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INTERNATIONAL

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Standard Test Method for Tensile Properties of Reinforced Thermosetting Plastics Using Straight-Sided Specimens[1]

This standard is issued under the fixed designation D5083; 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.

~~ε1 NOTE—Editorially corrected Fig. 1 in February 2015.~~

1. Scope*

1.1 This test method covers the determination of the tensile properties of thermosetting reinforced plastics using test specimens of uniform nominal width when tested under defined conditions of pretreatment, temperature, humidity, and testing-machine speed.

NOTE 1—Experience with this test method to date has been limited to glass-reinforced thermosets. Applicability to other materials remains to be determined.

1.2 This test method ~~can be~~ is used for testing materials of any thickness up to 14 mm (0.55 in.).

NOTE 2—This test method is not intended to cover precise physical procedures. It is recognized that the constant-rate-of-crosshead-movement type of test leaves much to be desired from a theoretical standpoint, that wide differences may exist between rate-of-crosshead movement and rate of strain between ~~gage~~gauge marks on the specimen, and that the testing speeds specified disguise important effects characteristic of materials in the plastic state. Further, it is realized that variations in the thicknesses of test specimens that are permitted by these procedures, produce variations in the surface-volume ratios of such specimens, and that these variations may influence the test results. Hence, where directly comparable results are desired, all samples should be of equal thickness. Special additional tests should be used where more precise physical data are needed.

NOTE 3—Use of this test method for testing materials of thicknesses greater than 14 mm (0.55 in.) is not recommended. Reducing the thickness by machining may be acceptable for materials of uniform reinforcement amount and direction, but is generally not recommended.

1.3 Test data obtained by this test method is relevant and appropriate for use in engineering design.

1.4 The values stated in SI units are to be regarded as standard. The inch-pound units given in parentheses are for information only.

1.5 *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.*

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NOTE 4—This ~~test method is technically equivalent to ISO 527-4 except as noted below:~~standard and ISO 527-4 address ~~(a) This test method does not include testing of the Type I dogbone shaped specimen described in ISO 527-4. Testing of this type of specimen, primarily used for reinforced and un-reinforced thermoplastic materials, is described in Test Method~~ the same subject matter, ~~D638~~. ~~(b) The thickness of test specimens in this test method includes the 2 mm to 10 mm thickness range of ISO 527-4, but expands the allowable test thickness to 14 mm.~~but differ in technical content.

(a) This test method does not include testing of the Type I dogbone shaped specimen described in ISO 527-4. Testing of this type of specimen, primarily used for reinforced and un-reinforced thermoplastic materials, is described in Test Method D638.

(b) The thickness of test specimens in this test method includes the 2 mm to 10 mm thickness range of ISO 527-4, but expands the allowable test thickness to 14 mm.

(c) ISO 527-4 allows for the use of holes in the tabs of the test specimen while this standard does not.

(d) The definitions for tensile strength and modulus differ between these two standards.

NOTE 5—For tensile properties of resin-matrix composites reinforced with oriented continuous or discontinuous high modulus > ~~20-Gpa~~20-GPa (> 3.0 × 10^6 -psi) fibers, tests shall be made in accordance with Test Method D3039/D3039M or ISO 527 Part 5.

2. Referenced Documents

2.1 *ASTM Standards:*[2]

D618 Practice for Conditioning Plastics for Testing

[1] This test method is under the jurisdiction of ASTM Committee D20 on Plastics and is the direct responsibility of Subcommittee D20.10 on Mechanical 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.

