

Standard Specification for

KINEMATIC GLASS VISCOMETERS¹



ASTM Designation: D 2515 - 66

This Standard of the American Society for Testing and Materials is issued under the fixed designation D 2515; the final number indicates the year of original adoption as standard or, in the case of revision, the year of last revision.

Scope

1. This specification covers glass capillary kinematic viscometers of all types described in detail in Appendixes A, B, and C as follows:

Type	Appendix
Modified Ostwald Viscometers.	A
Suspended-Level Viscometers.	B
Reverse-Flow Viscometers.	C

NOTE—This specification covers viscometers suitable for use in ASTM Method D 445, Test for Viscosity of Transparent and Opaque Liquids (Kinematic and Dynamic Viscosities).²

Materials and Manufacture

2. (a) Fully annealed, low-expansion borosilicate glass shall be used for all viscometers. The size number, serial number, and manufacturer's designation shall be permanently marked on each viscometer. All timing marks shall be etched and filled with an opaque color, or otherwise made a permanent part of the viscometer.

¹ Under the standardization procedure of the Society, this specification is under the jurisdiction of the ASTM Committee D-2 on Petroleum Products and Lubricants. A list of members may be found in the ASTM Year Book.

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² Appears in this publication.

(b) With the exception of the Fitz-Simons and Atlantic viscometers, all viscometers are designed to fit through a 51-mm hole in the lid of a constant-temperature bath having a liquid depth of at least 280 mm; it is assumed that the surface of the liquid will be not more than 45 mm from the top of the bath lid. For certain constant-temperature baths especially at low or high temperatures, it may be necessary to construct the viscometers with the uppermost tubes longer than shown to ensure adequate immersion in the constant-temperature bath; viscometers so modified can be used to measure viscosity within the precision of the test method. The lengths of tubes and bulbs on the figures should be held within ± 10 per cent or ± 10 mm, whichever is less.

Nomenclature for Figures

3. The more frequently used letters on the figures in the appendixes are as follows:

A	Lower reservoir
B	Suspended level bulb
C and J	Timing bulbs
D	Upper reservoir
E, F, and I	Timing marks
G and H	Filling marks

<i>K</i>	Overflow tube
<i>L</i>	Mounting tube
<i>M</i>	Lower vent tube
<i>N</i>	Upper vent tube
<i>P</i>	Connecting tube
<i>R</i>	Working capillary

Viscometer Holder and Alignment

4. (a) All viscometers shall be mounted in a constant-temperature bath with tube *L* held within 1 deg of the vertical as observed with a plumb bob or other equally accurate inspection means. A number of commercially available holders are so designed that tube *L* is held perpendicular to the lid of the constant-temperature bath, thus requiring that the lid be within 1 deg of the horizontal.

(b) Round metal tops, designed to fit above a 51-mm hole in the lid of the bath, are frequently cemented onto the Zeitfuchs, Zeitfuchs Cross-Arm, and Lantz-Zeitfuchs viscometers which then are permanently mounted onto the lid of the bath; a rectangular metal top, 25 by 59 mm, is often cemented onto the Zeitfuchs Cross-Arm and Zeitfuchs viscometers.

(c) In each figure, the numbers which follow the tube designation indicate the outside tube diameter in millimeters. It is important to adhere to these diameters and the designated spacing to ensure that holders will be interchangeable.

Viscosity Calculation³

5. (a) *Kinematic Viscosity*, expressed in centistokes (cSt), is calculated as follows:

$$\text{Kinematic viscosity, cSt} = Ct \dots (1)$$

where:

C = calibration constant, cSt/sec, and
t = flow time, sec.

³ M. R. Cannon, "Derivation of Viscosity Equation and Sources of Error in Viscometry," Private Report to ASTM Subcommittee on Viscosity, February, 1950. M. R. Cannon and R. E. Manning, "Viscosity Measurement, The Kinetic Energy Correction." Copies available free of charge from Cannon Instrument Co., P. O. Box 16, State College, Pa. 16801.

(b) *Kinetic Energy Correction*—A more general form of Eq 1 is as follows:

$$\text{Kinematic viscosity, cSt} = Ct - E/t^2 \dots (2)$$

where:

E = kinetic energy factor, cSt-sec².

While *E* is not a constant, it can be approximated by the following equation:

$$E = \frac{1.66 V^{3/2}}{L(CD)^{1/2}} \dots (3)$$

where:

V = volume of timing bulb, cm³,

L = working capillary length, cm, and

D = working capillary diameter, cm.

