Designation: D4812 – 19^{ε1}

Standard Test Method for Unnotched Cantilever Beam Impact Resistance of Plastics[1]

This standard is issued under the fixed designation D4812; 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.

ε[1] NOTE—Editorial changes were made in April 2022.

1. Scope*

1.1 This test method covers the determination of the resistance of plastics to breakage by flexural shock, as indicated by the energy extracted from standardized pendulum-type hammers, mounted in standardized machines, in breaking standard specimens with one pendulum swing. The result of this test method is reported as energy absorbed per unit of specimen width.

NOTE 1—The pendulum-type test instruments have been standardized in that they must comply with certain requirements, including a fixed height of hammer fall that results in a substantially fixed velocity of the hammer at the moment of impact. Pendulums of different initial energies (produced by varying their effective weights) are recommended for use with specimens of different impact strengths. Moreover, manufacturers of the equipment are permitted to use different lengths and constructions of pendulums (with resulting possible differences in pendulum rigidities (see Section 5), and other differences in machine design).

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

1.3 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

NOTE 2—This standard and ISO 180, Method U address the same subject matter, but differ in technical content.

1.4 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

D256 Test Methods for Determining the Izod Pendulum Impact Resistance of Plastics
D618 Practice for Conditioning Plastics for Testing
D883 Terminology Relating to Plastics
D5947 Test Methods for Physical Dimensions of Solid Plastics Specimens
E456 Terminology Relating to Quality and Statistics
E691 Practice for Conducting an Interlaboratory Study to Determine the Precision of a Test Method
E2935 Practice for Evaluating Equivalence of Two Testing Processes

3. Terminology

3.1 *Definitions*—Definitions used in this test method are in accordance with Terminology D883. For terms relating to precision and bias and associated issues, the terms used in this standard are defined in accordance with Terminology E456.

4. Summary of Test Method

4.1 This test method differs from others of similar character in that unnotched test specimens are used (see Test Methods D256 for procedures using notched test specimens). The lack of a notch makes this test method especially useful for reinforced materials where a notch may mask the effects of orientation. It may also be used with other filled or unreinforced materials where a stress-concentrating notch is not desired. It is not valid for materials that twist when subjected to this test.

5. Significance and Use

5.1 The pendulum-impact test indicates the energy to break standard test specimens of specified size under stipulated conditions of specimen mounting and pendulum velocity at impact.

[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

5.2 The energy lost by the pendulum during the breakage of the specimen is the sum of the energies required to produce the following results:

5.2.1 To initiate fracture of the specimen,

5.2.2 To propagate the fracture across the specimen,

5.2.3 To throw the free end (or pieces) of the broken specimen (toss correction),

5.2.4 To bend the specimen,

5.2.5 To produce vibration in the pendulum arm,

5.2.6 To produce vibration or horizontal movement of the machine frame or base,

5.2.7 To overcome friction in the pendulum bearing and in the indicating mechanism, and to overcome windage (pendulum air drag),

5.2.8 To indent or deform plastically the specimen at the line of impact, and

5.2.9 To overcome the friction caused by the rubbing of the striking nose (or other part of the pendulum) over the face of the bent specimen.

5.3 For relatively brittle materials for which fracture propagation energy is small in comparison with the fracture initiation energy, the indicated impact energy absorbed is, for all practical purposes, the sum of items given in 5.2.1 and 5.2.3. The toss correction (5.2.3) may represent a very large fraction of the total energy absorbed when testing relatively dense and brittle materials.

5.4 For materials for which the fracture propagation energy (5.2.2) may be large compared to the fracture initiation energy (5.2.1), factors (5.2.2, 5.2.5, and 5.2.9) can become quite significant, even when the specimen is accurately machined and positioned and the machine is in good condition with adequate capacity (Note 3). Bending (5.2.4) and indentation losses (5.2.8) may be appreciable when testing soft materials.

NOTE 3—Although the frame and base of the machine should be sufficiently rigid and massive to handle the energies of tough specimens without motion or excessive vibration, the pendulum arm cannot be made very massive because the greater part of its mass must be concentrated near its center of percussion at the striking nose. Locating the striking nose precisely at the center of percussion reduces vibration of the pendulum arm when used with brittle specimens. However, some losses due to pendulum-arm vibration, the amount varying with the design of the pendulum, will occur with tough specimens even when the striking nose is properly positioned.