***A Summary of Changes section appears at the end of this standard**

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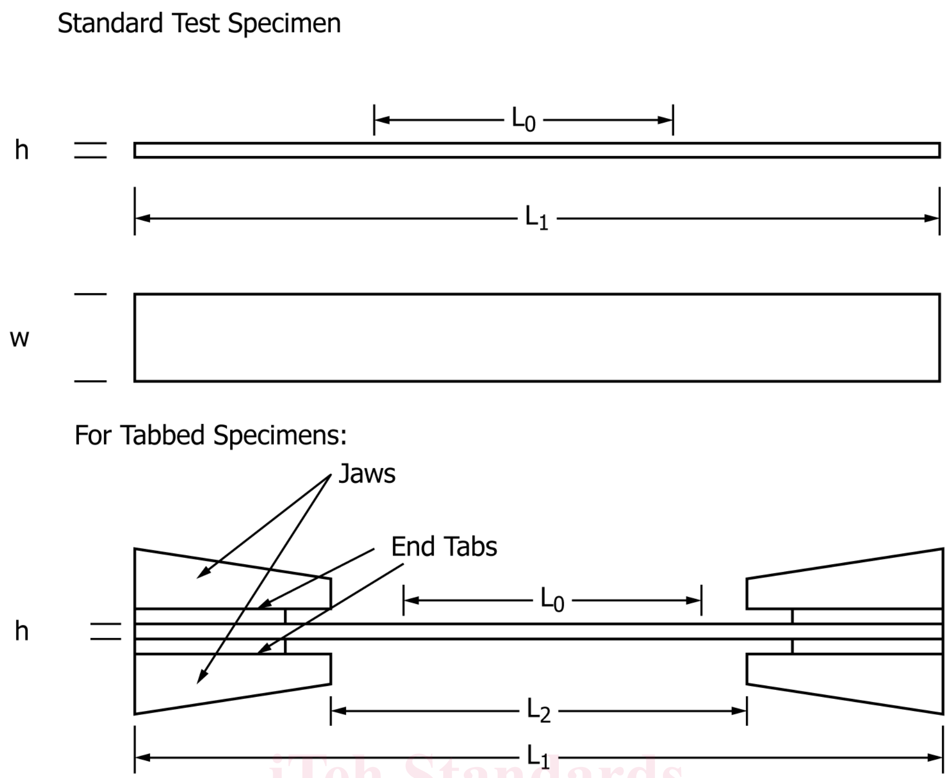

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Standard test specimen:		Dimensions in millimetres
L_1	Overall specimen length	≥250
w	Width	25 ±.5
h	Thickness	2 to 14
L_0	Gage length (recommended for extensometers)	50 ± 1
With optional end tabs:		
L_2	Distance between end tabs	
t	Thickness of end tabs	

FIG. 1 Standard and End Tabbed Specimen Dimensions

D638 Test Method for Tensile Properties of Plastics
D883 Terminology Relating to Plastics
D3039/D3039M Test Method for Tensile Properties of Polymer Matrix Composite Materials
D4000 Classification System for Specifying Plastic Materials
D5947 Test Methods for Physical Dimensions of Solid Plastics Specimens
E4 Practices for Force Verification of Testing Machines
E83 Practice for Verification and Classification of Extensometer Systems
E691 Practice for Conducting an Interlaboratory Study to Determine the Precision of a Test Method

2.2 *ISO Standard:*[3]

ISO 527 Plastics—Determination of Tensile Properties—Part 1: General Principles
ISO 527 Part 4 Plastics—Determination of Tensile Properties—Test Conditions for Isotropic and Orthotropic Fiber-Reinforced Plastic Composites
ISO 527 Plastics—Determination of Tensile Properties—Part 5: Test Conditions for Unidirectional Fiber-Reinforced Plastic Composites
ISO 1268 Fibre-Reinforced Plastics—Methods of Producing Test Plates

[3] Available from American National Standards Institute (ANSI), 25 W. 43rd St., 4th Floor, New York, NY 10036, http://www.ansi.org.

3. Terminology

~~3.1 *Definitions*—Definitions of terms applying to this test method appear in Terminology D883.~~

3.1 *Definitions*—Definitions of terms applying to this test method appear in Terminology D883 and D638.

4. Significance and Use

4.1 This test method is intended for tensile testing of fiber-reinforced thermosetting laminates. For injection molded thermoplastics, both reinforced and unreinforced, Test ~~Methods~~Method D638 is recommended. For most unidirectional fiber reinforced laminates, Test Methods D3039/D3039M is preferred.

4.2 This test method is designed to produce tensile property data for quality control and research and development. ~~Factors~~ Report all factors that influence the tensile properties, ~~and should therefore be reported, are:~~ such as: material, methods of material and specimen preparation, specimen conditioning, test environment, speed of testing, void content, and volume percent reinforcement. See Section 12 for reporting requirements.

4.3 It is realized that a material cannot be tested without also specifying the method of preparation of that material. Hence, when comparative tests of materials per se are desired, the greatest care must be exercised to ensure that all samples are prepared in exactly the same way, unless the test is to include the effects of sample preparation. Similarly, for referee purposes or comparisons within any given series of specimen, care must be taken to secure the maximum degree of uniformity in details of preparation, treatment, and handling.

