# ⟨911⟩ VISCOSITY—CAPILLARY METHODS

The following procedures are used to determine the viscosity of a Newtonian fluid, i.e., a fluid having a viscosity that is independent of the rate of shear. [NOTE—For additional information, see *Rheometry* ⟨1911⟩.]

- **METHOD I. SUSPENDED-LEVEL (OR UBBELOHDE-TYPE) CAPILLARY VISCOMETER**

**Apparatus:** The determination may be carried out with a suspended-level capillary viscometer (*Figure 1*).

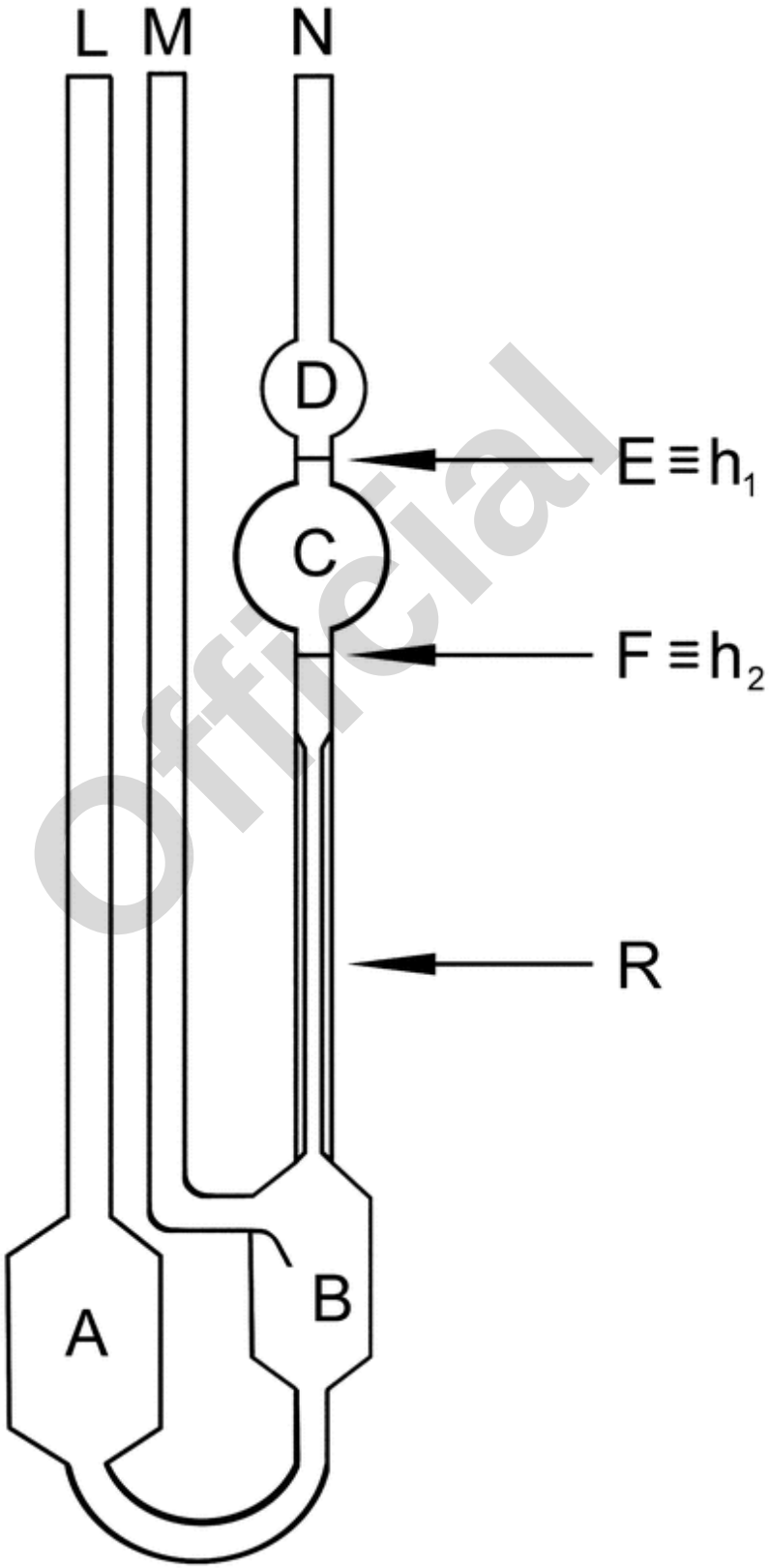




Figure 1. Suspended-level (or Ubbelohde-type) capillary viscometer.

