Designation: D1822 – 06

StandardTest Method for
Tensile-Impact Energy to Break Plastics and Electrical Insulating Materials[1]

This standard is issued under the fixed designation D1822; 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 energy required to rupture standard tension-impact specimens of plastic or electrical insulating materials. Materials that can be tested by this test method are those too flexible or too thin to be tested in accordance with Test Methods D256, as well as more rigid materials.

1.2 The values stated in SI units are to be regarded as standard. The values given in brackets are for information only.

NOTE 1—This test method is not equivalent to ISO 8256, and results cannot be directly compared between the two methods.

1.3 *This standard does not purport to address all of the safety problems, 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]

D256 Test Methods for Determining the Izod Pendulum Impact Resistance of Plastics

D618 Practice for Conditioning Plastics for Testing

D638 Test Method for Tensile Properties of Plastics

D883 Terminology Relating to Plastics

D1822 Test Method for Tensile-Impact Energy to Break Plastics and Electrical Insulating Materials

D1898 Practice for Sampling of Plastics (Withdrawn 1998)[3]

D4000 Classification System for Specifying Plastic Materials

D4066 Classification System for Nylon Injection and Extrusion Materials (PA)

E23 Test Methods for Notched Bar Impact Testing of Metallic Materials

3. Terminology

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

4. Summary of Test Method

4.1 The energy utilized in this test method is delivered by a single swing of a calibrated pendulum of a standardized tension-impact machine. The energy to fracture by shock in tension is determined by the kinetic energy extracted from the pendulum of an impact machine in the process of breaking the specimen. One end of the specimen is mounted in the pendulum. The other end of the specimen is gripped by a crosshead which travels with the pendulum until the instant of impact and instant of maximum pendulum kinetic energy, when the crosshead is arrested.

5. Significance and Use

5.1 Tensile-impact energy is the energy required to break a standard tension-impact specimen in tension by a single swing of a standard calibrated pendulum under a set of standard conditions (Note 2). In order to compensate for the minor differences in cross-sectional area of the specimens as they will occur in the preparation of the specimens, the energy to break can be normalized to units of kilojoules per square metre (or foot-pounds-force per square inch) of minimum cross-sectional area. An alternative approach to normalizing the impact energy that compensates for these minor differences and still retains the test unit as joules [foot-pounds] is shown in Section 11. For a perfectly elastic material the impact energy might be reported per unit volume of material undergoing deformation. However, since much of the energy to break the plastic materials for which this test method is written is dissipated in drawing of only a portion of the test region, such normalization on a volume basis is not feasible. The test method permits two specimen geometries so that the effect of elongation or rate of extension, or both, upon the result can be observed. With the Type S (short) specimen the extension is comparatively low, while with the Type L (long) specimen the extension is comparatively high. In general, the Type S specimen (with its

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[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. DOI: 10.1520/D1822-06.

[3] The last approved version of this historical standard is referenced on www.astm.org.

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

greater occurrence of brittle fracture) gives greater reproducibility, but less differentiation among materials. Results obtained with different capacity machines may not be comparable.

NOTE 2—Friction losses are largely eliminated by careful design and proper operation of the testing machine. Attention is drawn to Test Methods E23 for a general discussion of impact equipment and procedures.

5.2 The scatter of data may be due to different failure mechanisms within a group of specimens. Some materials may exhibit a transition between different failure mechanisms; if so, the elongation will be critically dependent on the rate of extension encountered in the test. The impact energy values for a group of such specimens will have an abnormally large dispersion. Some materials retract at failure with insignificant permanent set. With such materials it may not be possible to determine the type of failure, ductile, or brittle, by examining the broken pieces. A set of specimens may sometimes be sorted into two groups by observing the broken pieces to ascertain whether or not there was necking during the test. Qualitatively, the strain rates encountered here are intermediate between the high rate of the Izod test of Test Methods D256 and the low rate of usual tension testing in accordance with Test Method D638.

