Designation: D7945 – 26

Standard Test Method for Determination of Dynamic Viscosity and Derived Kinematic Viscosity of Liquids by Constant Pressure Viscometer[1]

This standard is issued under the fixed designation D7945; 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 measurement of dynamic viscosity and density for the purpose of derivation of kinematic viscosity of petroleum liquids, both transparent and opaque. The kinematic viscosity, ν, in this test method is derived by dividing the dynamic viscosity, η, by the density, ρ, obtained at the same test temperature. This test method also calculates the temperature at which petroleum liquids attain a specified kinematic viscosity using Practice D341.

1.2 The result obtained from this test method is dependent upon the behavior of the sample and is intended for application to liquids for which primarily the shear stress and shear rate are proportional (Newtonian flow behavior).

1.3 The range of kinematic viscosity covered by this test method is from 0.5 mm^2/s to 1000 mm^2/s in the temperature range between –40 °C to 120 °C; however the precision has been determined only for fuels and oils in the range of 2.06 mm^2/s to 476 mm^2/s at 40 °C and 1.09 mm^2/s to 107 mm^2/s at 100 °C (as stated in Section 12 on Precision and Bias). For jet fuels, the precision of kinematic viscosity has been determined in the range of 2.837 mm^2/s to 6.809 mm^2/s at –20 °C and 5.071 mm^2/s to 16.279 mm^2/s at –40 °C (as stated in Section 12 on Precision and Bias), and the precision of the temperature at 12 mm^2/s (cSt) has been determined in the range of –34.6 °C to –59.7 °C (as stated in Section 13 on Precision and Bias). The precision has only been determined for those materials, viscosity ranges, and temperatures as indicated in Section 12 on Precision and Bias. The test method can be applied to a wider range of materials, viscosity, and temperature. For materials not listed in Section 12 on Precision and Bias, the precision and bias may not be applicable.

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]

D341 Practice for Viscosity-Temperature Equations and Charts for Liquid Petroleum or Hydrocarbon Products

D445 Test Method for Kinematic Viscosity of Transparent and Opaque Liquids (and Calculation of Dynamic Viscosity)

D1655 Specification for Aviation Turbine Fuels

D2162 Practice for Basic Calibration of Master Viscometers and Viscosity Oil Standards

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

D6708 Practice for Statistical Assessment and Improvement of Expected Agreement Between Two Test Methods that Purport to Measure the Same Property of a Material

D7566 Specification for Aviation Turbine Fuel Containing Synthesized Hydrocarbons

2.2 *ISO Standards:*[3]

ISO 5725 Accuracy (Trueness and Precision) of Measurement Methods and Results

[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 www.astm.org/contact. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

[3] Available from American National Standards Institute (ANSI), 1180 Avenue of the Americas, 10th Floor, New York, NY 10036, http://www.ansi.org.

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

ISO/IEC 17025 General Requirements for the Competence of Testing and Calibration Laboratories

3. Terminology

3.1 *Definitions:*

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

3.1.2 *density, n*—mass per unit volume.

3.1.3 *dynamic viscosity (η), n*—the ratio between the applied shear stress and rate of shear of a liquid at a given temperature.

3.1.3.1 *Discussion*—It is sometimes called the coefficient of dynamic viscosity or, simply, viscosity. Thus, dynamic viscosity is a measure of the resistance to flow or to deformation of a liquid under external shear forces.

3.1.3.2 *Discussion*—The term dynamic viscosity can also be used in a different context to denote a frequency-dependent quantity in which shear stress and shear rate have a sinusoidal time dependence.

3.1.4 *kinematic viscosity, n*—the ratio of the dynamic viscosity (η) to the density (ρ) of a liquid at a given temperature.

3.1.4.1 *Discussion*—For gravity flow under a given hydrostatic head, the pressure head of a liquid is proportional to its density (ρ). Therefore, the kinematic viscosity (ν) is a measure of the resistance to flow of a liquid under gravity.

