Designation: ~~E2510 – 07 (Reapproved 2013)~~ E2510 – 20

Standard Test Method for Torque Calibration or Conformance of Rheometers[1]

This standard is issued under the fixed designation E2510; 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 conformance for the torque signal generated by commercial or custom-built rheometers. The specific range of the test depends upon the torque range of the rheometer.

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 There is no ISO standard equivalent to this test method.~~

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~~ safety, health, and ~~health~~environmental practices and determine the applicability of regulatory limitations prior to use.*

1.4 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]
E4 Practices for Force Verification of Testing Machines
E473 Terminology Relating to Thermal Analysis and Rheology
E617 Specification for Laboratory Weights and Precision Mass Standards
E1142 Terminology Relating to Thermophysical Properties

3. Terminology

3.1 Specific technical terms used in this test method are defined in Terminologies E473 and E1142. These terms include *angular frequency, frequency, loss modulus, rheometer, storage modulus, strain, stress, viscoelasticity, viscometer, viscometry*, and *viscosity*.

3.2 *Definitions:*

3.2.1 *torque, n*—force applied through a moment arm that produces or tends to produce rotation (N · m).

4. Summary of Test Method

4.1 A known force is applied to a rheometer coupling shaft through a moment arm to produce a torque. The torque thus applied is measured and compared to the ~~measured~~indicated torque. The ratio between indicated and applied torque is used to create a calibration coefficient that may be used in future determinations.

4.2 The known force generated by suspended precision mass or masses is transmitted to the rheometer coupling shaft by a line and an appropriate series of pulleys.

4.3 Torque is mathematically defined by Eq 1:

~~$$\tau = d\,F\sin\Phi \quad (1)$$~~

$$\tau = d\,F\sin\varphi \quad (1)$$

[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.

where:

τ = torque,
d = the length of the moment arm (m),
F = the applied force (N), and
φ = the angle to the moment arm over which the force is applied (°).

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~~τ = torque~~
~~d = the length of the moment arm (m)~~
~~F = the applied force (N)~~
~~Φ = the angle to the moment arm over which the force is applied (°)~~

4.3.1 If the force is applied tangentially at right angles (that is, ~~Φ~~φ = 90°) to the moment arm, then ~~sinΦ~~sinφ = 1 and Eq 1 reduces to Eq 2:

$$\tau = d\ F \tag{2}$$

4.4 The moment arm in this test method is created by attaching a fixture of known radius to the rheometer coupling shaft in lieu of a geometry, tool, or plate. The radius of the fixture is the value of d in Eq 2.

4.5 A force is applied to the fixture at a tangent by a suspended mass through a thin wire and a suitable pulley arrangement (see, for example, Fig. 1).

4.6 For a mass or masses of known value, the applied force is given by Eq 3:

~~$$F = M\ g\ f \tag{3}$$~~

$$F = M\ g\ f \tag{3}$$

where:

M = the suspended mass (kg),
g = standard acceleration due to gravity (=9.8065 m s^{-2}), and
f = correction factor for local gravity and air buoyancy taken from Table 1 (dimensionless).

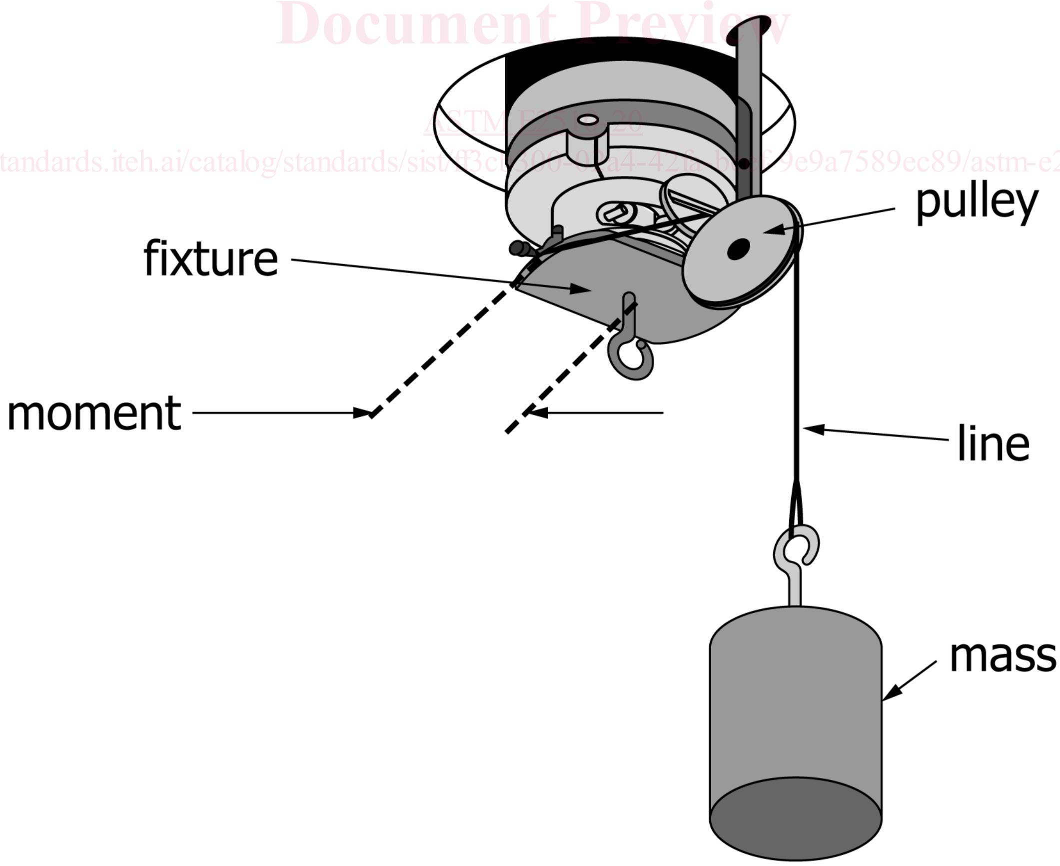

FIG. 1 Example of Suspended Mass

TABLE 1 Unit Force Exerted by a Unit Mass in Air at Various Latitudes and Elevations[A]