NOTE 6—Preparation techniques for reinforced thermosetting plastics can be found in the part of ISO 1268 appropriate to the manufacturing technique for the laminate.

4.4 ~~Tensile properties may provide useful data for engineering design purposes. However, because~~ Because of the high degree of sensitivity exhibited by many reinforced plastics to rate of straining and environmental conditions, data obtained by this test method cannot be considered valid for applications involving load-time scales or environments widely different from those of this test method. In cases of such dissimilarity, no reliable estimation of the limit of usefulness can be made for most plastics. This sensitivity to rate of straining and environment necessitates testing over a broad load-time scale (including impact and creep) and range of environmental conditions.

NOTE 7—Since the existence of a true elastic limit in plastics (as in many other organic materials and in many metals) is debatable, the propriety of applying the term "elastic modulus" in its quoted generally accepted definition to describe the "stiffness" or stress-strain characteristics of plastic materials is highly dependent on such factors as rate of application of stress, temperature, previous history of specimen, etc. However, stress-strain curves for plastics, determined as described in this test method, almost always show a linear region at low stresses. A straight line drawn tangent to this portion of the curve permits calculation of an elastic modulus of the usually defined type. Such a constant is useful if its arbitrary nature and dependence on time, temperature, and similar factors are realized.

4.5 For ~~many~~some materials, there ~~may be a specification that requires~~are specifications that require the use of this test method, but with some procedural modifications that take precedence when adhering to the specification. Therefore, it is advisable to refer to that material specification before using this test method. Table 1 of Classification D4000 lists the ASTM materials standards that currently exist.

5. Apparatus

5.1 *Testing Machine*—A testing machine of the constant-rate-of-crosshead-movement type and comprising essentially the following:

5.1.1 *Fixed Member*—A fixed or essentially stationary member carrying one grip.

5.1.2 *Movable Member*—A movable member carrying a second grip.

5.1.3 *Grip:*

5.1.3.1 Grips for holding the test specimen between the fixed member and the movable member. The grips shall be self-aligning, that is, they shall be attached to the fixed and movable member, respectively, in such a manner that they will move freely into alignment as soon as any load is applied, so that the long axis of the test specimen will coincide with the direction of the applied load through the center line of the grip assembly. Align the specimen as perfectly as possible with the direction of pull so that no rotary motion that ~~may induce~~ induces slippage will occur in the grips; there is a limit to the amount of misalignment self-aligning grips will accommodate.

5.1.3.2 Mount the test specimen in such a way that slippage relative to the grips is prevented insofar as possible. Grip surfaces that are deeply scored or serrated with a pattern similar to those of a coarse single-cut file, that is, serrations about ~~0.09 in. (2.4 mm)~~2.4 mm (0.09 in.) apart and about ~~0.06 in. (1.6 mm)~~1.6 mm (0.06 in.) deep or finer, have been found satisfactory for most thermosetting materials. The serrations ~~should~~ need to be kept clean and sharp. ~~Breaking~~ If breaking in the grips ~~may occur at times,~~ occurs, even when deep serrations or abraded specimen surfaces are used; other techniques ~~must be used in these cases.~~ need to be employed. Other techniques that have been found useful, particularly with smooth-faced grips, are abrading that portion of the surface of the specimen that will be in the grips, and interposing thin pieces of abrasive cloth, abrasive paper, or plastic or rubber-coated fabric, commonly called hospital sheeting, between the specimen and the grip surface. Number 80 double-sided

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abrasive paper has been found effective in many cases. An open-mesh fabric, in which the threads are coated with abrasive, has also been effective. The use of special types of grips is sometimes necessary to eliminate slippage and breakage in the grips.

5.1.4 *Drive Mechanism*—A drive mechanism for imparting to the movable member a controlled velocity with respect to the stationary member, this velocity to be regulated as specified in Section 8.

5.1.5 *Load Indicator*—A suitable load-indicating mechanism capable of showing the total tensile load carried by the test specimen when held by the grips. This mechanism shall be essentially free of inertia lag at the specified rate of testing and shall indicate the load with an accuracy of ±1 % of the indicated value, or better. The accuracy of the testing machine shall be verified in accordance with Practices E4.

NOTE 8—Experience has shown that many testing machines now in use are incapable of maintaining accuracy for as long as the periods between inspection recommended in Practices E4. Hence, it is recommended that each machine be studied individually and verified as often as may be found necessary. It may be necessary to perform this function daily.

