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.

INTERNATIONAL

Designation: D5083 – 17

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.

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 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 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.*

NOTE 4—This standard and ISO 527-4 address the same subject matter, 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 (> 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
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

[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.

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

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

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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. Terminology

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 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. Report all factors that influence the tensile properties, 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 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 some materials, there 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 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 2.4 mm (0.09 in.) apart and about 1.6 mm (0.06 in.) deep or finer, have been found satisfactory for most thermosetting materials. The serrations need to be kept clean and sharp. If breaking in the grips occurs, even when deep serrations or abraded specimen surfaces are used; other techniques 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 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 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*—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 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 0.0025 mm (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 If the specimen is instrumented with strain gauges, proper preparation of the specimen surface and gauge as well as mounting of the gauge to the specimen surface, is mandatory to ensure reliable and accurate strain measurements.

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

5.3 *Micrometers:*

5.3.1 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.) shall be used. All width and thickness measurements of rigid and semirigid plastics 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 are cut from sheets or plates or 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.

6.1.3 Normally test specimens do not need to be end tabbed. If during the testing, the specimen slips or breaks in the grips the use of bonded end tabs has been found to be helpful. The recommended tabs have a length of 50 mm. Tabs shall be placed at the ends of the specimen and on both sides of the specimen described in 6.1.2. Thickness of the end tabs shall be 1 to 3 mm. End tabs are made of cross-ply or fabric glass fiber/resin laminate with the fibers at ±45 degrees to the specimen. Alternative tabbing arrangements are permissible, but shall be shown, before use, to give at least equal strength and no greater coefficient of variation than the recommended tabs. Possible alternatives include tabs made from the material under test, mechanically fastened tabs, unbonded tabs made of rough material (such as emery paper or sandpaper, and the use of roughened grip faces).

NOTE 10—ISO 527 Part 4 designates specimens without end tabs as Type 2 and with end tabs as Type 3.

NOTE 11—Machining the thickness of laminates with certain constructions (such as woven roving) can change the material properties. In such cases, test the specimen in the as-produced thickness up to a maximum of 14 mm (0.55 in.).

6.2 *Preparation*—Prepare the test specimens by machining from materials in sheet, plates, slab, or similar form or by molding the material to be tested.

NOTE 12—Specimens prepared by injection molding may have different tensile properties than specimens prepared by machining because of the orientation induced. This effect may be more pronounced in specimens with narrow sections.

6.2.1 All surfaces of the specimen shall be free of visible flaws, scratches, or imperfections. If specimens are cut with a saw utilizing a water-cooled diamond abrasive blade there is no need for further sanding. If another type of device is used, carefully remove the marks left by coarse machining operations with a fine file or abrasive. The filed surfaces shall then be smoothed with abrasive paper (No. 00 or finer). Make sure that finishing sanding strokes are in a direction parallel to the long axis of the test specimen. Remove all flash from a molded specimen, taking care not to disturb the molded surfaces. In machining a specimen, avoid undercuts that would exceed the dimensional tolerances. Take care to avoid other common machining errors.

6.2.2 If it is necessary to place gauge marks on the specimen, make these with a wax crayon or India ink that will not affect the material being tested. Do not scratch, punch, or impress the specimen when making gauge marks.

6.2.3 When testing materials that are anisotropic, prepare duplicate sets of test specimens with their long axes respectively parallel with, and normal to, the suspected direction of anisotropy.

7. Number of Test Specimens

7.1 Test at least five specimens for each sample in the case of isotropic materials.

7.2 Test ten specimens, five normal to, and five parallel with the principal axis of anisotropy, for each sample in the case of anisotropic materials.

7.3 Discard specimens that break at some obvious fortuitous flaw, or that do not break between grips. Make retests, unless such flaws constitute a variable to be studied.

8. Speed of Testing

8.1 Speed of testing shall be the relative rate of motion of the grips or test fixtures during the test. Use the rate of motion of the driven grip or fixture when the testing machine is running idle if it can be shown that the resulting speed of testing is within the limits of variation allowed in Section 8 of Test Method D638.

8.2 The standard speed of testing shall be 5 mm/min for stress testing unless otherwise specified.

8.3 Modulus determinations are made at 2 mm/min.

9. Conditioning

9.1 *Conditioning*—Condition the test specimens in accordance with Procedure A of Practice D618, unless otherwise specified by contract or the relevant ASTM material specification. Conditioning time is specified as a minimum. Temperature and humidity tolerances shall be in accordance with Section 7 of Practice D618 unless specified differently by contract or material specification.