5.3 The energy for fracture is a function of the force times the distance through which the force operates. Thus, two

materials may have properties that result in equal tensile-impact energies on the same specimen geometry, arising in one case from a large force associated with a small elongation and in the other from a small force associated with a large elongation. It cannot be assumed that this test method will correlate with other tests or end uses unless such a correlation has been established by experiment.

5.4 Comparisons among specimens from different sources can be made with confidence only to the extent that specimen preparation, for example, molding history, has been precisely duplicated. Comparisons between molded and machined specimens must not be made without first establishing quantitatively the differences inherent between the two methods of preparation.

5.5 Only results from specimens of nominally equal thickness and tab width shall be compared unless it has been shown that the tensile-impact energy normalized to kilojoules per square metre [or foot-pounds-force per square inch] of cross-sectional area is independent of the thickness over the range of thicknesses under consideration.

5.6 Slippage of specimens results in erroneously high values. The tabs of broken specimens should be examined for an undistorted image of the jaw faces optically, preferably under magnification, and compared against a specimen which has been similarly clamped but not tested. Because slippage has
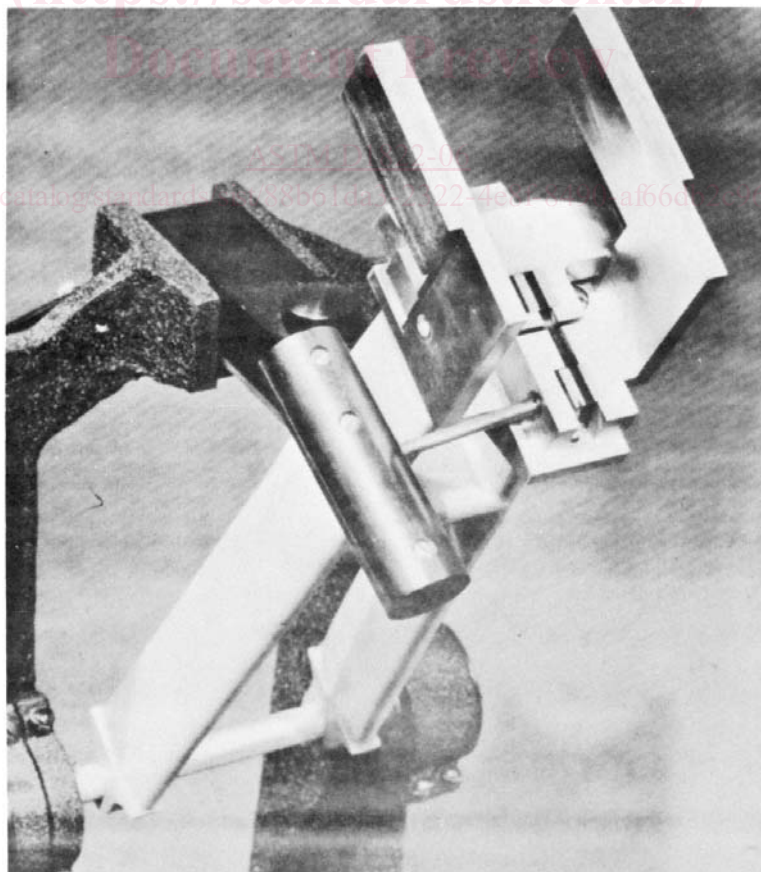

FIG. 1 Specimen-in-Head Tension-Impact Machine

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been shown to be present in many cases and suspected in others, the use of bolted specimens is mandatory. The function of the bolt is to assure good alignment and to improve the tightening of the jaw face plates.

5.7 The bounce of the crosshead supplies part of the energy to fracture test specimen (see Appendix X1).

5.8 For many materials, there may be a specification that requires 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 System D4000 lists the ASTM materials standards that currently exist.