Other viscometers may be used provided that the accuracy and precision is NLT that obtained with the viscometers described in this chapter.

**Procedure:** Fill the viscometer through tube (L) with a sufficient quantity of the sample liquid that is appropriate for the viscometer being used or by following the manufacturer's instructions. Carry out the experiment with the tube in a vertical position. Fill bulb (A) with the liquid, and also ensure that the level of liquid in bulb (B) is below the exit to the ventilation tube (M). Immerse the viscometer in a water or oil bath stabilized at the temperature specified in the individual monograph, and control the temperature to ±0.1°, unless otherwise specified in the individual monograph. Maintain the viscometer in a vertical position for a time period of NLT 30 min to allow the sample temperature to reach equilibrium. Close tube (M), and raise the level of the liquid in tube (N) to a level about 8 mm above mark ($E \equiv h_1$). Keep the liquid at this level by closing tube (N) and opening tube (M). Open tube (N), and measure the time required for the level of the liquid to drop from mark ($E \equiv h_1$) to mark ($F \equiv h_2$), using an appropriate accurate timing device. [NOTE—The minimum flow time should be 200 s.]

**Calibration:** Calibrate each viscometer at the test temperature by using fluids of known viscosities of appropriate viscosity standards to determine the viscometer constant, $k$. The viscosity values of the calibration standards should bracket the expected viscosity value of the sample liquid.

Calculate the viscometer constant, $k$, in $mm^2/s^2$:

$$k = \eta/(\rho \times t)$$

$\eta$ = known viscosity of the liquid (mPa · s)
$\rho$ = density of the liquid (g/mL)
$t$ = flow time for the liquid to pass from the upper mark to the lower mark (s)

**Calculation of kinematic and Newtonian viscosities of sample fluid:** A capillary viscometer is chosen so that the flow time, $t$, is NLT 200 s, and the kinematic energy correction is typically less than 1%. If the viscosity constant, $k$, is known, use the following equation to calculate the kinematic viscosity, $v$, in $mm^2/s$, from the flow time, $t$, in s.

$$v = k \times t$$

If the density of the fluid is known at the temperature of the viscosity measurement, then the Newtonian viscosity, $\eta$, in mPa · s, is calculated:

$$\eta = v \times \rho$$

$\rho$ = density of the fluid (g/mL)

The flow time of the fluid under examination is the mean of NLT three consecutive determinations. The result is valid if the percentage of the relative standard deviation (%RSD) for the three readings is NMT 2.0%.

