



Standard Test Method for Viscosity of Printing Inks and Vehicles by the Falling-Rod Viscometer¹

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1. Scope*

1.1 This test method covers the procedure for determining the falling-rod viscosity of printing inks, vehicles, and similar liquids that are essentially nonvolatile and unreactive under ordinary room conditions.

1.2 For printing inks, which are typically non-Newtonian, this test method is applicable in the apparent viscosity range from about 10 to 300 P at a shear rate of 2500 s⁻¹. For Newtonian liquids, the applicable viscosity range is about 10 to 1000 P (1 P = 0.1 Pa·s).

1.3 *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 hazard statements, see Section 8.

2. Referenced Documents

2.1 ASTM Standards:

D 445 Test Method for Kinematic Viscosity of Transparent and Opaque Liquids²

3. Terminology

3.1 Definitions:

3.1.1 *viscosity, V*—the ratio of shear stress to shear rate. The viscosity of a liquid is a measure of the internal friction of the liquid in motion. The cgs unit of viscosity is 1 g/cm·s (1 dyne·s/cm²) and is called a poise. The SI unit is 1 N·s/cm² and is equal to 10 P.

3.1.2 *shear stress, S*—shearing force per unit area; the unit is 1 g/cm·s² (1 dyne/cm²). In the falling-rod viscometer, shear stress is proportional to total weight *W* per unit of shearing area *A* times the gravitational constant *g*, in accordance with the equation: $S = Wg/A$.

3.1.3 *shear rate, D*—velocity gradient through the stressed liquid; the unit is 1/s or 1 s⁻¹. In the falling-rod viscometer,

shear rate is inversely proportional to fall time *F* per unit distance *L* over which a unit thickness *x* of the liquid is stressed: $D = L/xF$.

3.1.4 *Newtonian*—refers to a liquid whose viscosity is constant at all shear rates.

3.1.5 *non-Newtonian*—refers to a liquid whose viscosity varies with shear rate. Such liquids may be either shear-thinning (pseudoplastic) or shear-thickening (dilatant). Most printing inks are shear-thinning.

3.1.6 *apparent viscosity, V_D*—the viscosity of a non-Newtonian fluid at a particular shear rate *D*. A shear rate of 2500 s⁻¹ has been found useful for printing inks and is specified in this test method.

3.1.7 *yield stress, S_o*—the minimum shear stress required to initiate motion in a non-Newtonian liquid.

3.2 Definitions of Terms Specific to This Standard:

3.2.1 *power law*—a mathematical model that presumes that the viscosity of a liquid varies with shear rate in accordance with a power function as follows:

$$k = \frac{S}{D^N} \quad (1)$$

where:

k = a constant related to the viscosity of the liquid and

N = a constant describing the rate at which shear stress varies with shear rate.

The value of *N* is precisely 1.0 for a Newtonian fluid, less than 1.0 for a shear-thinning liquid, and greater than 1.0 for a shear-thickening liquid.

3.2.2 *power law plot*—a logarithmic plot of shear stress versus shear rate based on the expanded form of the power law equation:

$$\ln S = \ln k + N \ln D \quad (2)$$

For liquids conforming to the power law, the logarithmic plot of *S* versus *D* is linear over the shear rate range of interest. The slope of the line is the power law constant *N*.

3.2.3 *shortness*—the property of a non-Newtonian fluid that prevents it from being drawn into a filament.

3.3 Symbols: (for Power-Law Calculations):

¹ This test method is under the jurisdiction of ASTM Committee D-1 on Paint and Related Coatings, Materials, and Applications and is the direct responsibility of Subcommittee D01.56 on Printing Inks.

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