6. Apparatus

6.1 The machine shall be of the pendulum type shown schematically in Fig. 1 and Fig. 2. The base and suspending frame shall be of sufficiently rigid and massive construction to prevent or minimize energy losses to or through the base and frame. The pendulum should be released from such a position that the linear velocity of the center of impact (center of percussion) at the instant of impact shall be approximately 3.444 m/s [11.3 ft/s], which corresponds to an initial elevation of this point of 610 mm [2.00 ft].

6.2 The pendulum shall be constructed of a single- or multiple-membered arm holding the head, in which the greatest mass is concentrated. A rigid pendulum is essential to maintain the proper clearances and geometric relationships between related parts and to minimize energy losses, which always are included in the measured impact energy value. It is imperative that the center of percussion of the pendulum system and the point of impact can be demonstrated to be coincident within ±2.54 mm [±0.100 in.] and that the point of contact occur in the neutral (free hanging) position of the pendulum within 2.54 mm [0.100 in.], both with and without the crosshead in place.

NOTE 3—The distance from the axis of support to the center of percussion may be determined experimentally from the period of small amplitude oscillations of the pendulum by means of the following equation:

$$L = \left(g/4\pi^2\right) p^2 \qquad (1)$$

where:

L = distance from the axis of support to the center of percussion, mm (ft),

g = local gravitational acceleration (known to an accuracy of one part in one thousand), in mm/s^2 [ft/s^2],

π = 3.14159, and

p = period, s, of a single complete swing (to and fro) determined from at least 50 consecutive and uninterrupted swings (known to one part in two thousand). The angle of swing shall be less than 0.09 radians (5°) each side of the center.

6.3 The positions of the rigid pendulum and crosshead clamps on the specimen are shown in Fig. 2. The crosshead should be rigid and light in weight. The crosshead shall be supported by the pendulum so that the test region of the specimen is not under stress until the moment of impact, when the specimen shall be subjected to a pure tensile force. The clamps shall have serrated jaws to prevent slipping. Jaws should have file-like serrations and the size of serrations should be selected according to experience with hard and tough materials and with the thickness of the specimen. The edge of the serrated jaws in close proximity to the test region shall have a 0.40-mm [1/64-in.] radius to break the edge of the first serrations.

6.4 Means shall be provided for determining the energy expended by the pendulum in breaking the specimen. This is accomplished using either a pointer and dial mechanism or an electronic system consisting of a digital indicator and sensor (typically an encoder or resolver).

6.5 The indicated breaking energy is determined by detecting the height of rise of the pendulum beyond the point of impact in terms of energy removed from that specific pendulum.

6.5.1 Since the indicated energy must be corrected for pendulum-bearing friction, pointer friction, pointer inertia, and pendulum windage, instructions for making these corrections are found in Test Method D256. If the electronic display does not automatically correct for windage and friction, it shall be incumbent for the operator to determine the energy loss manually.
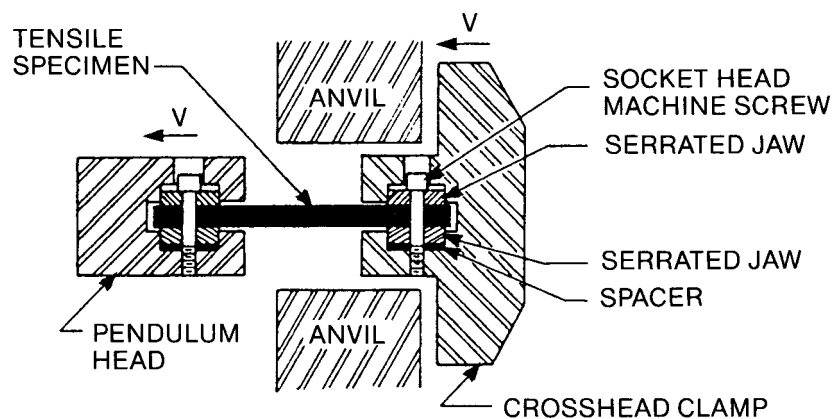

FIG. 2 Specimen-in-Head Tension-Impact Machine (Schematic)

6.5.2 Bounce correction is explained in Appendix X1 of Test Method D1822. Some electronic displays permit the user to enter an energy correction offset so that the bounce correction can be factored in before the breaking energy is displayed.

