



Designation: D6606 – 00 (Reapproved 2005)

# Standard Test Method for Viscosity and Yield of Vehicles and Varnishes by the Duke Viscometer<sup>1</sup>

This standard is issued under the fixed designation D6606; 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 ( $\epsilon$ ) indicates an editorial change since the last revision or reapproval.

## 1. Scope

1.1 This test method covers the procedure for determining the viscosity of varnishes, ink vehicles, and similar liquids that are essentially nonvolatile and unreactive under ordinary room conditions using the Duke Automated high-shear rod and collar viscometer.<sup>2</sup>

1.2 The instrument in this test method is similar in principle to the falling-rod viscometer described in Test Method D4040 except that the collar is motor driven and the range of available shear stresses is considerably greater. This instrument is capable of measured and extrapolated viscosity and yield values provided the proper model is chosen for the given application. See Section 6 for the ranges of specified models.

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

1.4 *This standard does not purport to address all of the safety concerns, if any, that may be associated with its use. It is the responsibility of the user of this standard to establish any appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

## 2. Referenced Documents

2.1 *ASTM Standards:*<sup>3</sup>

**D4040 Test Method for Rheological Properties of Paste Printing and Vehicles by the Falling-Rod Viscometer**

<sup>1</sup> 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 D01.37 on Ink Vehicles.

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<sup>2</sup> The sole source of supply of an automated high shear rod and collar viscometer known to the committee at this time is Duke Custom Systems, Inc., Pleasant View, TN. If you are aware of alternative suppliers, please provide this information to ASTM International Headquarters. Your comments will receive careful consideration at a meeting of the responsible technical committee,<sup>1</sup> which you may attend.

<sup>3</sup> 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. Terminology

3.1 *Definitions*— Terms relative to this test method are defined in Test Method D4040 except for those found in 3.2.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *yield value, n*—The Lehman's yield value that is defined as the stress at  $2.5 \text{ s}^{-1}$ .

3.2.1.1 *Discussion*—This value can be either extrapolated or measured.

3.2.2 *shortness ratio, n*—a ratio to determine the shortness characteristic of the fluid where  $SR = \text{yield value}/\text{apparent viscosity}$ .

## 4. Summary of Test Method

4.1 This automated test method is based upon accurate measurement of the force that is transferred at a known temperature into a stationary vertical rod as a fluid such as printing ink/varnish moves through a precision measurement gap formed between the outside diameter of the rod and the inside diameter of collar of specific geometry as said collar moves upward along the length of the rod at specified velocities.

4.2 The operator of the instrument and the customer must agree on the preprogrammed test sequence, which is to be run for a given material and the desired test temperature. Supervisory personnel should know the specifics of each preprogrammed test sequence, how to change a given test sequence, and how to make a new test sequence.

4.3 This test method provides actual measured test data of fluids at specified shear rates, which can be programmed to relate. In addition to actual measured data, extrapolated data using the "power law mathematical model" is provided that correlates with manual testing methods as outlined in Test Method D4040.

4.4 Specified test reference temperatures can range from 20 to 40°C. Allowable deviation from desired test reference temperature could be specified differently in each test sequence. Allowable programmable is within the range of 0.05 to 0.4°C.

**TABLE 1 Performance Ranges For Each Model**

Model Number	Stress Range (Dynes/cm <sup>2</sup> )	Viscosity Range Poise at 2500sec <sup>-1</sup>	Shear Rate Range (sec <sup>-1</sup> )	Temperature Range° C
D-2010 D-2010E D-2012 D-2012E	75 – 1.0×10 <sup>6</sup>	4 – 400	2.5 – 10,000	19–40
D-2020 D-2020E D-2022 D-2022E	150 – 2.0×10 <sup>6</sup>	10 – 800	2.5 – 10,000	19–40
D-2050 D-2050E D-2052 D-2052E	300 – 5.0×10 <sup>6</sup>	20 – 1,600	2.5 – 7,500	19–40
D-2100 D-2100E D-2102 D-2102E	600 – 10.0×10 <sup>7</sup>	40 – 3,200	2.5 – 7,500	19–40

## 5. Significance and Use

5.1 Actual direct measurements of apparent viscosity and stress at shear rates of interest can be useful in the practical control of ink viscosity during production and the specification acceptance between supplier and purchaser.

