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Standard Specification for Tensile Testing Machines for Textiles[1]

This standard is issued under the fixed designation D 76; 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 specification covers the operating characteristics of three types of tensile testing machines used for the determination of the force-elongation properties of textile materials. These types of tensile testing machines are:

1.1.1 Constant-rate-of-extension, CRE.

1.1.2 Constant-rate-of-traverse, CRT.

1.1.3 Constant-rate-of-loading (force), CRL.

1.2 Specifications for tensile testing machines to measure other tensile-related properties of textile materials not covered by this standard are given in the ASTM standards using those machines.

1.3 The values stated in SI units are to be regarded as standard; the values in inch-pound units are provided as information only and are not exact equivalents.

1.4 The following safety hazards caveat pertains only to the test methods described in this specification: *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:*

D 123 Terminology Relating to Textiles[2]

D 580 Specification for Greige Woven Glass Tapes and Webbings[2]

D 885 Methods of Testing Tire Cords, Tire Cord Fabrics, and Industrial Filament Yarns Made from Man-Made Organic-Base Fibers [Metric][2]

D 1578 Test Method for Breaking Strength of Skeins[2]

D 2256 Test Method for Tensile Properties of Yarns by the Single-Strand Method[2]

D 3822 Test Method for Tensile Properties of Single Textile Fibers[3]

D 5034 Test Method for Breaking Strength and Elongation of Textile Fabrics (Grab Test)[3]

D 5035 Test Method for Breaking Strength and Elongation of Textile Fabrics (Strip Method)[3]

E 4 Practices for Force Verification of Testing Machines[4]

E 74 Practice of Calibration of Force-Measuring Instruments for Verifying the Force Indication of Testing Machines[4]

3. Terminology

3.1 *Definitions:*

3.1.1 *bench marks*, *n*—marks placed on a specimen to define gage length, that is, the portion of the specimen that will be evaluated in a specific test.

3.1.2 *calibrate*, *v*—to determine and record the relationship between a set of standard units of measure and the output of an instrument or test procedure.

3.1.2.1 *Discussion*—This term is also commonly used to describe the checking of previously marked instruments, an operation more properly described as a description of verification.

3.1.3 *capacity*, *n—for tensile testing machines*, the maximum force for which the machine is designed.

3.1.3.1 *Discussion*—Capacity is the maximum force the tester-frame and the drive system can exercise on the specimen without inadmissible deformations of the tester-frame, etc. Within its capacity, there are available load-cells with different full-scale-ranges which may be chosen to select an appropriate full-scale-range for a special test.

3.1.4 *clamp*, *n*—that part of a testing machine used to grip the specimen by means of suitable jaws.

3.1.5 *constant-rate-of-extension (CRE) type tensile testing machine (CRE)*, *n—in tensile testing*, an apparatus in which the pulling clamp moves at a uniform rate, and the force-measuring mechanism moves a negligible distance with increasing force, less than 0.13 mm (0.005 in.).

3.1.6 *constant-rate-of-load tensile testing machine (CRL)*, *n—in tensile testing*, an apparatus in which the rate of increase of the force is uniform with time after the first 3 s and the

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[2] *Annual Book of ASTM Standards*, Vol 07.01.

[3] *Annual Book of ASTM Standards*, Vol 07.02.

[4] *Annual Book of ASTM Standards*, Vol 03.01.

specimen is free to elongate, this elongation being dependent on the extension characteristics of the specimen at any applied force.

3.1.7 *constant-rate-of-traverse tensile testing machine (CRT)*, *n—in tensile testing*, an apparatus in which the pulling clamp moves at a uniform rate and the force is applied through the other clamp, which moves appreciably to actuate a force-measuring mechanism, producing a rate of increase of force or extension that is usually not constant and is dependent on the extension characteristics of the specimen.

3.1.8 *effective carriage mass*, *n— in CRL-type tensile testing machine*, the force actually applied to a specimen by the mass of the carriage, plus any added weight.

3.1.9 *effective gage length*, *n— in tensile testing*, the estimated length of the specimen subjected to a strain equal to that observed for the true gage length.

3.1.9.1 *Discussion*—The effective gage length can be calculated using the following equation:

$$G_E = G_N \times \frac{E_N}{E_T} \quad (1)$$

where:
G_E = effective gage length,
G_N = nominal gage length,
E_N = percent elongation based on nominal gage length, and
E_T = percent elongation based on true gage length.

3.1.10 *grip*, *v—in tensile testing*, to hold, grasp, or secure, for example, to grip the specimen by the jaws of the clamps.

3.1.11 *jaw face*, *n—in tensile testing machines*, the surface of a jaw which in the absence of a liner contacts the specimen.