6.6 Setup and calibration procedures for tension-impact machines shall be followed as described in Appendix X2.

6.7 A ball-type micrometer shall be used for measuring the width of the restricted area of the Type S specimen. Either a ball-type or ordinary machinist's micrometer may be used to measure the thickness of the Type S specimen and the thickness and width of the Type L specimen. These measurements shall be made to an accuracy of 0.013 mm [0.0005 in.].

7. Sampling

7.1 Unless otherwise agreed upon between interested parties, the material shall be sampled in accordance with the sections on General Sampling Procedure in Practice D1898.

8. Test Specimen

8.1 At least five and preferably ten specimens from each sample shall be prepared for testing. For sheet materials that are suspected of anisotropy, duplicate sets of test specimens shall be prepared having their long axis respectively parallel with, and normal to, the suspected directions of anisotropy.

8.2 The test specimen shall be sanded, machined, or die cut to the dimensions of one of the specimen geometries shown in Fig. 3, or molded in a mold whose cavity has these dimensions. Fig. 4A shows bolt holes and bolt hole location and Fig. 4B shows a slot as an alternative method of bolting for easy insertion of the specimens into the grips. The No. 8-32 bolt size is recommended for the 9.53-mm [0.375-in.] wide tab and No. 8-32 or No. 10-32 bolt size is suggested for the 12.70-mm [0.500-in.] wide tabs. Final machined, cut, or molded specimen dimensions cannot be precisely maintained because of shrinkage and other variables in sample preparation.

8.3 A nominal thickness of 3.2 mm [⅛ in.] is optimum for most materials being considered and for commercially available machines. Thicknesses other than 3.2 mm [⅛ in.] are nonstandard and they should be reported with the tension-impact value.

Note 4—Cooperating laboratories should agree upon standard molds and upon specimen preparation procedures and conditions.

9. Conditioning

9.1 *Conditioning*—Condition the test specimens at 23 ± 2°C [73.4 ± 3.6°F] and 50 ± 5 % relative humidity for not less than 40 h prior to test in accordance with Procedure A of Practice D618, for those tests where conditioning is required. In cases of disagreement, the tolerances shall be ±1°C [±1.8°F] and ±2 % relative humidity.

9.1.1 Note that for some hygroscopic materials, such as nylons, the material specifications (for example, Specification D4066) call for testing "dry as-molded specimens." Such requirements take precedence over the above routine preconditioning to 50 % relative humidity and require sealing the specimens in water vapor-impermeable containers as soon as molded and not removing them until ready for testing.

9.2 *Test Conditions*—Conduct tests in the standard laboratory atmosphere of 23 ± 2°C [73.4 ± 3.6°F] and 50 ± 5 % relative humidity, unless otherwise specified in the test methods or in this test method. In cases of disagreement, the tolerances shall be ±1°C [±1.8°F] and ±2 % relative humidity.

10. Procedure

10.1 Measure the thickness and width of each specimen with a micrometer. Record these measurements along with the identifying markings of the respective specimens.

10.2 Bolt the specimen securely with a torque wrench in accordance with 5.3. Clamp the specimen to the crosshead while the crosshead is out of the pendulum. A jig may be necessary for some machines to position the specimen properly with respect to the crosshead during the bolting operation. With the crosshead properly positioned in the elevated pendulum, bolt the specimen at its other end to the pendulum itself, as shown in Fig. 1.

10.3 Use the lowest capacity pendulum available, unless the impact values go beyond the 85 % scale reading. If this occurs, use a higher capacity pendulum.