5.2 Use of the Duke automated viscometer provides direct measurements for viscosity and yield value versus extrapolating data points that may be far from the desired shear rates.

## 6. Apparatus

6.1 **Table 1** describes each model of the Duke automated high shear rod and collar viscometer with the appropriate ranges for the ink or varnish being tested.

## 7. Materials

7.1 *ASTM Standard Viscosity Fluids*—(For calibration purposes only.) At approximately 100, 200, and 400 poise, span the practical range of the instrument without inducing self-heating errors. The required fluids <sup>4</sup> are N4000 (100 poise at 25°C), S8000 (200 poise at 25°C), and N15000 (400 poise at 25°C).

7.2 *Lint and Metal-Free Rags or Tissues* of appropriate size, so that they may be pulled or pushed completely through the collar in a single pass.

7.3 *Naphtha or other Low-Boiling Solvent* in a wash bottle or closed metal container.

## 8. Hazards

8.1 **Warning:** Solvents may be hazardous to the skin and eyes. In addition to other precautions, always wear protective gloves and safety glasses during cleanup to avoid solvent contact with skin and eyes. See supplier's material safety data sheet for further information on each solvent used.

8.2 **Instrument Warning:** Never operate the instrument with the rod installed without fluid in the collar.

## 9. Preparation of Apparatus

9.1 Set the viscometer up on a sturdy vibration-free bench capable of supporting at least 6.75 sq. m.

9.2 Locate the viscometer in an area free of direct sunlight to prevent sun-induced heating inside the clear temperature-controlled enclosure.

9.3 Level the viscometer by turning the adjustable feet up or down until the spirit level is centered and the instrument is free from wobble.

9.4 Clean the rod and collar thoroughly with tissues wetted with naphtha or other appropriate solvent. Remove residual solvent with clean dry tissue. Ensure rod and collar are free of lint or other particles from tissue or environment. **Warning:** Failure to clean instrument adequately will severely influence results.

9.5 Ensure identification code on rod and collar match.

9.6 Properly install and lock into viscometer the rod with rod cup and collar in accordance with manufacturer's recommendations.

9.7 Plug in collar/sample temperature probe.

9.8 Allow instrument to equilibrate at a desired test temperature.

## 10. Calibration

10.1 Ensure instrument is within calibration window by reading information contained in "Days to Next Calibration Window" on the computer screen. The number of days until the next factory-authorized calibration is displayed whenever the instrument is not in active use.

10.2 Periodically check calibration as in Section 17.

## 11. Sample Preparation

11.1 Transport sample to be tested to the test area and preserve in a suitable clean closed container. Skin paper should be used for oxidative fluids.

11.2 Samples should be uniform dispersions or structures throughout. Samples to be tested should be free of bubbles, skin, or other debris. If variations in structure are suspected, the sample must be remixed until it is of uniform consistency.

11.3 Fill pipet with the sample and place filled pipet into the temperature-controlled enclosure of viscometer. **Warning:** Do not work the sample vigorously. Be sure to close the sample container immediately after removing the desired sample to be tested.

## 12. Conditioning

12.1 The test sequence and reference temperatures are programmable and are protected by password security to prevent unauthorized changes from desired temperatures. The reference temperature for this test method is 25.0° and the enclosure temperature for this test method is 24.95°C.

12.2 The pipet containing the sample should remain inside the temperature-controlled enclosure a minimum of one minute

<sup>4</sup> The sole source of supply of the certified standard viscosity oil known to the committee at this time is Cannon Instrument Company, P.O. Box 16, State College, PA 16801. If you are aware of alternative suppliers, please provide this information to ASTM International Headquarters. Your comments will receive careful consideration at a meeting of the responsible technical committee,<sup>1</sup> which you may attend.