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# Standard Test Method for Kinematic Viscosity of Volatile and Reactive Liquids[1]

This standard is issued under the fixed designation D 4486; 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.

ε[1] NOTE—Footnote 4 was corrected editorially in December 1996.

## 1. Scope

1.1 This test method covers the measurement of kinematic viscosity of transparent, Newtonian liquids which because of their reactivity, instability, or volatility cannot be used in conventional capillary kinematic viscometers. This test method is applicable up to $2 \times 10^{-5}$ N/m$^2$ (2 atm) pressure and temperature range from − 53 to + 135°C (−65 to + 275° F).

1.1.1 For the measurement of the kinematic viscosity of other liquids, see Test Method D 445.

1.2 *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.* For specific precautionary statements, see 6.2, 6.3, and 6.4.

## 2. Referenced Documents

2.1 *ASTM Standards:*

D 445 Test Method for Kinematic Viscosity of Transparent and Opaque Liquids (and the Calculation of Dynamic Viscosity)[2]

D 2162 Test Method for Basic Calibration of Master Viscometers and Viscosity Oil Standards[2]

E 1 Specification for ASTM Thermometers[3]

## 3. Terminology

3.1 *Definitions of Terms Specific to This Standard:*

3.1.1 *viscosity*—the ratio between the applied shear stress and rate of shear.

3.1.1.1 *Discussion*—This ratio is called the coefficient of viscosity. The coefficient of viscosity (η) is thus a measure of the resistance to flow of the liquid. This is commonly called the viscosity of the liquid. The cgs unit of viscosity is the poise. P, which has the dimensions of dyne-seconds per square centimetre: the centipoise (0.01 poise) is frequently used. The SI unit of viscosity has the dimensions of newton second/metre$^2$, and is equivalent to 10 P.

3.1.2 *density*—the mass per unit volume of the liquid.

3.1.2.1 *Discussion*—The cgs unit of density (ρ) has the dimensions of grams per cubic centimetre. The SI unit of density has the dimensions of kilograms per cubic metre.

3.1.3 *kinematic viscosity*—The ratio of the viscosity to the density of the 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. For any particular viscometer, the time of flow of a fixed volume of liquid is directly proportional to η/ρ. This ratio is the kinematic viscosity coefficient (ν). The cgs unit of kinematic viscosity is the stoke and has the dimensions of centimetre squared per second: the centistoke (0.01 St) is frequently used. The SI unit of kinematic viscosity has the dimensions of metre$^2$/second, and is equivalent to $10^4$ St.

3.1.4 *vulnerable liquid*—a liquid which by reason of its volatility, instability or reactivity in the presence of air or any other specific gaseous medium may undergo physical or chemical changes that may affect its viscosity.

## 4. Summary of Test Method

4.1 The time is measured, in seconds, for a fixed volume of liquid to flow under gravity through the capillary of the viscometer under a reproducible driving head and at a closely controlled temperature. The kinematic viscosity is calculated from the measured flow time and the calibration constant of the viscometer.

## 5. Significance and Use

5.1 Kinematic viscosity is a physical property which is of importance in the design of systems in which flowing liquids are used or handled.

## 6. Apparatus

6.1 *Viscometer Thermostat*—Any transparent liquid or vapor bath of sufficient depth such that at no time during the measurement will any portion of the sample in the viscometer be less than 20 mm below the surface of the bath liquid or less than 20 mm above the bottom of the bath may be used. The temperature control must be such that for the range from 15 to 100°C (60 to 212°F) the temperature of the bath medium does not vary by more than 0.02°F (0.01°C) over the length of the viscometers, or between the position of each viscometer, or at the location of the thermometer. For temperatures outside this range, the variation must not exceed 0.05°F (0.03°C).

[1] This test method is under the jurisdiction of Committee D-2 on Petroleum Products and Lubricants and is the direct responsibility of Subcommittee D02.11 on Engineering Science of High Performance Fluids and Solids.

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[2] *Annual Book of ASTM Standards*, Vol 05.01.

[3] *Annual Book of ASTM Standards*, Vol 14.03.

6.2 *Temperature-Measuring Device*—Suitable liquid-in-glass Kinematic Viscosity Test Thermometers, covering the range of test temperatures indicated in Table 1, as listed in Specification E 1, make certain that they have been standardized before use (see 5.2). Any other thermometric device is permissible provided that the same accuracy can be obtained.

6.3 *Timing Device*—Any timing device may be used provided that the readings can be taken with a discrimination of 0.2 s or better, and that it has an accuracy within ±0.07 % when tested over intervals of 15 min.

6.3.1 Electrical timing devices may be used if the current frequency is controlled to an accuracy of 0.05 % or better. Alternating currents, as provided by some public power systems, are intermittently rather than continuously controlled. When used to actuate electrical timing devices, such control can cause large errors in viscosity flow measurements.

## 7. Reagents and Materials

7.1 *Viscosity Oil Standards*, conforming to ASTM viscosity oil standards having the approximate kinematic viscosity shown in Table 2. Certified kinematic viscosity values are compared by annual cooperative tests by a number of laboratories and are supplied with each portion.