Note 5—In changing pendulums, the tensile-impact energy will decrease as the mass of the pendulum is increased.

10.4 Measure the tension-impact energy of each specimen and record its value, and comment on the appearance of the specimen regarding permanent set or necking, and the location of the fracture.

11. Calculation

11.1 Calculate the corrected impact energy to break as follows:

$$X = E - Y + e \qquad (2)$$

where:
X = corrected impact energy to break, in J [ft·lbf],
E = scale reading of energy of break, in J [ft·lbf],
Y = friction and windage correction in J [ft·lbf], and
e = bounce correction factor, in J [ft·lbf] (Fig. 5).

Note 6—Fig. 5 is a sample curve. A curve must be calculated in accordance with Appendix X1 for the crosshead and pendulum used before applying any bounce correction factors.
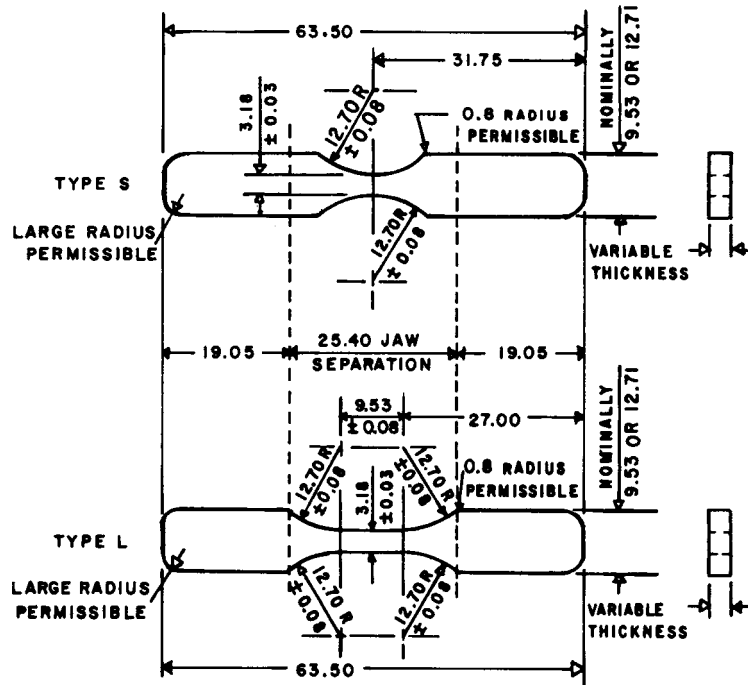
FIG. 3

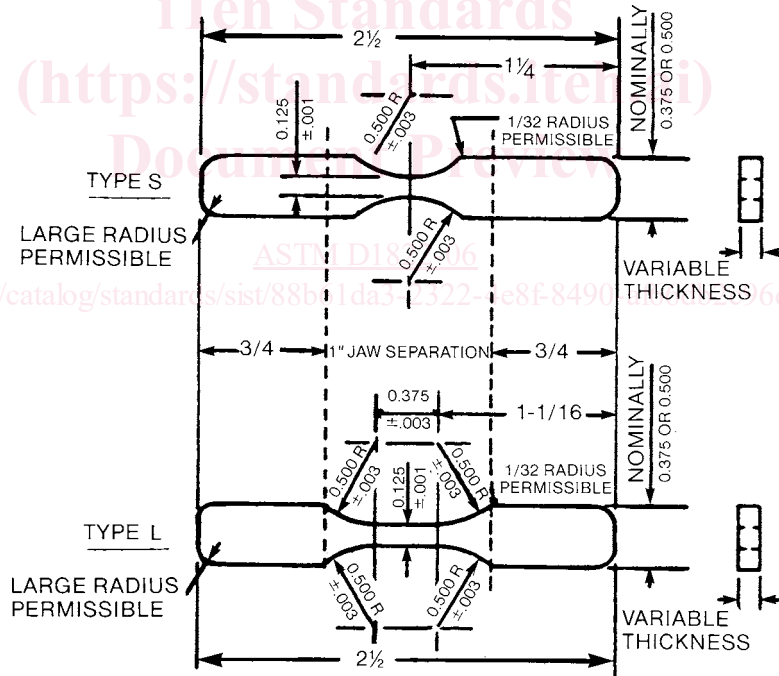**FIG. 3A Mold Dimensions of Types S and L Tension-Impact Specimens (Dimensioned in Millimetres)**

