INTERNATIONAL

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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~~ 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.

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 to 107 mm^2/s at 100 °C (as stated in Section 12 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 and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

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

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

D6300 Practice for Determination of Precision and Bias Data for Use in Test Methods for Petroleum Products 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

2.2 *ISO Standards:*[3]

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

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

3. Terminology

3.1 *Definitions:*

3.1.1 *density (ρ), n*—mass per unit volume.

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

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

3.1.2.1 *Discussion—*

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

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.

3.1.2.2 *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.

3.1.3 *kinematic viscosity (ν), n*—the ratio of the dynamic viscosity (η) to the density (ρ) of a liquid.

3.1.3.1 *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.

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 test specimen is driven to flow along the tube by a constant and regulated pressure of compressed air. The transit time of the test sample as it flows past an array of optical detectors is measured. (See Fig. 1.) The dynamic viscosity is proportional to the measured transit time.

6.1.1.1 *Pressure Control*—A pressure generating and regulating device able to maintain an air pressure between 6.89 kPa to 68.9 kPa (1 psi to 10 psi) used to drive a test specimen to flow along a capillary tube.

6.1.2 *Density Measurement*—Density is measured by a suitable method so to achieve the precision in kinematic viscosity as stated in the tables in Section 12. A U-shaped oscillating sample tube with a system for electronic excitation and frequency counting as described in the manufacturer's instructions is suitable. However, for this test method, the purpose of the density result is for the calculation from dynamic to kinematic viscosity.

6.1.3 *Temperature Control*—A thermal block surrounds the viscosity measuring cell so that both are at the same temperature. A thermoelectric heating and cooling system (see Fig. 1) ensures temperature stability of the block to be within ±0.01 °C from the set temperature.

6.2 *Autosampler,* for use in sample introduction process. The autosampler shall be designed to ensure the integrity of the test specimen prior to and during the analysis and be equipped to transfer a representative volume of test specimen into the measuring cells. The autosampler shall transfer the test specimen from the sample vial to the measuring cells of the apparatus without interfering with the integrity of the test specimen. The autosampler may have heating capability as a means to lower the viscosity of the sample for filling the measuring cells.

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[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.