9.2 *Test Conditions*—Conduct tests at the same temperature and humidity used for conditioning with tolerances in accordance with Section 7 of Practice D618 unless otherwise specified by contract or the relevant ASTM material specification.

10. Procedure

10.1 Measure the width and thickness of the rigid flat specimen with a suitable micrometer to the nearest 0.025-mm (0.001-in.) at several points along its length. Calculate and record the minimum value of the cross-sectional area. Also determine and record the average cross-sectional area for modulus calculations (see 11.2).

10.2 Place the specimen in the grips of the testing machine, taking care to align the long axis of the specimen and the grips with an imaginary line joining the points of attachment of the grips to the machine. The distance between the ends of the gripping surfaces, when using flat specimens, shall be 150 ± 1 mm for specimens with no end tabs or 136 mm ± 1 mm for specimens with end tabs (see Fig. 1). Tighten the grips evenly and firmly to the degree necessary to prevent slippage of the specimen during the test, but not to the point where the specimen would be crushed.

10.3 Attach the extension indicator. When the modulus is being determined, the extension indicator must continuously record the distance the specimen is stretched (elongated) within the gauge length as a function of the load through the initial (linear) portion of the load-elongation curve.

10.4 Set the speed of testing at the proper rate as required in Section 8, and start the machine.

10.5 Record the load-extension curve of the specimen.

10.6 Record the load and extension at the yield point (if one exists) and the load and extension at the moment of rupture.

NOTE 13—If it is desired to measure both the modulus and failure properties (yield or break, or both), it may be necessary, in the case of highly extensible materials, to run two independent tests. The high magnification extensometer normally used to determine properties up to the yield point may not be suitable for tests involving high extensibility. If allowed to remain attached to the specimen, the extensometer could be permanently damaged. A broad-range incremental extensometer may be needed when such materials are taken to rupture.

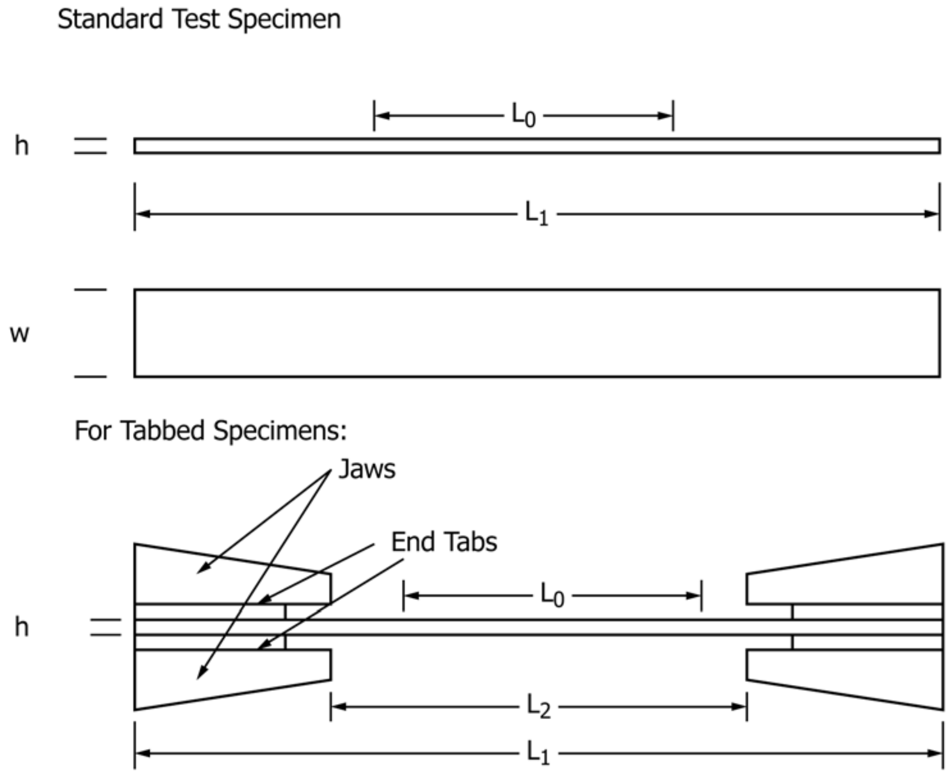
10.7 Use a suitable statistical technique to identify any possible outliers in the data. However, do not discard any outliers unless some physical reason is identified to explain the presence of the outlier, such as an aberrant specimen, a temporary change in testing condition, etc.