(1) The viscometers described in Appendixes A, B, and C are designed such that the kinetic energy correction term, *E/t*², is negligible if the flow time is more than 200 sec, with the exception of several sizes for the measurement of low-viscosity liquids as noted in the tables of dimensions of viscometers.

(2) The viscosity ranges shown in these tables are based upon a minimum flow time of 200 sec and a maximum flow time of 1000 sec. For viscometers whose constants are 0.05 cSt/sec or less, a kinetic energy correction may be significant if the minimum 200-sec flow time is not observed; the maximum flow time of 1000 sec is arbitrarily set for convenience. The precision section of Method D 445 is based on a 200-sec minimum flow time. Where the minimum flow time exceeds 200 sec, a note appears in the appropriate table.

(c) *Surface Tension Correction*—If the two menisci have different average diameters during the flow time and if the surface tension of the sample differs substantially from the calibrating liquid, a surface tension correction is necessary. The change in the *C* constant is given approximately as follows:

$$C_2 = C_1 \left[1 + \frac{2}{gh} \left(\frac{1}{r_u} - \frac{1}{r_1} \right) \left(\frac{\gamma_1}{\rho_1} - \frac{\gamma_2}{\rho_2} \right) \right] \dots (4)$$

where:

g = acceleration of gravity, cm/sec²,

h = average driving head, cm,

r_u = average radius of the upper meniscus, cm,

r_l = average radius of the lower meniscus, cm,

γ = surface tension, dynes/cm,

ρ = density, g/cm³, and

1, 2 subscripts = calibration liquid and test sample, respectively.

While this correction applies to all viscometers, a number of viscometers are designed to minimize the surface tension correction. The greatest correction normally encountered is with a viscometer calibrated with water and used for oils. Generally viscometers are calibrated and used with hydrocarbons whose surface tensions are close enough so these corrections are insignificant.

(d) *Effect of Temperature*—The calibration constant, C , is independent of temperature for all suspended-level viscometers and those viscometers which have the volume of sample adjusted at bath temperatures.

(1) The following viscometers, which have a fixed volume charged at ambient temperature, have a variation in C constant with temperature: Can-

non-Fenske Routine, Pinkevitch, Cannon-Manning Semi-Micro, and Cannon-Fenske Opaque.

(2) The following equation can be used to calculate C at temperatures other than the calibration temperature for the Cannon-Fenske Routine, Pinkevitch, and Cannon-Manning Semi-Micro viscometers:

$$C_2 = C_1 \left[1 + \frac{4V(\rho_2 - \rho_1)}{\pi D^2 h \rho_2} \right] \dots (5)$$

The temperature dependence of C for the Cannon-Fenske Opaque (reverse-flow) viscometer is given as follows:

$$C_2 = C_1 \left[1 - \frac{4V(\rho_2 - \rho_1)}{\pi D^2 h \rho_2} \right] \dots (6)$$

where:

V = volume of charge, cm³,

D = average diameter of the meniscus in the lower reservoir for the Cannon-Fenske Routine, Pinkevitch and Cannon-Manning Semi-Micro viscometers, and in the upper reservoir of the Cannon-Fenske Opaque viscometer, cm,

h = average driving head, cm, and

1, 2 subscripts = calibration and test temperature, respectively.

APPENDIX A

MODIFIED OSTWALD VISCOMETERS

Scope

A1. The modified Ostwald viscometers for transparent liquids have the basic design of the Ostwald viscometer, but are modified as follows to ensure a constant volume of sample in the viscometer: at the filling temperature for the Cannon-Fenske Routine, Cannon-Manning Semi-Micro and Pinkevitch viscometers, and at the test temperature for the Zeitfuchs, SIL, BS/U-tube, and BS/U Miniature viscometers. These viscometers are used for the measurement of the kinematic viscosity of transparent Newtonian liquids up to 20,000 cSt.

Apparatus

A2. Detailed drawings of the modified Ostwald viscometers are shown in Figs. A1 through A7. Tables A1 through A7 give the size designation, approximate constants, kinematic viscosity range, capillary diameter, and bulb volumes for each viscometer.