3.1.12 *jaw liner*, *n—in tensile testing machines*, any material placed between the jaw face and the specimen to improve the holding power of the jaws.

3.1.13 *jaws*, *n—in tensile testing machines*, the elements of a clamp which grip the specimen.

3.1.14 *least count*, *n—in tensile testing machines*, the smallest change in the indicated property that can customarily be determined (*see also sensitivity*).

3.1.14.1 *Discussion*—In tensile testing machines with close graduations for force or elongation indications, the least count may be the value of a graduation interval; with open graduations, or with magnifiers for reading, the least count may be an estimated fraction (rarely as fine as 0.1) of a graduation interval; and with verniers, the least count is ordinarily the difference between the scale and vernier graduations measured in terms of scale units. If the indicating mechanism includes a stepped detent, the detent action may determine the least count. (See also *sensitivity, in mechanical systems.*)

3.1.15 *nominal gage length*, *n— in tensile testing*, (*1*) the length of a specimen under specified pretension measured from nip-to-nip of the jaws of the holding clamps in their starting position at the beginning of the test, and including any portion of the specimen in contact with bollard or snubbing surfaces.

(*2*) the length of a specimen under specific pretension between frets, in instruments where the specimen is not held by clamps, for example, in a vibroscope.

(*3*) the length of a specimen measured between the points of attachment to the tabs while under specified pretension.

3.1.15.1 *Discussion*—The calculated percentage of elongation based on the nominal gage length may be in error due to extension of that part of the specimen which lies between the jaws of the clamps.

3.1.16 *response time*, *n— in tensile testing machines*, the time required by the indicating or recording device to reflect an instantaneous change in force, usually 0 to 90% of full scale.

3.1.17 *sensitivity*, *n— in electronic systems*, the minimum change in the input signal that produces a change in the output signal that can be reliably measured.

3.1.17.1 *Discussion*—Sometimes the term sensitivity is used for the ratio of the response or change induced in the output to a stimulus or change in the input. For this ratio "amplification" is a better term.

3.1.18 *sensitivity*, *n— in mechanical systems*, the smallest change that can be induced on a material by the system and be reliably measured. (See also least count.)

3.1.19 *stress*, *n*—the resistance to deformation developed within a material subjected to an external force.

3.1.20 *tensile testing machine*, *n*—an apparatus designed to impart, or transmit, force/extension, or stress/strain, to a material and to measure the effect of the action. (See also constant-rate-of-extension tensile testing machine, constant-rate-of-load type tensile testing machine, constant-rate-of-traverse tensile testing machine.)

3.1.21 *test skein*, *n*—a small skein which has a prescribed length of yarn and is used for the determination of linear density or breaking, or both.

3.1.22 *time-to-break*, *n*—the time interval during which a specimen is under prescribed conditions of tension and is absorbing the energy required to reach maximum load.

3.1.22.1 *Discussion*—Time-to-break does not include the time required to remove slack from the specimen.

3.1.23 *true gage length*, *n—in tensile testing*, a precise length between welldefined bench marks located on the specimen while under known tension in the unsupported portion between the holding clamps and free from contact with any snubbing surfaces or other sources which could result in nonuniform strain.

3.1.24 *verify*, *v*—(*1*) to determine whether a previously calibrated instrument, standard solution, or other standard is still properly calibrated, (*2*) to establish that an operation has been completed correctly.

3.1.25 For definitions of other textile terms used in this specification, refer to Terminology D 123.

3.2 *Abbreviations:*

3.2.1 CRE—constant-rate-of-extension.

3.2.2 CRL—constant-rate-of-load.

3.2.3 CRT—constant-rate-of-traverse.

4. Performance Requirements

4.1 Individual ASTM methods for tensile testing of textile materials that prescribe apparatus which conforms to this specification shall also include such other detailed specifications as may be necessary to describe the testing machine and its operation completely.

4.1.1 This specification shall not be construed as being intended to preclude the evolution of improved methods of testing or testing apparatus, which is recognized as being vital in an advancing technology.

4.2 Comparison of results from tensile testing machines operating on different principles is not recommended. When these machines are used for comparison testing however, constant time-to-break at 20 ± 3 s is the established way of producing data, but even then the data may differ significantly.

4.2.1 Comparison of test data from machines of the same type, especially two or more CRT-type or two or more CRL-type machines, requires consideration of the effect of individual machine characteristics; for example, inertia effects, capacity, sensitivity, type of loadcell, etc., which may cause significant differences in results even though uniform procedures are employed. Data from different CRE-type testing machines, however, should not be significantly different.

4.2.2 In any case, all types of tensile testing machines must satisfy the accuracy requirements as given in Section 7.

4.3 While changes in humidity affect the tensile properties of many textile materials, changes in humidity normally do not affect the testing machines themselves.