11. Calculation

11.1 *Tensile Strength*—Calculate the tensile strength by dividing the maximum load in newtons (or pounds-force) by the original minimum cross-sectional area of the specimen in square metres (or square inches). Express the result in pascals (or pounds-force per square inch) and report it to three significant figures as "tensile strength at yield" or "tensile strength at break," whichever term is applicable.

11.2 *Modulus of Elasticity*—Calculate the modulus of elasticity by extending the initial linear portion of the load-extension curve and dividing the difference in stress corresponding to any segment of section on this straight line by the corresponding difference in strain. Compute all elastic modulus values using the average initial cross-sectional area of the test specimens. Express the result in pascals (or pounds-force per square inch) reported to three significant figures.

11.3 For each series of tests, calculate the arithmetic mean of all values obtained and report it as the "average value" for the particular property in question.



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

11.4 Calculate the standard deviation (estimated) as follows and report it to two significant figures:

$$s = \sqrt{\left(\sum \bar{X}^2 - nX^2\right)/(n-1)} \tag{1}$$

where:

s = estimated standard deviation,
X = value of single observation,
n = number of observations, and
$\bar{X}$ = arithmetic mean of the set of observations.

12. Report

12.1 Report the following information:

12.1.1 Complete identification of the material tested, including type, source, manufacturer's code numbers, form, principal dimensions, and previous history,

12.1.2 Method of preparing test specimens,

12.1.3 Type of test specimen and dimensions,

12.1.4 Conditioning procedure used,

12.1.5 Atmospheric conditions in test room,

12.1.6 Type and description of the extension or strain-measurement device and the recording equipment used,

12.1.7 Number of specimens tested,

12.1.8 Speed of testing,

12.1.9 Tensile strength at yield or break, average value and standard deviation,

12.1.10 Tensile stress at yield or break, if applicable, average value and standard deviation,

12.1.11 Modulus of elasticity, average value and standard deviation, and

12.1.12 Date of test.

13. Precision and Bias

13.1 Table 1 is based on a round robin conducted in 1991 and analyzed by the procedures of Practice E691. It involved

TABLE 1 Tensile Strength at Break, psi, for Six Laboratories, Six Materials

NOTE 1—SMC = Sheet Molding Compound.
BMC = Bulk Molding Compound.
POLY = Polyester Resin/Glass Fiber Mat Reinforced.
PUL = Pultruded Ladder Rail.
CSM = Vinylester/Glass Fiber Mat Reinforced.
URE = Urethane Resin/Glass Fiber Mat Reinforced.

Straight-Sided					
Material	Average	S_r [A]	S_R [B]	r [C]	R [D]
BMC	6125	580	784	1624	2197
SMC	9650	669	708	1875	1983
CSM	12 882	1431	1475	4009	4131
URE	16 491	844	844	2365	2365
POLY	17 784	1599	1599	4477	4477
PUL	81 868	1902	3188	5326	8927

[A] S_r is the within-laboratory standard deviation of the average (median/other function).
[B] S_R is the between laboratories standard deviation of the average (median/other function).
[C] r is the within-laboratory repeatability limit = 2.8 S_r.
[D] R is the between-laboratories reproducibility limit = 2.8 S_R.

TABLE 2 Modulus of Elasticity, psi, for Six Laboratories, Six Materials

NOTE 1—SMC = Sheet Molding Compound.
BMC = Bulk Molding Compound.
POLY = Polyester Resin/Glass Fiber Mat Reinforced.
PUL = Pultruded Ladder Rail.
CSM = Vinylester/Glass Fiber Mat Reinforced.
URE = Urethane Resin/Glass Fiber Mat Reinforced.

Straight-Sided					
Material	Average	S_r [A]	S_R [B]	r [C]	R [D]
BMC	2 036 997	114 331	160 376	320 126	449 051
SMC	1 739 808	78 248	145 115	219 096	406 321
CSM	1 303 284	93 862	115 137	262 813	322 382
URE	1 133 010	64 164	64 164	179 659	179 659
POLY	1 629 407	107 570	131 608	301 197	368 503
PUL	4 358 796	174 997	180 470	489 991	505 315

[A] S_r is the within-laboratory standard deviation of the average (median/other function).
[B] S_R is the between laboratories standard deviation of the average (median/other function).
[C] r is the within-laboratory repeatability limit = 2.8 S_r .
[D] R is the between-laboratories reproducibility limit = 2.8 S_R .

six materials tested by six laboratories. Each laboratory prepared and tested five specimens per average. Three averages per laboratory were generated for each material evaluated.