Operating Instructions

A3. A standard operating procedure applicable to all glass capillary kinematic viscometers is contained in Method D 445. Operating instructions for the modified Ostwald viscometers are

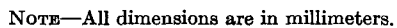
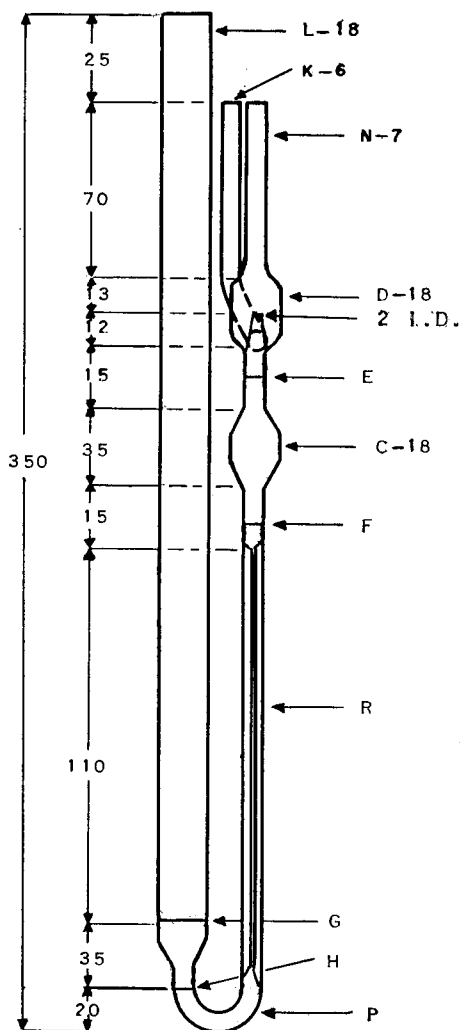
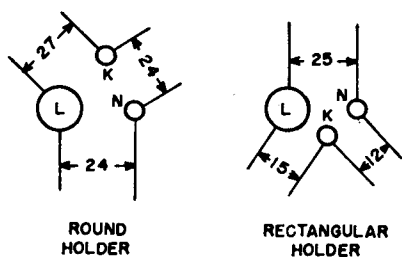


FIG. A1—Cannon-Fenske Routine Viscometer for Transparent Liquids.



NOTE—All dimensions are in millimeters.

FIG. A2—Zeitfuchs Viscometer for Transparent Liquids.