4.4 When machines are moved to different locations, their calibration shall be verified to make sure that they still meet the specified tolerances.

4.5 When each of the sub-systems (force, extension, clamping) has been individually calibrated, verified, or checked, it is recommended that the total system be verified using a standard material appropriate for the type testing to be carried out.[5] This testing of the total system is the established way of ensuring that the clamping system is operating properly.

5. Apparatus

5.1 *Tensile Testing Machines*—Tensile testing machines for textile materials are classified according to their operating principle as follows:

Type	Principle of Operation
CRE	Constant rate-of-extension
CRT	Constant rate-of-traverse (pendulum type)
CRL	Constant rate-of-load (inclined plane type)

5.1.1 *CRE-Type*—A testing machine in which the pulling clamp moves at a uniform rate, and the force-measuring mechanism (load cell) moves a negligible distance with increasing force less than 0.13 mm (0.005 in.).

5.1.2 *CRT-Type*—A testing machine in which the pulling clamp moves at a uniform rate and the force is applied through the other clamp, which moves appreciably to actuate a force-measuring mechanism, producing a rate of increase of force or extension which is usually not constant and is dependent on the extension characteristics of the specimen.

5.1.3 *CRL-Type*—A testing machine in which the rate of increase of the force is uniform with time after the first 3 s and the specimen is free to elongate, this elongation being dependent upon the extension characteristics of the specimen at any applied force.

5.1.4 *Multiple-Purpose Type*—Machines capable of being operated as both a CRE-type and a CRL-type may be used.

5.2 *Measuring Devices*—Machines shall be equipped with a suitable device for measuring the force and, when needed, a device to measure elongation. Preferably a force-elongation curve shall be recorded graphically, or the force and elongation data may be indicated on appropriate scales or displays.

5.2.1 Most testing machines record only force-elongation data. When the capacity of a testing machine is adjusted to fit the predetermined linear density or cross-sectional area of the specimen, the force recorded will be stress. When the machine is adjusted to record extension in terms of unit specimen length, the chart can be read directly in percent elongation or strain. When these conditions do not exist, the force-elongation curve must be converted to obtain stress-strain characteristics.

5.2.2 The force-indicating and force-recording devices shall be in conformance with the requirements of this specification as to accuracy, sensitivity, and response time, and shall permit calibration or verification by appropriate methods described or referenced herein.

5.3 *Clamping or Holding Devices*—Specimen clamping or holding devices shall be prescribed in the individual test methods in sufficient detail for all users to employ the same or comparable devices.

5.3.1 The prescribed specimen clamping or holding devices shall be designed to ensure that the pulling axis of the testing machine and the central axis of a properly mounted specimen coincide.

5.3.2 The clamping or holding device may be designed for manual or automatic mounting of specimens.

5.3.3 The required clamping force can be obtained with the clamping or holding devices by any suitable mechanism; for example, screw, cam action, pneumatic, or toggle.

5.3.4 Clamping surfaces in contact with a test specimen shall be of any suitable material and configuration which provides the required restraint, preclude slippage, and minimize specimen failure in the clamped areas. Clamp liners may be used, provided the above conditions are met.

5.3.5 When the flat-faced type clamp proves unsatisfactory because of slippage or excessive breakage in the clamp, snubbing type devices (capstan, drum, split-drum, etc.) may be used.

5.4 *Calibrating Devices*—Calibrating weights or other calibrating devices conforming to Practice E 74 are required for verification of calibration. Calipers, a steel rule that can be read to 0.25 mm (0.01 in.), or a suitable cathetometer, and a stop watch are required for verification of recorded elongation, and crosshead and chart speed.

6. Machine Operational Design

6.1 The use of motor-driven machines is preferred over manually driven machines because of improved control of testing.

6.2 Testing machines of the CRT-type shall not be used for measuring forces below fifty times their resolution. For example, if the minimum force that can be read is 0.5 cN (0.5 gf), the testing machine may not be used for materials which test at 25.0 cN (25 gf) or less.

[5] Two styles of standard break fabrics obtained from Testfabrics, Inc., P.O. Drawer O, Middlesex, NJ 08846 have been found satisfactory for this purpose. See also A1.3 of this specification.

6.2.1 Choose the full scale force such that the expected maximum force falls within:

6.2.1.1 10 to 90% full scale for the CRE-type testing machines,

6.2.1.2 15 to 85% full scale for the CRT-type testing machines,

6.2.1.3 15 to 85% full scale for the CRL-type testing machines,

6.3 Machines shall operate at a uniform rate of pulling clamp (CRE), and (CRT), or loading (CRL) as specified in 6.4, 6.5, and 6.6.