4. Summary of Test Method

4.1 A test specimen is introduced into the measuring cells, which are controlled at a specified and known temperature. The measuring cells consist of a horizontal capillary tube with optical sensors and an oscillating U-tube densitometer. The dynamic viscosity is determined from the flow time of the test specimen along the capillary under a constant pressure of compressed air in conjunction with calculations. The density is determined by the oscillation frequency of the U-tube in conjunction with calculations. The kinematic viscosity is calculated by dividing the dynamic viscosity by the density.

4.2 Based on the calculations of at least two kinematic viscosities at different temperatures of a test specimen, the temperature at which the test specimen attains a specified kinematic viscosity is calculated and reported according to Practice D341, Annex A1.

5. Significance and Use

5.1 Many petroleum products are used as lubricants and the correct operation of the equipment depends upon the appropriate viscosity of the liquid being used. In addition, the viscosity of many petroleum fuels is important for the estimation of optimum storage, handling, and operational conditions. Thus, the accurate determination of viscosity is essential to many product specifications.

5.2 Density is a fundamental physical property that can be used in conjunction with other properties to characterize both the light and heavy fractions of petroleum and petroleum products and in this test method is used for the calculation from dynamic to kinematic viscosity.

6. Apparatus

6.1 *Constant Pressure Viscometer:*[4,5]

6.1.1 *Viscosity Measurement*—The Constant Pressure viscometer uses the Hagen-Poiseuille principle of capillary flow to determine the viscosity. A length of capillary tube is enclosed horizontally in a thermal block maintained at a constant temperature by thermoelectric coolers/heaters. The

[4] The Constant Pressure viscometer is covered by a patent. Interested parties are invited to submit information regarding the identification of an alternative to this patented item to the ASTM International headquarters. Your comments will receive careful consideration at a meeting of the responsible technical committee, which you may attend.

[5] The sole source of supply of the apparatus known to the committee at this time is PhasePSL, 11168 Hammersmith Gate, Richmond, BC Canada. 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.

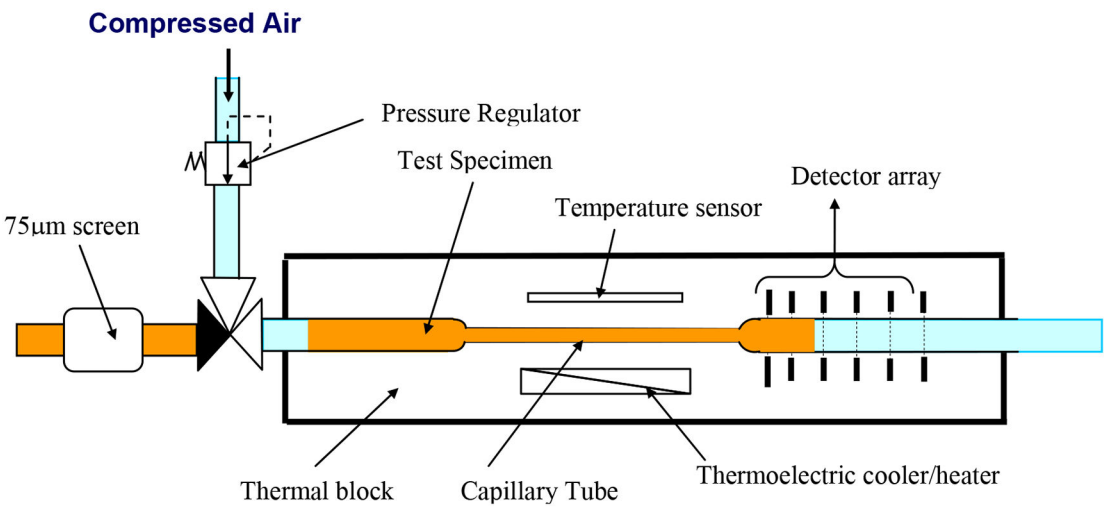

FIG. 1 Viscosity Block