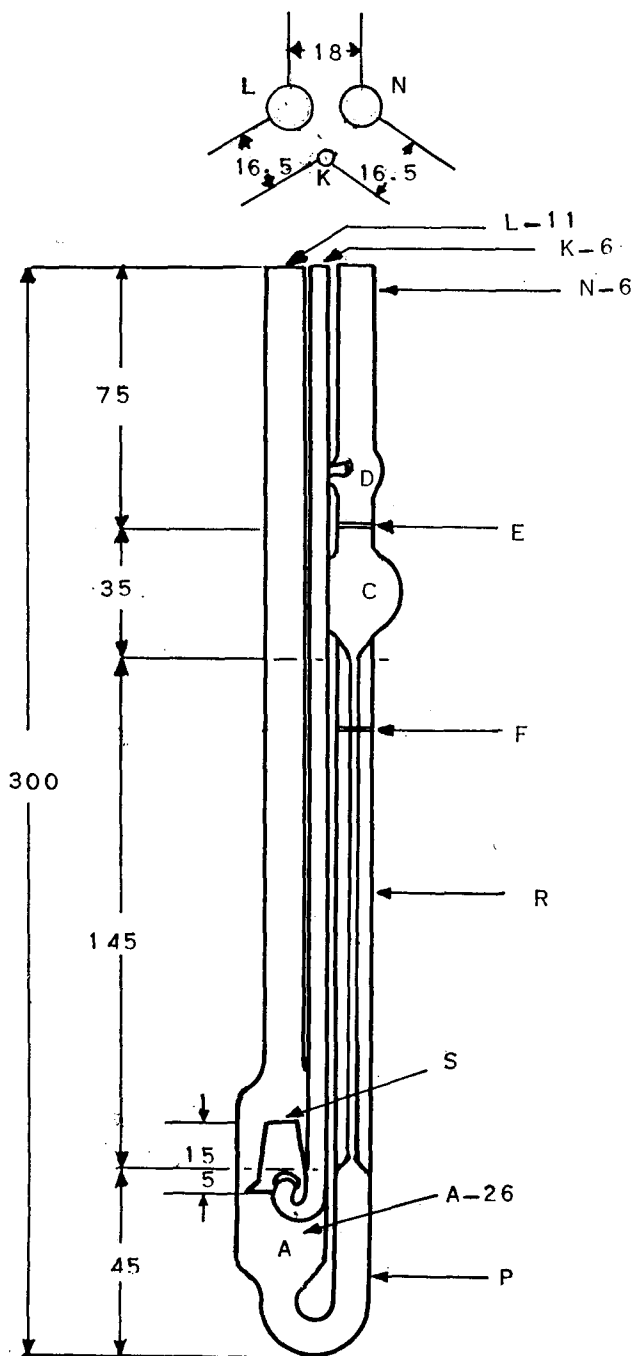
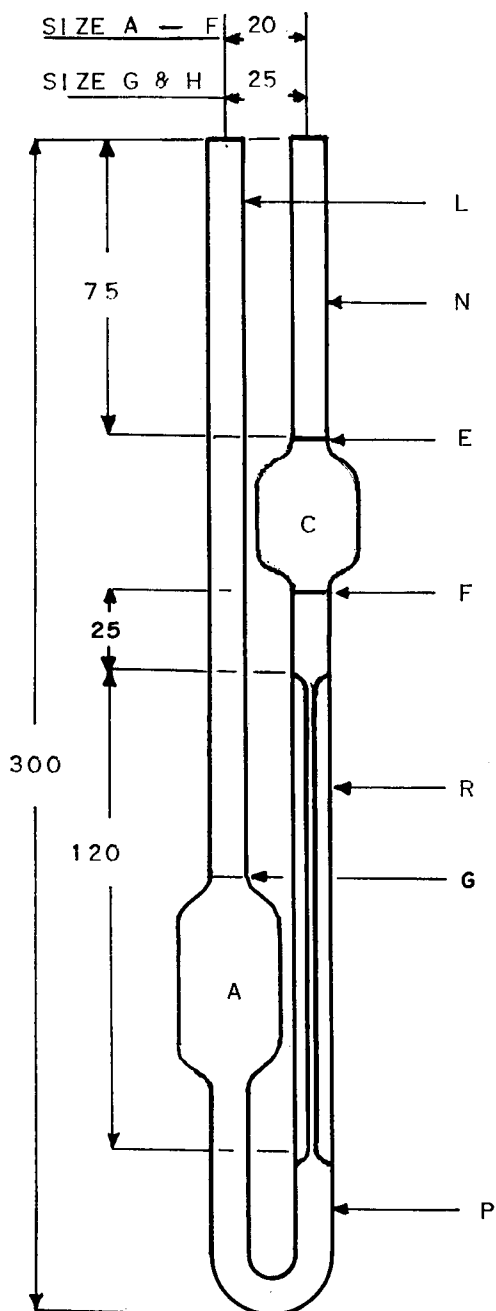
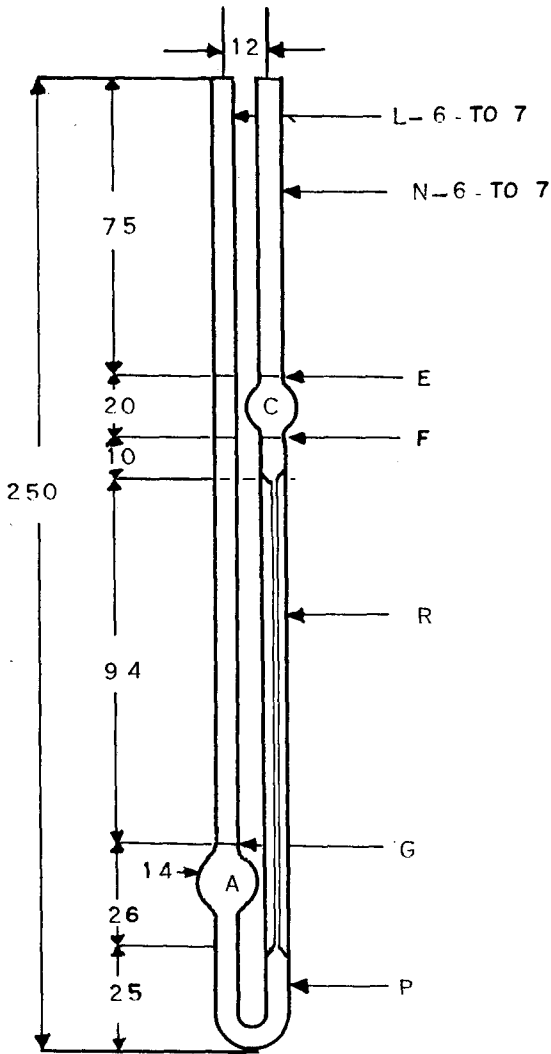


FIG. A3—SIL Viscometer for Transparent Liquids.