6.3.1 Machines may be built for operating at various rates of operation or at a single constant rate.

6.3.2 When machines are intended for operation at a specified or required average time to break as specified in individual standards (for example, 20 s to break as in Test Method D 2256 and Test Methods D 1682) then their rate of operation must be adjustable. The adjustment may be continuous or in steps not exceeding 125:100. Machines with a continuously adjustable rate of operation shall be equipped with a device indicating the rate of operation.

6.3.3 The machine rate of operation shall be within the tolerances prescribed in the individual standards.

6.4 *CRE-Type*:

6.4.1 Machines shall be designed for operation at such uniform rates of pulling clamp as are specified in individual standards.

6.4.2 The force-measuring system, including the recording mechanism, shall have a full-scale pen response time less than 2 s in either direction. In addition, the response time for pen deflections of less than full scale shall be proportional to the fraction of full-scale time represented by those deflections within a tolerance of ±10% of the nominal full-scale response time.

NOTE 1—The response time of the recording mechanism is the limiting factor affecting the choice of a rate for testing. The rate chosen shall give the maximum slope of the recorded curve which does not exceed one half of the slope of the maximum pen speed. See Fig. 1.

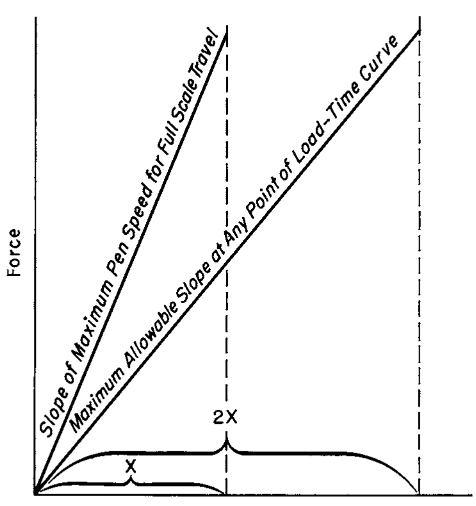

FIG. 1 Limitations on Response Speed of Recorder Pen

6.5 *CRT-Type*—Machines shall be designed for operation of the pulling clamp at a uniform rate as specified in individual standards.

6.6 *CRL-Type*—Machines shall be designed to apply forces at a uniform rate, or at a uniform rate of loading per unit of specimen linear density, as specified in individual standards.

6.7 Machines may be built for either manual or automatic mounting of the specimen into the clamp or holding devices.

7. Tolerance on Indicated Force, Recorded Elongation, Nominal Gage Length, and Speed of Moving Clamp

7.1 On instruments where the capacity of the force measuring mechanism (load cell) is used for digital analysis without regard to the full scale force displayed on the recorder, the maximum allowable error in force indication shall be ±0.5 % of the reading for CRE-type machines and ±1.0 % for CRT- and CRL-type machines (see Section 8).

7.2 The maximum allowable error in recorded grip displacement shall be ±1% of the recorded values for CRE-type machines and± 2.5 mm (0.5 in.) for CRT- and CRL-type machines (see Section 9 for CRE-type machines and Section 10 for CRT- and CRL-type machines).

7.3 The maximum allowable variation in nominal gage length on repeated return of the clamps to their starting position shall be less than 0.25 mm (0.01 in.).

7.4 The maximum allowable variation of crosshead speed of the CRE-type tester or moving clamp of the CRT-type tester from the required testing speed shall be less than 4%.

7.5 The maximum allowable variation of the loading rate for the CRL-type of tester from the required rate shall be less than 5%.

8. Verification of Indicated Force

8.1 This section provides a general procedure for the verification of the force calibration of tensile testing machines for textiles. No attempt is made to give detailed instructions applicable to any particular case. The verification should be performed or supervised by a qualified person competent to exercise scientific judgment in matters not covered herein. Detailed instructions are given in Annex A1 covering verification of one variety of testing machine of the CRL-type.

8.2 Verify tensile testing machines as directed in the applicable procedure and at the suggested time intervals listed in Practices E 4, except as otherwise provided in the following paragraphs.

8.3 Verify the machine in the condition under which it is used, with all attachments and recording mechanisms in operation if they are to be used in actual testing; but with any pawls or other detent device in the force-measuring mechanism rendered inoperative. Following the application of each test force, eliminate the effect of friction by gently oscillating the force-measuring mechanism or by tapping the machine to ensure that the applied force is in equilibrium with the force registered by the measuring mechanism.

8.4 Examine the measuring, indicating, and recording mechanisms for friction or slack. Estimate, in terms of the units in which the machine is calibrated, the magnitude of such factors and, if excessive, reduce the error at the source to conform to the tolerance as stated in 7.1.