Designation: ~~D7483 – 08~~ D7483 – 13

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

This standard is issued under the fixed designation D7483; 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 derivation of kinematic viscosity of liquids, such as new and in-service lubricating oils, by means of an oscillating piston viscometer.

1.2 This test method is applicable to Newtonian and non-Newtonian liquids; however the precision statement was developed using Newtonian liquids.

1.3 The range of dynamic viscosity covered by this test method is from 0.2 mPa·s to 20 000 mPa·s (which is approximately the kinematic viscosity range of 0.2 mm^2/s to 22 000 mm^2/s for new oils) in the temperature range between –40 to 190°C; however the precision has been determined only for new and used oils in the range of ~~1.434 mPa·s to 154.4 mPa·s at temperatures of 40 and 100°C (as stated in~~34 to 1150 mPa·s at 40°C, 5.7 to 131 mPa·s at 100°C, and 46.5 to 436 mm^2 ~~the precision section).~~/s at 40°C.

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
D4057 Practice for Manual Sampling of Petroleum and Petroleum Products
D4177 Practice for Automatic Sampling of Petroleum and Petroleum Products
D5967 Test Method for Evaluation of Diesel Engine Oils in T-8 Diesel Engine
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
D6792 Practice for Quality System in Petroleum Products and Lubricants Testing Laboratories

2.2 *ISO Standards:*[3]

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

2.3 *NIST Standard:*[4]

NIST Technical Note 1297 Guideline for Evaluating and Expressing the Uncertainty of NIST Measurement Results

3. Terminology

3.1 *Definitions:*

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

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[1] This test method is under the jurisdiction of ASTM Committee D02 on Petroleum Products 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 International Organization for Standardization (ISO), 1, ch. de la Voie-Creuse, Case postale 56, CH-1211, Geneva 20, Switzerland, http://www.iso.ch.

[4] Available from http://physics.nist.gov/ccu/Uncertainty/index.html.

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

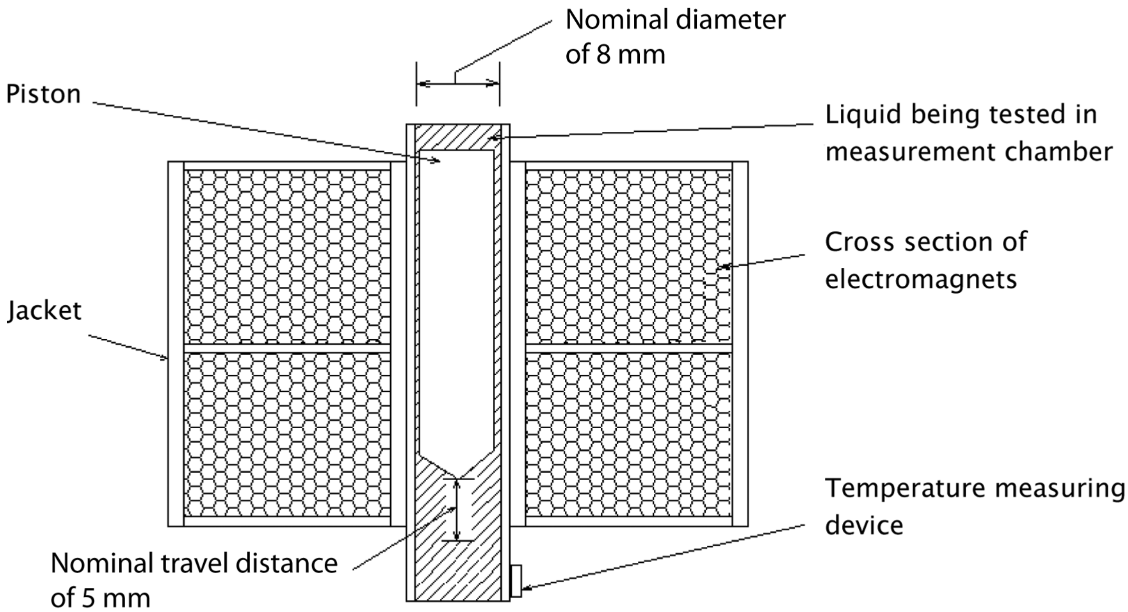

FIG. 1 Cross Sectional View of Measurement Chamber

3.1.1.1 *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.

3.1.1.2 *Discussion—*

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

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

3.1.2.1 *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.

3.1.3 *rate of shear (shear rate), n*— in liquid flow, the velocity gradient across the liquid.

3.1.4 *shear stress, n*—the force per unit area in the direction of the flow.

3.1.4.1 *Discussion—*

The SI unit for shear stress is the pascal (Pa).

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

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *oscillating piston viscometer, n*—a device that measures the travel time of a piston driven electromagnetically into stationary oscillating motion through a liquid at a controlled force in order to determine the dynamic viscosity of the liquid.