NOTE 14—The values shown in Table 1 and Table 2 were obtained from a round robin which was not done strictly by the procedures established in Practice E691. However, the data will serve as a guide to the reproducibility and repeatability of the test until a more thorough round robin can be completed. (**Warning—**The following explanation of *r* and *R* (13.2.1 – 13.2.3) are only intended to present a meaningful way of considering the approximate precision of this test method. The data in Table 1 and Table 2 should not be rigorously applied to acceptance or rejection of material, as those data are specific to the round robin and may not be representative of other lots, conditions, materials, or laboratories. Users of this test method should apply the principles outlined in ASTM Practice E691 to generate data specific to their laboratory and materials, or between specific laboratories. The principles outlined in 13.2.1 through 13.2.3 would then be valid for such data.)

13.2 *Concept of r and R*—If S_r and S_R have been calculated from a large enough body of data, and for test results that were averages (medians/other functions) from testing X^A specimens are as follows:

13.2.1 *Repeatability Limit, r*—(Comparing two test results for the same material, obtained by the same operator using the same equipment on the same day.) Consider two test results not equivalent if they differ by more than the "*r*" value for that material.

13.2.2 *Reproducibility Limit, R*—(Comparing two test results for the same material, obtained by different operators using different equipment in different laboratories on different days.) Consider two test results not equivalent if they differ by more than the "*R*" value for that material.

13.2.3 Any judgment in accordance with 13.2.1 or 13.2.2 would have an approximate 95 % (0.95) probability of being correct.

13.3 There are no recognized standards by which to estimate bias of this test method.

NOTE 15—Change in the specimen length was made to harmonize this test method with ISO 527-4. To determine whether the round robin numbers reported above remain indicators of the differences between labs, a single laboratory evaluated the differences in the specimen lengths of 8.5 in. and 250 mm (10 in.) which represent previous versions of this test method and ISO 527-4, respectively. Although some statistical differences were seen with some specimens, the above table remains a reasonable estimate of the differences which may be seen among laboratories. Data summarizing the single laboratory study is shown in Appendix X1.

APPENDIX

(Nonmandatory Information)

X1. SUMMARY OF THE VARIANCE AND MEAN COMPARISONS

The following table is a summary of the variance and mean comparisons done by t-test and F-tests (for variance) for data collected on homogeneous samples tested in a single laboratory.

Property	D5083		ISO 527–4		Variance Test	t-test[A] P-value	Mean Comparison[A]
	Mean	Standard Development	Mean	Standard Development			
Stress							
SMC	9.44	0.942	10.3	0.767	No difference	0.001	Different
Mat	7.48	1.09	7.5	1.19	No difference	0.963	Not different
Woven Roving	43.41	3.97	44.66	3.26	No difference	0.229	Not different
Segment Modulus							
SMC	1.263	0.09	1.294	0.075	No difference	0.183	Not different
Mat	1.113	0.145	1.1	0.158	No difference	0.775	Not different
Woven Roving	2.431	0.635	2.164	0.113	Different	0.05	Not different
Elongation							
SMC	1.207	0.205	1.309	0.177	No difference	0.065	Not different
Mat	0.7122	0.097	0.7157	0.0717	No difference	0.886	Not different
Woven Roving	1.794	0.321	2.033	0.289	No difference	0.008	Different

[A] 95 % confidence.

The conclusion from the above information is:

(1) All values are statistically equivalent at 95 % confidence except for SMC stress mean, woven roving elongation, and woven roving segment modulus variance

(2) Where the values are different, ISO 527-4 with the longer specimen size gives higher mean values or less variation, or both.

(3) SMC materials are known to have higher within part variability than mat or woven roving samples. This may influence the mean values shown above.

(4) The high variance in the woven roving modulus values are unusual. The reason for this is not obvious from the data.

(5) The difference in elongation mean values for woven roving are also unexplained. It is not logical to think they would be different as the measurement of modulus with an extensometer is done in exactly the same way in both ISO 527-4 and this test method. The added specimen length should not logically be factor.

SUMMARY OF CHANGES

Committee D20 has identified the location of selected changes to this standard since the last issue (D5083 - 10$^{\varepsilon 1}$) that may impact the use of this standard. (March 15, 2017)

(1) Changed the ISO equivalency statement, Note 4.
(2) Deleted permissive language.
(3) Changed 13.4 to Note 15 because this is an explanatory section with no requirements.
(4) Some editorial changes were made.
(5) Revision of Summary of Changes section.

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