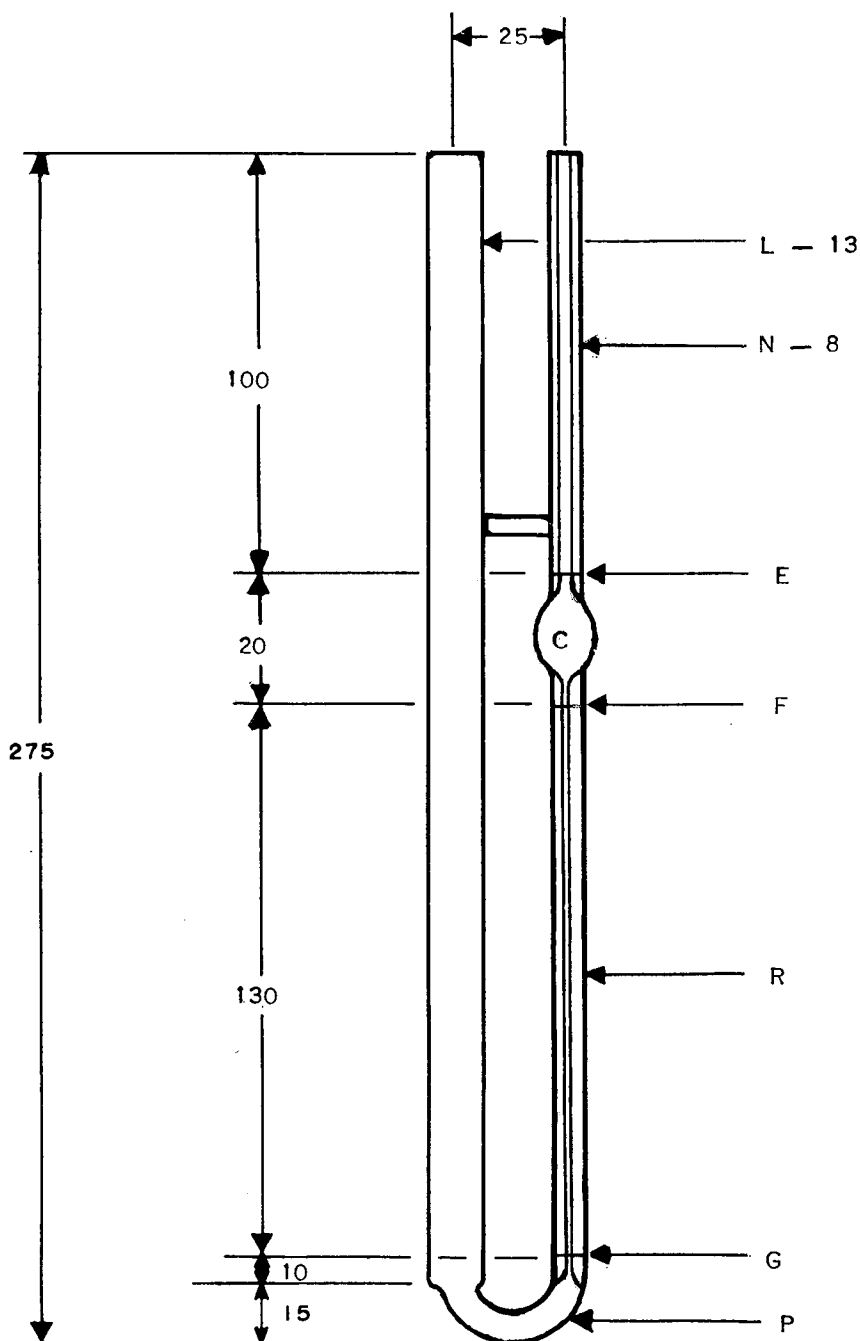
NOTE—All dimensions are in millimeters.

FIG. A4—BS/U-Tube Viscometer for Transparent Liquids.



NOTE—All dimensions are in millimeters.

FIG. A5—BS/U/M Miniature Viscometer for Transparent Liquids.



NOTE—All dimensions are in millimeters.

FIG. A6—Cannon-Manning Semi-Micro Viscometer for Transparent Liquids.