4. Summary of Test Method

4.1 A specimen of sample is placed in the thermally controlled measurement chamber where the piston resides. The piston is driven into oscillatory motion within the measurement chamber by a controlled magnetic field. Once the sample is at the test temperature, as determined by the temperature detector, the piston is propelled repeatedly through the liquid (by the magnetic field). A shear stress (ranging from 5 Pa to 750 Pa) is imposed on the liquid under test due to the piston travel. The dynamic viscosity is determined by measuring the average travel time of the piston. The kinematic viscosity is derived by additionally measuring the ratio between the up and down travel times. This information is then applied to a calibration curve using liquids of known viscosity to calculate the dynamic viscosity and kinematic viscosity of the liquid. See Fig. 1.

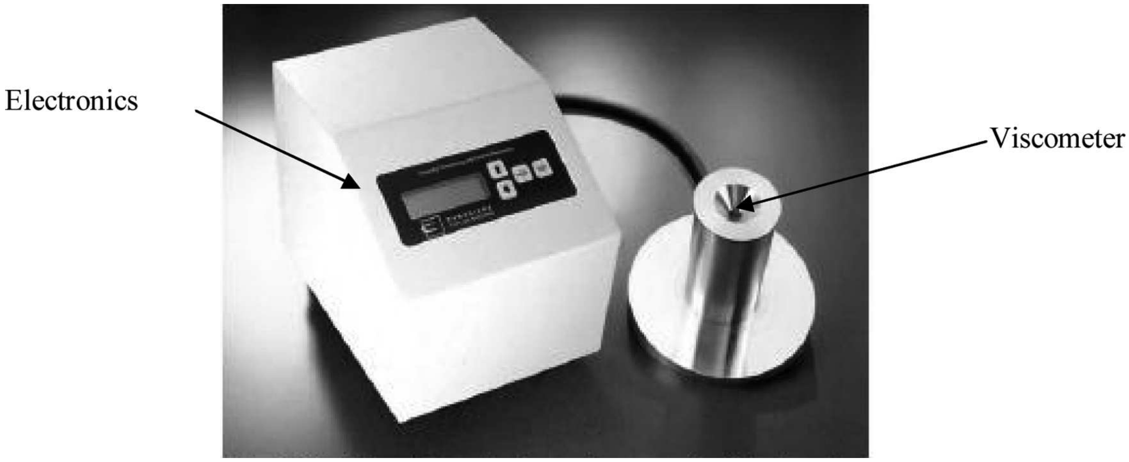

FIG. 2 Viscometer with Electronics

5. Significance and Use

5.1 Many petroleum products, as well as non-petroleum materials, are used as lubricants for bearings, gears, compressor cylinders, hydraulic equipment, etc. Proper operation of this equipment depends upon the viscosity of these liquids.

5.2 Oscillating piston viscometers allow viscosity measurement of a broad range of materials including transparent, translucent and opaque liquids. The measurement principle and stainless steel construction makes the Oscillating Piston Viscometer resistant to damage and suitable for portable operations. The measurement itself is automatic and does not require an operator to time the oscillation of the piston. The electromagnetically driven piston mixes the sample while under test. The instrument requires a sample volume of less than 5 mL and typical solvent volume of less than 10 mL which minimizes cleanup effort and waste.

6. Apparatus

6.1 *Oscillating Piston Viscometer:*[5,6]

6.1.1 The oscillating piston viscometer (see Fig. 2) comprises a measurement chamber and calibrated piston capable of measuring the dynamic viscosity within the limits of precision given in Section 16.

6.1.2 *Piston*—Free moving, magnetically driven body within a Oscillating Piston Viscometer which is used for measuring the viscosity of liquids. Individual pistons are sized to measure specific viscosity ranges by varying the sensor annulus. See Table 1 for the selection of the piston according to the viscosity range.

6.1.3 *Measurement Chamber*—Location within Oscillating Piston Viscometer where piston motion (through the liquid under test) occurs due to an imposed electromagnetic field. See Fig. 1.

6.1.4 *Electronics*—Capable of controlling the electromagnetic field to propel and detect the travel time of the piston with a discrimination of 0.01 s or better and uncertainty within ±0.07 %. The travel time is calibrated to be between 0.4 s and 60 s, at a distance of 5 mm.

6.1.5 *Temperature Controlled Jacket*—Sufficient for maintaining measurement chamber temperature within ±0.06°C.

6.1.6 *Temperature Measuring Device*—Industrial platinum resistance thermometer (IPRT) or equivalent sensor with a maximum permissible error of ±0.02°C. It is recommended, that the temperature measuring device be verified with an independent, calibrated temperature probe at the test temperature.

6.2 *Temperature Regulation System:*

6.2.1 Any liquid bath or thermoelectric means for regulating the jacket temperature.

6.2.2 The temperature control must be such that the temperature of the measurement chamber is held within ±0.06°C of the desired measurement temperature.

6.3 *Sample Introduction Mechanism*—A syringe, micropipette, or flow-through adapter for introducing between 3.2 mL and 5 mL, inclusive by pressure, into the measurement chamber.

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[5] The Oscillating Piston 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.

[6] The sole sources of supply for the apparatus known to the committee at this time is Cambridge Viscosity Inc., 101 Station Landing, Medford, MA 02155 (www.cambridgeviscosity.com). 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, which you may attend.