5.5 In a well-designed machine of sufficient rigidity and mass the losses due to the items given in 5.2.6 and 5.2.7 should be very small. Vibrational losses (5.2.6) can be quite large when specimens of tough materials are tested in machines of insufficient mass which are not securely fastened to a heavy base.

5.6 This test method requires that the type of failure for each specimen be recorded as one of the three coded categories defined as follows:

5.6.1 C (*Complete Break*)—A break in which the specimen is separated into two or more pieces.

5.6.2 P (*Partial Break*)—An incomplete break that has fractured at least 90 % of the depth of the specimen.

5.6.3 NB (*Non-Break*)—An incomplete break where the fracture extends less than 90 % of the depth of the specimen.

5.6.3.1 For tough materials the pendulum may not have the energy necessary to completely break the extreme outermost fibers and toss the broken piece or pieces. Results obtained from "non-break" specimens shall be considered a departure from standard and shall be reported as "NB" only and a numerical value shall not be reported. Impact values cannot be directly compared for any two materials that experience different types of failure as defined by this code.

5.6.4 Averages reported must likewise be derived from specimens contained within a single failure category. This letter code will be included with the reported impact identifying the types of failure associated with the reported value. If more than one type of failure is observed for a sample material, then the report will indicate the average impact value for each type of failure, followed by the percent of the specimens failing in that manner and identified by the letter code.

5.7 The value of this impact test method lies mainly in the areas of quality control and materials specification. The fact that a material shows twice the energy absorption of another under these conditions of test does not indicate that this same relationship will exist under another set of test conditions. The ranking of materials may even be changed under different testing conditions.

5.8 Before proceeding with this test method, reference should be made to the specification of the material being tested. Any test specimen preparation, conditioning, dimensions, or testing parameters, or combination thereof, covered in the material specification shall take precedence over those mentioned in this test method except in cases where to do so would conflict with the purpose for conducting testing. If there are no material specifications, then the default conditions apply.

6. Apparatus

6.1 *Impact Machine,* consisting of a massive base on which is mounted a vise for holding the specimen and to which is connected, through a rigid frame and antifriction bearings, one of a number of pendulum-type hammers (or one basic hammer to which extra weights may be attached) having an initial energy suitable for use with the particular specimen to be tested, plus a pendulum holding and releasing mechanism and a mechanism for indicating the breaking energy of the specimen. A jig for positioning the specimen in the vise and graphs or tables to aid in the calculation of the correction for friction and windage should be included. See Fig. 1 for one type of machine that may be used. The type of machine that is depicted can also be used for the testing of notched specimens using Test Methods D256. Detailed requirements are given in 6.2 – 6.5. See Appendix X1 for general methods for checking and calibrating the machine. Additional instructions for adjusting a particular machine should be supplied by the manufacturer.

6.2 *Pendulum,* consisting of a single or multimembered arm with a bearing on one end and a head, containing the striking nose, on the other. Although a large proportion of the mass of the pendulum should be concentrated in the head, the arm must be sufficiently rigid to maintain the proper clearances and geometric relationships between the machine parts and the specimen and to minimize vibrational losses which are always included in the measured impact value.

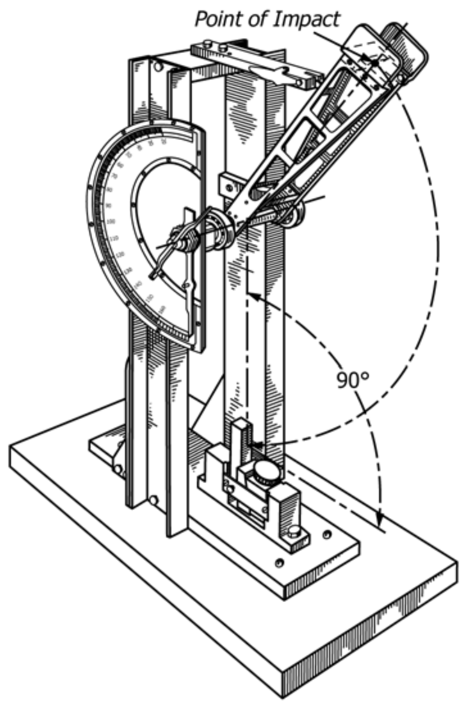

FIG. 1 Cantilever Beam Impact Test Equipment

6.2.1 *Striking Nose (of the Pendulum),* of hardened steel and cylindrical surface having a radius of curvature of 0.80 ± 0.20 mm (0.031 ± 0.008 in.) with its axis horizontal and perpendicular to the plane of swing of the pendulum.