	Elevation Above Sea Level, m (ft)					
Latitude, °	–30.5 to 152 (–100 to 500)	152 to 457 (500 to 1500)	457 to 762 (1500 to 2500)	762 to 1067 (2500 to 3500)	1067 to 1372 (3500 to 4500)	1372 to 1676 (4500 to 5500)
	~~Elevation Above Sea Level, m (ft)~~					
~~Latitude, °~~	~~–30.5 to 152 (–100 to 500)~~	~~152 to 457 (500 to 1500)~~	~~457 to 762 (1500 to 2500)~~	~~762 to 1067 (2500 to 3500)~~	~~1067 to 1372 (3500 to 4500)~~	~~1372 to 1676 (4500 to 5500)~~
20	0.9978	0.9977	0.9976	0.9975	0.9975	0.9974
25	0.9981	0.9980	0.9979	0.9979	0.9978	0.9977
30	0.9985	0.9984	0.9983	0.9982	0.9982	0.9981
35	0.9989	0.9988	0.9987	0.9987	0.9986	0.9985
40	0.9993	0.9993	0.9992	0.9991	0.9990	0.9989
45	0.9998	0.9997	0.9996	0.9996	0.9995	0.9994
50	1.0003	1.0002	1.0001	1.0000	0.9999	0.9999
55	1.0007	1.0006	1.0005	1.0005	1.0004	1.0003

[A] Taken from Practice E4.

~~where:~~

~~M = the suspended mass (kg)~~
~~g = standard acceleration due to gravity (= 9.8065 m s^{-2})~~
~~f = correction factor for local gravity and air buoyancy taken from Table 1 (dimensionless)~~

5. Significance and Use

5.1 The test method calibrates or demonstrates conformity of the torque signal of a rheometer at ambient temperature.

5.2 A calibration factor thus determined may be used to obtain correct torque values.

5.3 This test method may be used in research, development, specification acceptance, and quality control or assurance.

6. Apparatus

6.1 *Rheometer*—The essential instrumentation required providing the minimum rheological analytical capabilities include:

6.1.1 *Drive ~~Actuator,~~actuator,* to apply torque or angular displacement to the specimen in a periodic manner capable of frequencies of oscillation from 0.001 to 100 rad/s. This actuator may also be capable of providing static torque or displacement on the specimen.

6.1.2 *Coupling ~~Shaft,~~shaft,* or other means to transmit the torque or displacement from the motor to the specimen.

6.1.3 *Geometry* or *~~Tool,~~tool,* to fix the specimen between the drive shaft and a stationary position.

6.1.4 *Sensor,* to measure the torque developed by the specimen, a position sensor to measure the angular displacement of 50 nanoradians of the test specimen, or both.

6.1.5 *Temperature ~~Sensor,~~sensor,* to provide an indication of the specimen temperature readable to within ~~±0.1°C.~~±0.1 °C.

6.1.6 *Furnace,* or *~~Heating/Cooling Element,~~heating/cooling element,* to provide controlled heating or cooling of a specimen at a constant temperature or at a constant rate within the temperature range of interest.

6.1.7 *Temperature ~~Controller,~~controller,* capable of executing a specific temperature program by operating the furnace or heating/cooling element between selected temperature limits constant to within ~~±0.1°C.~~±0.1 °C.

6.1.8 ~~*Recording Device,* capable~~A ~~*of recording and*~~*data collection device,* ~~displaying on the Y-axis any fraction of the measured signal (here applied torque) or calculated signal (such as viscosity, storage and loss modulus, etc.) including signal noise using a linear or logarithmic scale as a function of any fraction of the independent experimental parameter (such as temperature, time) or calculated signals (such as stress or strain) on the X-axis including signal noise.~~to provide a means of acquiring, storing, and displaying measured or calculated signals, or both. The minimum output signals required for rheology are torque, viscosity, storage modulus, loss modulus, and time

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

6.1.9.1 *Cooling ~~Capability,~~capability,* to hasten cool down from elevated temperatures, to provide constant cooling rates, or to sustain an isothermal sub-ambient temperature.

6.1.9.2 *Data ~~Analysis Capability,~~analysis capability,* to provide viscosity, storage and loss modulus, stress, strain, ~~etc.~~etc., or other useful parameters derived from the measured signals.

6.1.10 A test fixture of known radius to attach a tangentially applied load to the coupling shaft in lieu of the geometry, tool, or plate.

NOTE 1—Test fixtures of appropriate design may be obtained from the manufacture of the rheometry apparatus.

6.1.11 *Mass* or *~~Masses,~~masses,* with a suspending hook, the mass value for which are known to within ±0.1 % (see E617). The value of the required mass or masses depends upon the nominal torque range of the rheometer and is given by Eq 4: