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.

Designation: D1322 – 24

Designation: 598/23

Standard Test Method for Smoke Point of Kerosene and Aviation Turbine Fuel[1,2]

This standard is issued under the fixed designation D1322; 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.

This standard has been approved for use by agencies of the U.S. Department of Defense.

1. Scope*

1.1 This test method covers two procedures for determination of the smoke point of kerosene and aviation turbine fuel, a manual procedure and an automated procedure, which give results with different precision.

1.2 The automated procedure is the referee procedure.

1.3 The values stated in SI units are to be regarded as standard. No other units of measurement are included in this 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, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.5 *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:*[3]

D4057 Practice for Manual Sampling of Petroleum and Petroleum Products

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

D6299 Practice for Applying Statistical Quality Assurance and Control Charting Techniques to Evaluate Analytical Measurement System Performance

2.2 *Energy Institute Standard:*[4]

IP 367 Petroleum products—Determination and application of precision data in relation to methods of test

IP 598 Petroleum products—Determination of the smoke point of kerosene, manual and automated method

NOTE 1—Only IP 598 published in 2012 by the Institute of Petroleum (now Energy Institute) is equivalent to D1322; IP 57 is not equivalent.

3. Terminology

3.1 *Definitions:*

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

3.1.2 *aviation turbine fuel, n*—refined petroleum distillate, generally used as a fuel for aviation gas turbines.

3.1.2.1 *Discussion*—Different grades are characterized by volatility ranges, freeze point, and by flash point.

3.1.3 *kerosene, n*—refined petroleum distillate, boiling between 140 °C and 300 °C, generally used in lighting and heating applications.

3.1.3.1 *Discussion*—Different grades are characterized by volatility ranges and sulfur content.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *smoke point, n*—the maximum height, in millimetres, of a smokeless flame of fuel burned in a wick-fed lamp of specified design.

4. Summary of Test Method

4.1 The sample is burned in an enclosed wick-fed lamp that is calibrated against pure hydrocarbon blends of known smoke point. The maximum height of flame that can be achieved with the test fuel without smoking determined by the manual and automated apparatus is reported to the nearest 0.1 mm.

[1] This test method is under the jurisdiction of ASTM International Committee D02 on Petroleum Products, Liquid Fuels, and Lubricants and is the direct responsibility of ASTM Subcommittee D02.J0.03 on Combustion and Thermal Properties. The technically equivalent standard as referenced is under the jurisdiction of the Energy Institute Subcommittee SC-B-10.

Current edition approved March 1, 2024. Published March 2024. Originally approved in 1954. Last previous edition approved in 2023 as D1322 – 23. DOI: 10.1520/D1322-24.

[2] This test method has been developed through the cooperative effort between ASTM and the Energy Institute, London. ASTM and IP standards were approved by ASTM and EI technical committees as being technically equivalent but that does not imply both standards are identical.

[3] 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.

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

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

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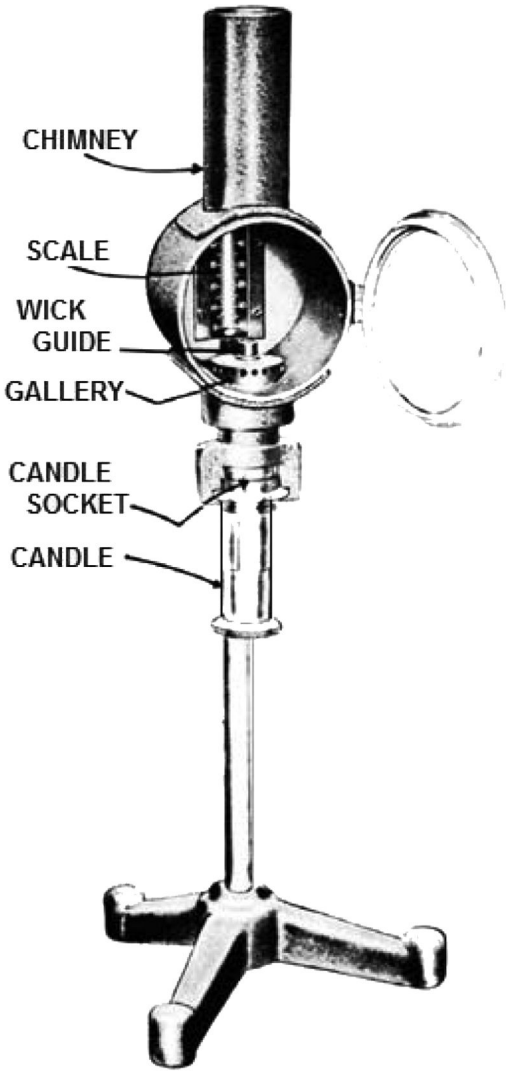

FIG. 1 Smoke Point Lamp (Manual)

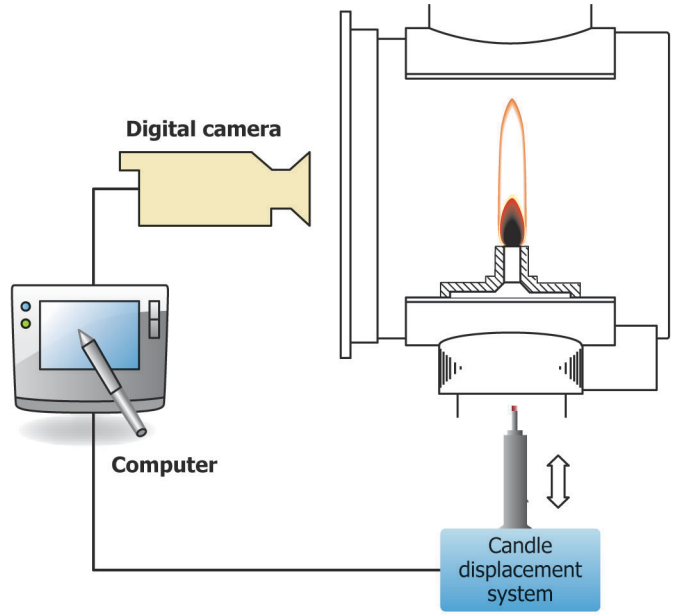

FIG. 2 Smoke Point Principle (Automated)

5. Significance and Use

5.1 This test method provides an indication of the relative smoke producing properties of kerosenes and aviation turbine fuels in a diffusion flame. The smoke point is related to the hydrocarbon type composition of such fuels. Generally the more aromatic the fuel the smokier the flame. A high smoke point indicates a fuel of low smoke producing tendency.

5.2 The smoke point is quantitatively related to the potential radiant heat transfer from the combustion products of the fuel. Because radiant heat transfer exerts a strong influence on the metal temperature of combustor liners and other hot section parts of gas turbines, the smoke point provides a basis for correlation of fuel characteristics with the life of these components.

6. Apparatus

6.1 *Smoke Point Lamp (Manual),* as shown in Fig. 1 and described in detail in Annex A1.

6.2 *Smoke Point Lamp (Automated)*[5,6], in addition to the basic components described in Annex A1, as shown in Fig. 2, automated units also shall be equipped with a digital camera connected to a computer to analyze and record the height of the flame, a candle displacement system to adjust the height of the flame, and a barometric pressure acquisition system associated to a calibration database to select the right calibration value for the automatic calculation of the correction factor defined in 10.1.2.

6.2.1 The digital camera associated to its dedicated software shall have a minimum resolution of 0.05 mm for the flame height measurement.

6.2.2 Due to the vastly superior resolution of the digital camera compared to the human eye, smoke point shall be measured by the automated unit when available. In case of dispute between results from manual and automated methods, the referee shall be considered the automated method.

6.3 *Barometer*—With accuracy of ±0.5 kPa.

6.4 *Wick,* of woven solid circular cotton of ordinary quality, having the following characteristics:

Casing	17 ends, 66 tex by 3
Filling	9 ends, 100 tex by 4
Weft	40 tex by 2
Picks	6 per centimetre

6.5 *Pipettes or Burettes,* Class A.

[5] The sole source of supply of the automated apparatus known to the committee at this time is model SP20 (current model in production), available from AD Systems, 5 Allée de Cindais, 14320 Saint-André-sur-Orne, France. 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.

[6] The legacy model SP10 may also be used, but with limited support by the manufacturer. Supporting data on the different models have been filed at ASTM International Headquarters and may be obtained by requesting Research Report RR:D02-2060. Contact ASTM Customer Service at service@astm.org.

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TABLE 1 Reference Fuel Blends

Standard Smoke Point at 101.3 kPa	Toluene	2,2,4-trimethylpentane
mm	% (V/V)	% (V/V)
14.7	40	60
20.2	25	75
22.7	20	80
25.8	15	85
30.2	10	90
35.4	5	95
42.8	0	100

7. Reagents and Materials

7.1 *Toluene,* ASTM Reference Fuel grade or ACS Reagent grade ≥99.5 %. (**Warning—**Flammable, vapor harmful. (See Annex A2.1.))

7.2 *2,2,4-trimethylpentane (isooctane),* minimum purity 99.75 % by mass. (**Warning—**Flammable, vapor harmful. (See Annex A2.2.))

