



Designation: D4040 – 10 (Reapproved 2019)

Standard Test Method for Rheological Properties of Paste Printing and Vehicles by the Falling-Rod Viscometer¹

This standard is issued under the fixed designation D4040; 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

1.1 This test method covers the procedure for determining the falling-rod viscosity and degree of non-Newtonian behavior 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 = $0.1 \text{ Pa}\cdot\text{s}$).

1.3 This test method uses a falling-rod viscometer in which shear conditions are altered by manually adding weight to the rod. A fully automatic instrument is described in Test Method **D6606**.

1.4 This test method, as does Test Method **D6606**, bases calculations on the power law model of viscosity. ISO 12644 covers not only the power law but also the Casson and Bingham models.

1.5 The values stated in SI units are to be regarded as standard. No other units of measurement are included in this standard.

1.6 *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, health, and environmental practices and determine the applicability of regulatory limitations prior to use.* For specific hazard statements, see Section 8.

1.7 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 ASTM Standards:²

D445 Test Method for Kinematic Viscosity of Transparent and Opaque Liquids (and Calculation of Dynamic Viscosity)

D6606 Test Method for Viscosity and Yield of Vehicles and Varnishes by the Duke Viscometer

2.2 Other Standards:

ISO 12644 Graphic Technology—Determination of rheological properties of paste inks and vehicles by the falling rod viscometer³

3. Terminology

3.1 Definitions:

3.1.1 *apparent viscosity*, V_D , n —the viscosity of a non-Newtonian fluid at a particular shear rate D .

3.1.1.1 *Discussion*—A shear rate of 2500 s^{-1} has been found useful for printing inks and is specified in this test method.

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

3.1.3 *non-Newtonian*, *adj*—refers to a liquid whose viscosity varies with shear rate.

3.1.3.1 *Discussion*—Non-Newtonian liquids may be either shear-thinning (pseudoplastic) or shear-thickening (dilatant). Most printing inks are shear-thinning.

3.1.4 *shear rate*, D , n —velocity gradient through the stressed liquid; the unit is $1/\text{s}$ or 1 s^{-1} .

3.1.4.1 *Discussion*—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: $D = L/xF$.

3.1.5 *shear stress*, S , n —shearing force per unit area; the unit is $1 \text{ g/cm}\cdot\text{s}^2$ (1 dyne/cm^2).

3.1.5.1 *Discussion*—In the falling-rod viscometer, shear

¹ This test method is under the jurisdiction of ASTM Committee **D01** 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 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 American National Standards Institute (ANSI), 25 W. 43rd St., 4th Floor, New York, NY 10036, <http://www.ansi.org>.