FIG. 3B Mold Dimensions of Types S and L Tension-Impact Specimens (Dimensioned in Inches)
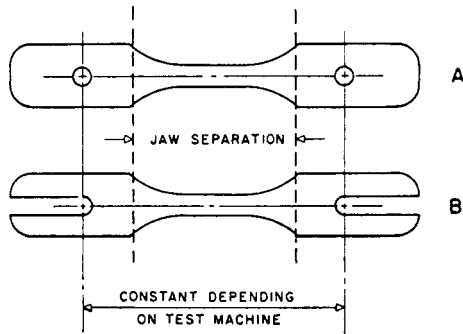
FIG. 4 Bolt Hole Location

Note 7—*Examples*:

Case A— *Low-Energy Specimen:*
Scale reading of energy to break   0.58 J
     [0.43 ft·lbf]

Friction and windage correction
−0.03 J [−0.02 ft·lbf]
Bounce correction factor, e   +0.22 J
(from Fig. 5 in Appendix X1)   [0.16 ft·lbf]
+0.25 J (+0.18 ft·lbf)
= +0.22 (+0.16 ft·lbf)
Corrected impact energy to break   0.80 J
     [0.59 ft·lbf]

Case B—*High-Energy Specimen*:
Scale reading of energy to break   2.33 J
     [1.72 ft·lbf]

Friction and windage correction
−0.01 J [−0.01 ft·lbf]
Bounce correction factor. e   +0.33 J
(from Fig. 5 in Appendix X1)   [0.24 ft·lbf]

Corrected impact energy to break   2.66 J
     [1.96 ft·lbf]

Note 8—Corrections for a slight variation in specimen dimensions due to specimen preparation or mold shrinkage can be made as follows:

$$X = \frac{E - Y + e}{\left(\dfrac{w}{a}\right)\left(\dfrac{t}{a}\right)} \tag{3}$$

where:
X, E, Y, and *e* are as described in 10.1,

a = 3.2 mm [0.125 in.],
w = specimen width, mm [in.], and
t = specimen thickness, mm [in.].

This would normalize the value of tensile impact energy to a standard specimen whose cross section is 3.2 mm [0.125 in.] by 3.2 mm [0.125 in.].

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

$$s = \sqrt{\sum X^2 - n\bar{X}^2 / n - 1} \tag{4}$$

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 number, form, principal dimensions, and previous history.

12.1.2 Specimen type (S or L), and tab width.

12.1.3 A statement of how the specimens were prepared, the testing conditions, including the size of the bolts and torque used, thickness range, and direction of testing with respect to anisotropy, if any.

12.1.4 The capacity of the pendulum in kilo-joules [or foot-pounds-force or inch-pounds-force].

12.1.5 The average and the standard deviation of the tensile-impact energy of specimens in the sample. If the ratio of the minimum value to maximum value is less than 0.75, report average and maximum and minimum values. If there is an apparent difference in the residual elongation observed due to some of the sample necking, report the number of specimens displaying necking.

12.1.6 Number of specimens tested per sample or lot of material (that is, five or ten or more).

13. Precision and Bias[4]

13.1 In round-robin tests of triplicate bolted specimens, the nine participating laboratories averaged the standard deviations shown in Table 1.

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[4] Supporting data are available from ASTM Headquarters. Request RR: D20 - 1034.