7.3 *Methanol (methyl alcohol),* anhydrous. (**Warning—**Flammable, vapor harmful. (See Annex A2.3.))

7.4 *Reference Fuel Blends,* appropriate to the fuels under test, prepared accurately from toluene and 2,2,4-trimethylpentane, in accordance with the compositions given in Table 1, by means of calibrated burettes or pipettes, with a precision of ±0.2 % or better.

7.5 *Heptane,* minimum purity 99 % by mass. (**Warning—**Extremely flammable, vapor harmful if inhaled. (See Annex A2.4.))

8. Sampling and Preparation of Samples

8.1 It is recommended samples shall be taken by the procedures described in Practice D4057. Use the sample as received. Allow all samples to come to ambient temperature (20 °C ± 5 °C), without artificial heating. If the sample is hazy or appears to contain foreign material, filter through qualitative filter paper.

9. Preparation of Apparatus

Manual Apparatus

9.1 Place the lamp in a vertical position in a room where it can be completely protected from drafts. Carefully inspect each new lamp to ensure that the air holes in the gallery and the air inlets to the candle holder are all clean, unrestricted, and of proper size. The gallery shall be so located that the air holes are completely unobstructed.

NOTE 2—Slight variations in these items all have a marked effect on the precision of the result obtained.

9.1.1 If the room is not completely draft-free, place the lamp in a vertical position in a box constructed of heat-resistant material (not containing asbestos), open at the front. The top of the box shall be at least 150 mm above the top of the chimney and the inside of the box painted dull black.

Automated Apparatus

9.2 Prepare the apparatus according to the manufacturer's instructions.

9.3 Extract all wicks, either new or from a previous determination, for at least 25 cycles in an extractor, using a mixture of equal volumes of toluene and anhydrous methanol. Allow the wicks to dry partially in a hood before placing in the oven, or use a forced-draft and explosion-proof oven for drying wicks, or both. Dry for 30 min at 100 °C to 110 °C, and store in a dessicator until used.

9.3.1 Extracted wicks are commercially available and may be used, provided that they have been certified as being extracted by the procedure outlined in 9.3. Store purchased extracted wicks in a desiccator over desiccant until use. After use, extract these wicks as in 9.3 before using again.

10. Calibration of Apparatus

Manual Apparatus

10.1 Confirm calibration of the apparatus in accordance with 10.1.3 or calibrate, if needed, in accordance with 10.1.1 prior to first use of the day. Recalibrate when there has been a change in the apparatus or operator, or when a change of more than 0.7 kPa occurs in the barometric pressure reading.

10.1.1 Calibrate the apparatus by testing two of the reference fuel blends specified in 7.4, using the procedure specified in Section 11 and, if possible, bracketing the smoke point of the sample. If this is not possible, use the two test blends having their smoke points nearest to the smoke point of the sample.

10.1.2 Determine the correction factor, *f*, for the apparatus from the equation:

$$f = \frac{(A\ s / A\ d) + (B\ s / B\ d)}{2} \quad (1)$$

where:

As = the standard smoke point of the first reference fuel blend,
Ad = the smoke point determined for the first reference fuel blend,
Bs = the standard smoke point of the second reference fuel blend, and
Bd = the smoke point determined for the second reference fuel blend.

If the smoke point determined for the test fuel exactly matches the smoke point determined for a reference fuel blend, use as the second bracketing reference fuel the reference fuel blend with the next higher smoke point, if there is one. Otherwise, use the one with the next closest smoke point.

10.1.3 An alternative approach to confirm calibration of the apparatus is for each operator to run a control sample each day the apparatus is in use. Record the results and compare the average from the database of the control sample using control charts or equivalent statistical techniques. If the difference exceeds the control limits or when new apparatus is used, then the apparatus must be recalibrated.

Automated Apparatus

10.2 The apparatus shall have a calibration database for the storage of the reference fuel blends values specified in Table 1. Each calibration test performed with the reference fuel blends

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shall be stored in this database in addition with the barometric pressure observed at the moment the calibration was performed.

10.2.1 The apparatus shall have the capability to automatically calculate the correction factor *f* according to Eq 1 by automatically selecting in its calibration database the reference fuel blends values specified in Table 1, using the procedure specified in Section 11 and the calculation specified in Section 12 and, if possible, bracketing the smoke point of the sample. If this is not possible, it shall use the two test blend results having their smoke points nearest to the smoke point of the sample.

NOTE 3—The digital camera and the associated software replace the operator eyes for the observation of the flame. Consequently it is not necessary to recalibrate the apparatus when there has been a change in the operator.

10.2.2 Calibrate the apparatus by testing the seven reference fuel blends specified in 7.4, using the procedure specified in Section 11. For more details, refer to the instruction manual of the apparatus manufacturer.

