Designation: D2556 – 14

Standard Test Method for Apparent Viscosity of Adhesives Having Shear-Rate-Dependent Flow Properties Using Rotational Viscometry[1]

This standard is issued under the fixed designation D2556; 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.

This standard has been approved for use by agencies of the U.S. Department of Defense.

1. Scope

1.1 This test method covers the measurement of the apparent viscosity of shear-rate-dependent adhesives using a rotational viscometer.

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

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.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

D907 Terminology of Adhesives

3. Terminology

3.1 *Definitions:*

3.1.1 Many terms in this test method are defined in Terminology D907.

3.1.2 *Newtonian behavior, n*—the property of a liquid in which its viscosity is constant over a stated range of strain rates. (Compare *non-Newtonian behavior*.)

3.1.3 *non-Newtonian behavior, n*—the property of a liquid in which its viscosity is not constant over a stated range of strain rates.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *apparent viscosity, n*—resistance to shear at a given rate of shear, expressed as viscosity in mPa·s.

NOTE 1—The SI unit of mPa·s is equivalent to cP.

3.2.2 *thixotropic index, n*—the ratio of apparent viscosities at two rotational speeds.

4. Significance and Use

4.1 The principle of measurement is based upon a reversible isothermal change in apparent viscosity with change in rate of shear produced by a change in rotational speed.

4.2 Measurement is performed with a rotational viscometer under standardized conditions with rigid control of the time intervals of measurement. Viscosity readings are obtained at the end of 1 min for each rotational speed. Changes from the lowest speed to the highest speed, and return to the lowest speed, are made without stopping the instrument.

5. Apparatus

5.1 *Rotational Viscometer*—The essential instrumentation required providing the minimum rotational viscometer analytical capabilities include:

5.1.1 A *drive* motor, to apply a unidirection rotational displacement to the specimen at a rate of 0.2 revolutions per minute to 60 rev/min constant to within ±1%.

5.1.2 A *force sensor* to measure the torque developed by the specimen to within ±1%.

5.1.3 A *coupling* shaft or other means to transmit the rotational displacement from the motor to the specimen.

5.1.4 A *spindle, geometry, tool, or rotational element* to fix the specimen between the drive shaft and a stationary position.

NOTE 2—Each rotational element typically covers a range of 1.5 decades of viscosity. The rotational element may be a spindle, disk, T-bar, coaxial cylinder of other configuration selected by mutual agreement among the parties involved.

NOTE 3—Do not use a scored, warped, or otherwise damaged rotational element.

5.1.5 A specimen *container* with capacity to contain the test specimen during testing.

NOTE 4—The size of the container used is determined by the size and design of the rotational element used. The container used may be specified by mutual agreement among the parties involved.

5.1.6 A *guard* to protect the geometry from mechanical damage.

[1] This test method is under the jurisdiction of ASTM Committee D14 on Adhesives and is the direct responsibility of Subcommittee D14.10 on Working Properties.

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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.

5.1.7 A *temperature sensor* to provide an indication of the specimen temperature in the range from 21 to 25°C readable to within ±0.2°C.

NOTE 5—Other temperatures may be used but shall be reported.

5.1.8 A *data collection* device to provide a means of acquiring, storing and displaying measured or calculated signals, or both. The minimum output signals required for rotational viscometry are torque, rotational speed, temperature and time.

5.1.9 A *stand* to support, level, and adjust the height of the drive motor, shaft and rotational element.

5.1.10 Auxiliary instrumentation considered necessary or useful in conducting this method includes:

5.1.10.1 *Data analysis capability* to provide viscosity, stress or other useful parameters derived from the measured signals.

5.1.10.2 A *level* to indicate the vertical plumb of the drive motor, shaft, and spindle.

6. Conditioning

6.1 Condition the adhesive sample and instrument at 23 ± 0.5°C for at least 16 h (see Note 5).

7. Procedure

7.1 Select a rotational viscometer and rotational element suited to the viscosity range of the test material such that the rotational speed and rotational element combination will give a torque reading between 20 and 80 % of the full scale.

7.2 Assemble the motor, shaft, and rotational element and mount them vertically plumb on the stand over the container.

7.3 Pour a quantity of the test specimen into the container sufficient to cover the immersed rotational element.

7.4 Slowly immerse the rotational element in the test specimen to the depth recommended by apparatus manufacturer.

NOTE 6—Other immersion depths may be used but shall be reported.

NOTE 7—Take care as the rotational element is lowered into the solution to ensure that no air is trapped under or around it.

7.5 Start the viscometer motor at the lowest rotational speed. Maintain this speed for 60 ± 2 s. Record the rotational speed and apparent viscosity.

7.6 Without stopping the motor, increase the rotational speed to the next higher setting and maintain this speed for 60 s. Record the rotational speed and apparent viscosity.

7.7 Repeat step 7.6 until the maximum readable torque (90 % full scale) is achieved.

7.8 Decrease the rotational speed to the next lower rotational speed setting and maintain this speed for 60 ± 2 s. Record the rotational speed and the apparent viscosity determined from the measured torque value according to the manufacturer's operations manual.

7.9 Repeat 7.8 until the lowest speed has been reached.

7.10 Using the information obtained in steps 7.5 – 7.9, prepare a plot of rotational speed versus apparent viscosity. A non-linear plot indicates the shear-rate dependency of the material.

7.11 A value of apparent viscosity as a function of rotational speed may be obtained from any point on the curve.

7.12 If desired, the thixotropic index (the ratio of apparent viscosities at two rotational speeds) may be determined and reported.

NOTE 8—The rotational speeds for the measurement of the thixotropic index shall be selected by agreement between supplier and customer. Speeds that differ by an order of magnitude are commonly selected (for example, 2 and 20 rev/min).

8. Report

8.1 Report the following information:

8.1.1 Date of test and complete identification of the adhesive tested, including type, source, manufacturer's code numbers, form, date of manufacture,

8.1.2 A complete description of the apparatus used including manufacturer, model, rotational element type and number and container dimensions,

8.1.3 Conditioning procedure employed in preparation of the test specimen for testing,

8.1.4 Time elapsed between various operations in preparation of the test specimen and between rotational element immersion and start of test,

8.1.5 Temperature of the test specimen,

8.1.6 Depth of immersion of rotational element, and

8.1.7 Apparent viscosity at one or more selected rotational speeds and whether obtained while increasing or decreasing the rotational speeds.

8.1.8 If needed, the thixotropic index at two different speeds. For example:

$$\text{Thixotropic index (at 2 and 20 rev/min)} = 80\ \text{Pa·s}/20\ \text{Pa·s} = 4$$

8.1.9 The dated version of this standard used.

9. Precision and Bias

9.1 No precision and bias data are available for this test method.

10. Keywords

10.1 apparent viscosity; rotational viscometer; viscometry; viscosity