5.1.6 The fixed member, movable member, drive mechanism, and grips shall be constructed of such materials and in such proportions that the total elastic longitudinal strain of the system constituted by these parts does not exceed 1 % of the total longitudinal strain between the two ~~gage~~gauge marks on the test specimen at any time during the test and at any load up to the rated capacity of the machine.

5.2 *Strain*—~~Strain may be determined~~ Determine strain by means of an extension indicator or strain indicator. If Poisson's ratio is to be determined, the specimen must be instrumented to measure strain in both longitudinal and lateral directions.

5.2.1 *Extension Indicator (Extensometer)*—A suitable instrument for determining the distance between two designated fixed points within the ~~gage~~gauge length of the test specimen as the specimen is stretched. It is desirable, but not essential, that this instrument automatically record the distance, or any change in it, or of the elapsed time from the start of the test, or both. If only the latter is obtained, load-time data must also be taken. This instrument shall be essentially free of inertia at the specified speed of testing. Extensometers shall be classified and calibration periodically verified in accordance with Practice E83.

5.2.2 *Modulus Measurements*—For modulus measurement, an extensometer with a maximum strain error of 0.0002 mm/mm or 0.0002 in./in. that automatically and continuously records strain shall be used. A Class B-2 extensometer (see Practice E83) meets this requirement.

5.2.3 *Low-Extension Measurements*—For low-extension measurements beyond the modulus range but below 20 % extension, the extensometer system must meet, at least, Practice E83 Class C requirements. This requires a fixed strain error of ~~.00025~~0.0025 mm ~~(.001~~(0.001 in.) or less, or the capability of reading to ±1 % of the indicated strain, whichever is greater.

5.2.4 *High-Extension Measurements*—For measurements greater than 20 %, and beyond the yield point of the material, strain-measuring techniques with error no greater than ±10 % of the measured value are acceptable.

5.2.5 ~~When desired,~~ If the specimen ~~may be~~ is instrumented with strain ~~gages. Proper~~gauges, proper preparation of the specimen surface and ~~gage~~gauge as well as mounting of the ~~gage~~gauge to the specimen surface, is mandatory to ensure reliable and accurate strain measurements.

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NOTE 9—Bonded strain ~~gages~~gauges can accurately measure strain directly below the ~~gage.~~gauge. Reinforced or discontinuous laminates may produce localized strain fields directly under the ~~gage~~gauge that are not identified by standard averaging extensometers. For strain ~~gages~~gauges whose lengths are too short, localized strain fields under the ~~gage~~gauge may cause misleading results.

5.3 *Micrometers:*

5.3.1 ~~Suitable micrometers~~Micrometers suitable for measuring the width and thickness of the test specimen to an incremental discrimination of at least 0.025 mm (0.001 in.) ~~should~~shall be used. All width and thickness measurements of rigid and semirigid plastics ~~may be~~are usually measured with a hand micrometer with ratchet. A suitable instrument for measuring the thickness of non-rigid test specimens shall have: a contact measuring pressure of 25 ± 2.5 kPa (3.6 ± 0.36 psi); a movable circular contact foot 6.35 ± 0.025 mm (0.250 ± 0.001 in.) in diameter; and a lower fixed anvil large enough to extend beyond the contact foot in all directions and parallel to the contact foot within 0.005 mm (0.0002 in.) over the entire foot area. Flatness of foot and anvil shall conform to Test Methods D5947.

5.3.2 An optional instrument equipped with a circular contact foot 15.88 ± 0.08 mm (0.625 ± 0.003 in.) in diameter is recommended for thickness measuring of process samples or larger specimens at least 15.88 mm (0.625 in.) in minimum width.

6. Test Specimen

6.1 *Geometry:*

6.1.1 The test specimen shall be of uniform nominal width. These specimens ~~may be prepared by cutting materials~~ are cut from sheets or plates or ~~may be~~ prepared by compression or injection molding of the material to be tested. Take care in machining the sides of the specimen so that smooth flat parallel surfaces and sharp clear edges to within 0.025 mm (0.001 in.) result.

6.1.2 The standard test specimen shall be in the form of a rectangular prism. The preferred specimen size is as follows:
Overall length: >250 mm
Width: 25 mm ± .5 mm
Thickness: between 2 mm and 14 mm.