10.2.3 At regular intervals of not more than seven days or when there has been a change in the apparatus, verify that the apparatus is performing properly by using a quality control (QC) sample that is representative of the fuel(s) routinely tested by the laboratory to confirm that the apparatus is in statistical control following the guidelines given in Practice D6299. If the difference exceeds the control limits, recalibrate the apparatus.

11. Procedure

11.1 Soak a piece of extracted and dried wick, not less than 125 mm long, in the sample and place it in the wick tube of the candle (Fig. 3). Carefully ease out any twists arising from this operation. In cases of dispute, or of referee tests, always use a new wick, prepared in the manner specified in 9.3.

11.1.1 It is advisable to resoak the burning-end of the wick in the sample after the wick is inserted in the wick tube.

11.2 Introduce as near to 20 mL of the prepared sample as available, but not less than 10 mL, at room temperature, into the clean, dry candle.

11.3 Place the wick tube in the candle and screw home. Take care that the candle air vent is free from fuel. If a wick-trimmer assembly is not being used, cut the wick horizontally and trim it free of frayed ends so that 6 mm projects from the end of the candle. Use a clean razor blade or other sharp instrument.

11.3.1 Some razor blades have a protective coating; in such cases, remove the coating with a solvent before using the blade.

11.3.2 An alternative method of preparing a wick free of twists and frayed ends utilizes a wick-trimmer assembly (Fig. 4). The wick-trimmer holder is inserted over the top of the wick tube (Fig. 5—Step 1) and the long-nosed triceps are inserted through the tube and holder (Fig. 5—Step 2). The wick is grasped (Fig. 5—Step 3) and carefully pulled through the tube without twisting (Fig. 5—Step 4). The tube is then inserted into the candle and screwed home (Fig. 5—Step 5). A new, clean, sharp razor is used to cut the wick at the face of the holder and remove wisps and frayed ends (Fig. 5—Step 6). When the holder is removed, the wick will be at the correct height in the tube (Fig. 5—Step 7).

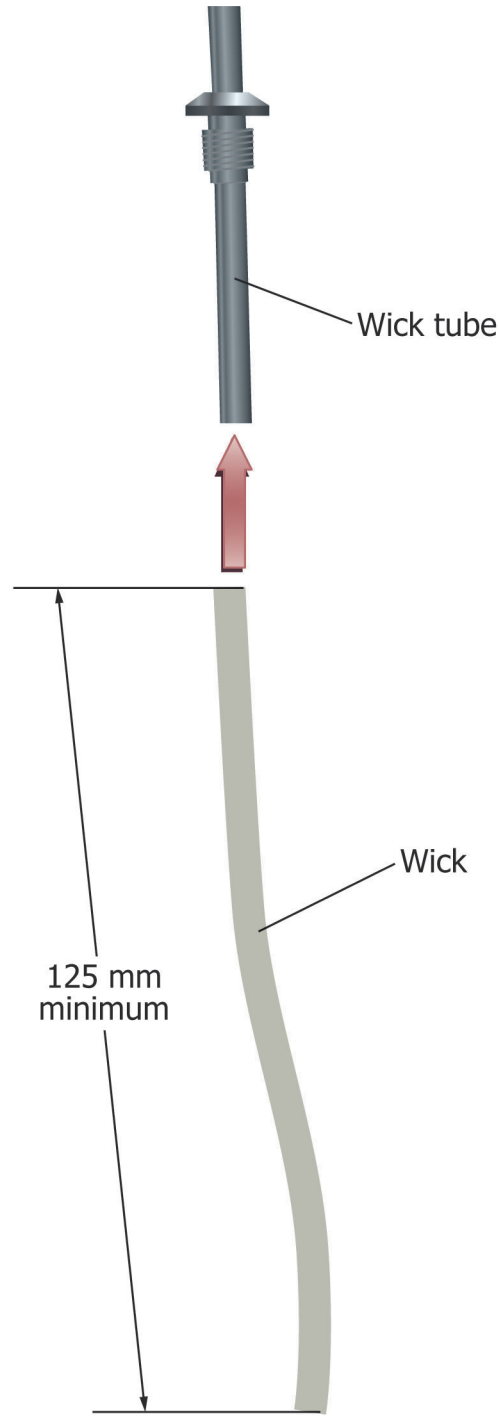

FIG. 3 Wick Tube

Manual Apparatus

11.4 Insert the candle into the lamp.

11.5 Light the candle and adjust the wick so that the flame is approximately 10 mm high and allow the lamp to burn for 5 min. (See Fig. 6 and Fig. 7.) Raise the [illegible] smoky

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