7.2 *Chromic Acid (Cleaning Solution)*—(**Warning**—Causes severe burns. A recognized carcinogen. Strong oxidizer, contact with organic material may cause fire. Hygroscopic. See A1.2.)

**TABLE 1 Kinematic Viscosity Test Thermometers**[A]

| Test Temperature[B] Scale Error[B] | | Thermometer Number | |
|---|---|---|---|
| °F | °C | ASTM[C] | IP[D] |
| −65 | −53.9 | 74F | 69F, C |
| −60 to − 35 | −51 to − 35 | 43F | 65F, C |
| −40 | −40 | 73F, C | 68F, C |
| 0 | −17.8 | 72F | 67F, C |
| 32 | 0 | | 33F, C |
| 68 and 70 | 20 and 21.1 | 44F, C | 29F, C |
| 77 | 25 | 45F, C | 30F, C |
| 86 | 30 | 118F, C | |
| 100 | 37.8 | 28F | 31F, C |
| | 40 | 120C | |
| 122 | 50 | 46F, C | 66F, C |
| 130 | 54.4 | 29F | 34F, C |
| 140 | 60 | 47F, C | 35F, C |
| 180 | 82.2 | 48F | 90F, C |
| 200 | 93.3 | | 36F, C |
| 210 and 212 | 98.9 and 100 | 30F | 32F, C |
| | 100 | 121C | |
| 275 | 135 | 110F, C | |
| | −20 | | 99C |
| | 80 | | 100C |
| | 40 | 120C | 92C |

[A] The smallest graduation of the Fahrenheit thermometers is 0.1°F and for the Celsius thermometers is 0.05°C except for ASTM 43F and IP 65F for which it is 0.2°F.

[B] Scale error for the Fahrenheit thermometers is not to exceed ±0.2°F (except for ASTM 110F which is ±0.3°F); for the Celsius thermometers it is ±0.1°C. These scale errors are required to apply only at the given test temperature.

[C] Complete construction detail is given in Specification E 1.

[D] Complete construction detail is given in Part 1 of IP Standards for Petroleum and its Products.

7.2.1 Other suitable cleaning solutions[4] are available. In referee testing situations, glassware shall be cleaned with a cleaning solution agreed upon by the parties involved.

7.3 *Acetone*—(**Warning**—Extremely flammable. Vapors may cause flash fire. See Annex A1.3.)

7.4 *Hydrochloric Acid (Concentrated)*—(**Warning**—Poison. Corrosive. May be fatal if swallowed. Liquid and vapor cause severe burns. Harmful if inhaled. See Annex A1.4.)

## 8. Standardization

8.1 *Viscometers*—Only calibrated viscometers standardized as described in Annex A2 shall be used.

8.2 *Thermometers*—Liquid-in-glass thermometers shall be checked to the nearest 0.01°C (0.02°F) by direct comparison with a suitable standardized thermometer. Kinematic Viscosity Test Thermometers shall be standardized at "total immersion" which means immersion to the top of the mercury column, with the remainder of the stem and the expansion chamber at the top of the thermometer exposed to room temperature; do not submerge the expansion bulb at the top of the thermometer. It is essential that the ice point of standardized thermometers be determined periodically and the official corrections be adjusted to conform to the change in ice point.

8.3 *Timers*—Standard time signals available in some nations may be used in checking the accuracy of timing devices. In the United States of America, time signals, as broadcast by the National Bureau of Standards, Station WWV, Washington, D. C. 20234, at 2.5, 5, 10, 15, 20, 25, 30, and 35 MHz are a convenient and primary standard reference for calibrating timing devices; the signals are broadcast 24 h daily. Station CHU from Ottawa, Canada, at 3.330, 7.335, and 14.670 MHz or Station MSF at Rugby, United Kingdom, at 2.5, 5, and 10 MHz may be received better in some locations.

8.4 Viscosity standards may also be used to check the over-all kinematic viscosity procedure in a laboratory. If the measured kinematic viscosity does not agree within ±0.35 % of the certified value, each step in the procedure should be rechecked, including thermometer and viscometer calibration to locate source of error.

## 9. Cleaning of Viscometer

9.1 Between successive determinations, clean the viscometer thoroughly by several rinsings with an appropriate solvent completely miscible with the sample, followed by a completely volatile solvent. Dry the viscometer with vacuum attached to Tube *A* or by placing viscometer in a vacuum oven.

9.2 Periodically clean the instrument with chromic acid (**Warning**—Causes severe burns. A recognized carcinogen. Strong oxidizer, contact with organic material may cause fire. Hygroscopic. See Annex A1.2) to remove organic deposits, rinse thoroughly with distilled water and acetone, (**Warning**—Extremely flammable. Vapors may cause flash fire. See Annex A1.3) and dry with clean dry air. Inorganic deposits may be removed by hydrochloric acid (**Warning**—Poison. Corrosive.

[4] Other suitable chromium free, sulfuric acid-based cleaning solutions are available.