• **METHOD II. SIMPLE U-TUBE (OR OSTWALD-TYPE) CAPILLARY VISCOMETER**

**Apparatus:** The determination may be carried out with a simple U-tube capillary viscometer (*Figure 2*).

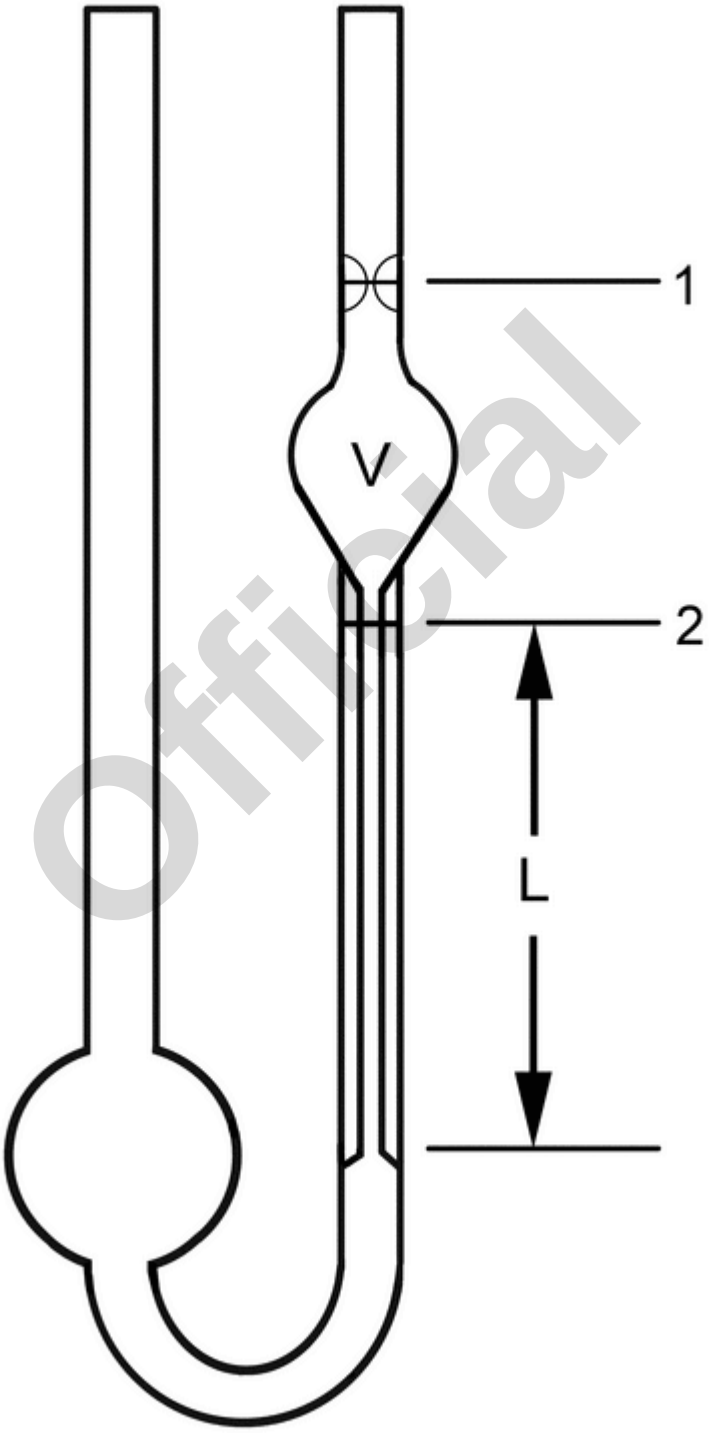




Figure 2. Simple U-tube (or Ostwald-type) capillary viscometer.

Variables and line numbers in *Figure 2* are defined as:

| | |
|---|---|
| Line 1 | = upper mark in the tube |
| $V$ | = given volume of fluid ($m^3$) |
| Line 2 | = lower mark in the tube |
| $L$ | = capillary tube length (m) |

Other viscometers, such as modified Ostwald-type capillary viscometers,[1] may be used provided that the accuracy and precision is NLT that obtained with the viscometers described in this chapter.

**Procedure:** Fill the tube with an amount of the sample that is appropriate for the viscometer being used or by following the manufacturer's instructions. The volume of fluid used should be such that the lower bulb is not entirely emptied when the fluid is drawn up through the capillary tube to the uppermost graduation mark. Carry out the experiment with the tube in a vertical position. Immerse the viscometer in a water or oil bath stabilized at the temperature specified in the individual monograph, and control the temperature to ±0.1°, unless otherwise specified in the individual monograph. Maintain the viscometer in a vertical position for a time period of NLT 30 min to allow the sample temperature to reach equilibrium. Using suction, draw the fluid up through the capillary tube until the meniscus is at the level of the uppermost graduation. With both the filling and capillary tubes open to atmospheric pressure, record the time, in s, required for the liquid to flow from the upper mark to the lower mark in the capillary tube. [NOTE—The minimum flow time should be 200 s.]

**Calibration** and **Calculation of kinematic and Newtonian viscosities of sample fluid:** Proceed as directed in *Method I*. For certain simple U-tube capillary viscometers, determine the viscometer constant at the same temperature as the sample liquid under test.



[1] For example, the Cannon-Fenske capillary viscometer is one of the simple U-tube capillary viscometers and is also called a modified Ostwald-type capillary viscometer.