is the combined accuracy of the DCT unit which is the display and sensor.
[C]Sensor sheath is the tube that holds the sensing element. The value is the outside diameter of the sheath segment containing the sensor element.
[D]The physical length of the temperature sensing element.
[E]As determined by Practice D7962 or an equivalent procedure.
[F]Response Time—The time for a DCT to respond to a step change in temperature. The response time is 63.2 % of the step change time as determined per Section 9 of Test Method E644. The step change evaluation begins at 20 °C ± 5 °C air to 77 °C ± 5 °C with water circulating at 0.9 m/s ± 0.09 m/s past the sensor.

NOTE 4—A DCT display mounted on the end to the probe's sheath is likely not suitable due to temperature exposure of the electronics. Consult manufacturer for temperature limitations.

NOTE 5—When making measurements below –40 °C with a PRT, it may be necessary to use a 1000 ohm sensor in order to obtain accurate measurements.

6.1.9.3 The DCT calibration drift shall be checked at least annually by either measuring the ice point or against a reference thermometer in a constant temperature bath at the prescribed immersion depth to ensure compliance with 6.1.9.2. See Practice D7962.

NOTE 6—When a DCT's calibration drifts in one direction over several calibration checks, it may be an indication of deterioration of the DCT.

6.1.10 *Cooling Bath:*

6.1.10.1 The type of cooling bath is optional, but it shall be of a shape and size suitable for containing the jacket (see 6.1.3) in a stable and upright position at the required depth.