Designation: ~~E2975 – 14~~ E2975 – 15

Standard Test Method for Calibration of Concentric Cylinder Rotational Viscometers[1]

This standard is issued under the fixed designation E2975; 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 describes the calibration (or performance validation) of rotational viscometers in which the rotational element is immersed in the test fluid under ambient temperature conditions. It is not intended for cone-and-plate or parallel plate viscometers.

1.2 Calibration shall be performed with Newtonian reference materials using experimental conditions, such as temperature, viscosity range and shear rate (rotational speed), as close as practical to those to be used for measurement of test specimens.

1.3 The values stated in SI units are to be regarded as standard. The values given in parentheses are mathematical conversions to inch-pound units that are provided for information only and are not considered standard.

1.3.1 Common viscosity units of Poise (P) are related to the SI units by the equivalency 1 cP = 1 mPa·s.

1.4 *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]

E473 Terminology Relating to Thermal Analysis and Rheology

E1142 Terminology Relating to Thermophysical Properties

E1970 Practice for Statistical Treatment of Thermoanalytical Data

3. Terminology

3.1 *Definitions*—Specific technical terms used in this test method are described in Terminologies E473 and E1142 including *Newtonian, non-Newtonian, stress, strain, viscometer, viscometry*, and *viscosity*.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *apparent viscosity (η), n*—viscosity determined by this test method.

[1] This test method is under the jurisdiction of ASTM Committee E37 on Thermal Measurements and is the direct responsibility of Subcommittee E37.08 on Rheology.

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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.

3.2.1.1 *Discussion*—

Because the velocity gradient in this test method may not be the same at all points of the rotational element for non-Newtonian fluids, the result determined may not be the true viscosity. Therefore, the viscosity determined by this test method is called the "apparent viscosity."

4. Summary of Test Method

4.1 An element is rotated in a Newtonian fluid at a known (or measured) speed. The viscous drag experienced by the immersed element is measured (or known) as a torque. Viscosity may then be determined from these properties (torque and rotational speed) and the dimensions of the rotational element by equations such as Eq 1 and 2.

$$\eta = E\,\tau\,S/\acute{\omega} = 9.55\,E\,\tau\,S/\nu \quad (1)$$

$$\eta = 9.55\,E\,\tau\,S/\acute{\omega} \quad (1)$$

~~$S = [(r_c^2 - r_g^2)/(4 \quad r_c^2 \quad r_g^2 \quad L)]$~~ (2)

$S = [(r_c^2 - r_g^2)/(4 \quad \pi \quad r_c^2 \quad r_g^2 \quad L)]$ (2)

where:

η = viscosity (Pa·s),
~~ω = rotational speed (revolutions/min),~~
ω = rotational speed (r/min),
E = calibration coefficient (dimensionless),
τ = torque (N·m),
S = rotational element factor (mm^{-3}) supplied by the apparatus vendor,
L = length of the cylindrically shaped rotational element (mm),
~~r_g = radius of the cylindrically shaped rotational element (mm),~~
r_g = radius of the cylindrically shaped rotational element (m), and
~~r_c = radius of the cylindrically shaped container (mm), and~~
r_c = radius of the cylindrically shaped container (m).
~~v = rotational speed (rad/s).~~

NOTE 1—1 Pa = 1 N/m^2; 1 cP = 1 mPa·s; 1 ~~rev/min~~/min = 0.1047 rad/s.

4.2 Calibration of a viscometer and its associated rotational element may be achieved by comparing the viscosity indicated by the apparatus with the known viscosity of a calibration fluid as their product using Eq 3, under experimental conditions used in measuring an unknown fluid:

$$E = \eta_t / \eta_o \quad (3)$$

where:

η_t = the viscosity of the calibration fluid (Pa·s), and
~~η_i = the viscosity indicated by the apparatus (Pa·s).~~
η_o = the viscosity indicated by the apparatus (Pa·s).

5. Significance and Use

5.1 This test method may be used to calibrate a rotational viscometer and its associated rotational element.

5.2 The apparent viscosity (η) of a test specimen may then be obtained using Eq 4:

$$\eta = E\ \eta_o \quad (4)$$

6. Apparatus

6.1 *Viscometer, Concentric Cylinder Rotational*—The essential instrumentation required providing the minimum rotational viscometer analytical capabilities for this test method include:

6.1.1 A *drive motor*, to apply a rotational displacement to the specimen at a rate from ~~3 to 380 rad/min (0.5 to 60 revolutions/min)~~0.5 to 60 r/min constant to ±0.2 % of full scale or alternatively a torque to the specimen constant to ±0.2 % of full scale.

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

NOTE 2—It is convenient to have a mark on the shaft to indicate the fluid level of the test specimen appropriate for the measurement.

6.1.3 A *cylindrical rotational element, spindle, bob, or tool*, composed of material inert to the material being tested, to fix the specimen between the drive shaft and a stationary position.

NOTE 3—Each rotational element typically covers about two decades of viscosity. The rotational element is selected so that the measured viscosity is between 15 and 95 % of the range that element.

NOTE 4—This test method is intended for rotational elements that are immersed in the test specimen. It is not intended for cone-and-plate or parallel plate viscometers.

6.1.4 A *sensor* to measure the torque within ±1 % of full scale developed by the specimen or alternatively to measure rotational speed within ±1 % of full scale.

6.1.5 A *temperature sensor* to provide an indication of the specimen temperature of the range of 19°C to 26°C to within ±0.1°C.

6.1.6 A *temperature bath* to provide a controlled isothermal temperature environment for the specimen within the applicable temperature range of this test method.

6.1.7 A *temperature controller*, capable of maintaining the bath at a temperature constant to ±0.1°C over the range of 19°C to 26°C.

6.1.8 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 viscosity are torque, rotational speed, temperature, and time.

6.1.9 A *stand*, to support, level, lower and raise the drive motor, shaft and rotational element.

6.1.10 A specimen *container*, cylindrical in shape suitable for the rotational element (6.1.3), to contain the test specimen during testing.