6.2.1.1 The line of contact of the striking nose shall be located at the center of percussion of the pendulum within ±2.54 mm (±0.100 in.) (Note 4). Those portions of the pendulum adjacent to the cylindrical striking edge shall be recessed or inclined at a suitable angle so that there will be no chance for other than this cylindrical surface coming into contact with the specimen during the break.

6.2.2 *Pendulum Holding and Releasing Mechanism,* in a position such that the vertical height of fall of the striking nose shall be 610 ± 2 mm (24.0 ± 0.1 in.); this will produce a velocity of the striking nose at the moment of impact of approximately 3.46 m (11.35 ft)/s. The mechanism shall be so constructed and operated that it will release the pendulum without imparting acceleration or vibration to it.

6.2.3 The effective length of the pendulum shall be between 0.325 and 0.406 m (12.8 and 16.0 in.) so that the above required elevation of the striking nose may be obtained by raising the pendulum to an angle between 60 and 30° above the horizontal.

NOTE 4—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, as follows:

$$L = (g/4\pi^2)p^2 \quad (1)$$

where:

L = distance from the axis of support to the center of percussion, m (ft),
g = local gravitational acceleration (known to an accuracy of one part in one thousand), m/s^2 (ft/s^2),
π = 3.1416 ($4\pi^2$ = 39.4786), and
p = period, s, of a single complete swing (to and fro) determined from at least 20 consecutive and uninterrupted swings (known to one part in two thousandths). The angle of swing shall be less than 5° each side of center.

6.2.4 The machine shall be provided with a basic pendulum capable of delivering an energy of 2.710 ± 0.135 J (2.00 ± 0.10 ft-lbf). This pendulum shall be used with all specimens that extract less than 85 % of this energy. Heavier pendulums shall be provided for specimens that require more energy to break. These may be separate interchangeable pendulums or one basic pendulum to which extra pairs of equal calibrated weights may be attached rigidly to opposite sides of the pendulum at its center of percussion. It is imperative that the extra weights shall not change the position of the center of percussion of the free-hanging rest point of the pendulum.

6.2.4.1 A range of pendulums having energies from 2.710 to 21.680 J (2 to 16 ft-lbf) has been found to be sufficient for use with most plastic specimens and may be used with most machines. A series of pendulums such that each has twice the energy of the next lighter one will be found convenient. Each pendulum shall have an energy within ±0.5 % of its nominal capacity.

6.2.5 When the pendulum is free-hanging, the striking surface shall come within 0.2 % of scale of touching the front face of a standard specimen. During an actual swing this element shall make initial contact with the specimen on a line 22.00 ± 0.05 mm (0.866 ± 0.002 in.) above the top surface of the vise.

6.2.6 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). In either case, 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. Since the indicated energy must be corrected for pendulum-bearing friction, pointer friction, pointer inertia, and pendulum windage, instructions for making these corrections are included in 9.3 and Annex A1 and Annex A2. 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. (See Note 5)

NOTE 5—Many digital indicating systems automatically correct for windage and friction. The equipment manufacturer may be consulted for details concerning how this is performed, or if it is necessary to determine the means for manually calculating the energy loss due to windage and friction.

6.3 *Vise,* for clamping the specimen rigidly in position so that the long axis of the specimen is vertical and at right angles to the top plane of the vise. The top edges of the jaws of the vise shall have a radius of 0.25 ± 0.12 mm (0.010 ± 0.005 in.) (see Fig. 2).

NOTE 6—It is especially important that the correct radius be maintained on the moveable vise jaw. Any sharp edge, nick, or burr on this jaw will create a "notch" or stress concentration point when the jaw is clamped against the test specimen. This stress concentration point has lowered values of some materials to less than 50 % of the value obtained when the