



Designation: D6110 – 18

Standard Test Method for Determining the Charpy Impact Resistance of Notched Specimens of Plastics¹

This standard is issued under the fixed designation D6110; 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 reappraisal. A superscript epsilon (ϵ) indicates an editorial change since the last revision or reappraisal.

1. Scope*

1.1 This test method is used to determine the resistance of plastics to breakage by flexural shock as indicated by the energy extracted from standardized (see [Note 1](#)) pendulum-type hammers, mounted in standardized machines, in breaking standard specimens with one pendulum swing. This test method requires specimens to be made with a milled notch (see [Note 2](#)). The notch produces a stress concentration which promotes a brittle, rather than a ductile, fracture. The results of this test method are reported in terms of energy absorbed per unit of specimen width (see [Note 3](#)).

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

NOTE 2—The specimens are standardized in that they have a fixed length and fixed depth, however, the width of the specimens is permitted to vary between limits. One design of milled notch is allowed. The notch in the specimen serves to concentrate the stress, minimize plastic deformation, and direct the fracture to the part of the specimen behind the notch. Scatter in energy-to-break is thus reduced. Because of differences in the elastic and viscoelastic properties of plastics, however, response to a given notch varies among materials.

NOTE 3—Caution must be exercised in interpreting the results of this test method. The following testing parameters have been shown to affect test results significantly: method of specimen fabrication, including but not limited to processing technology, molding conditions, mold design, and thermal treatment; method of notching; speed of notching tool; design of notching apparatus; quality of the notch; time between notching and test; test specimen thickness; test specimen width under notch; and environmental conditioning.

1.2 *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 appro-*

priate safety, health, and environmental practices and determine the applicability of regulatory limitations prior to use.

NOTE 4—This standard resembles ISO 179 in title only. The content is significantly different.

1.3 *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

- [D618 Practice for Conditioning Plastics for Testing](#)
- [D647 Practice for Design of Molds for Test Specimens of Plastic Molding Materials \(Withdrawn 1994\)³](#)
- [D883 Terminology Relating to Plastics](#)
- [D4000 Classification System for Specifying Plastic Materials](#)
- [D4066 Classification System for Nylon Injection and Extrusion Materials \(PA\)](#)
- [D5947 Test Methods for Physical Dimensions of Solid Plastics Specimens](#)
- [E691 Practice for Conducting an Interlaboratory Study to Determine the Precision of a Test Method](#)

3. Terminology

3.1 *Definitions*—For definitions related to plastics, see [Terminology D883](#).

4. Summary of Test Method

4.1 A notched specimen is supported as a horizontal simple beam and is broken by a single swing of the pendulum with the impact line midway between the supports and directly opposite the notch.

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 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

5. Significance and Use

5.1 Before proceeding with this test method, refer to the material specification for the material being tested. Any test specimen preparation, conditioning, dimensions and testing parameters required by the materials specification shall take precedence over those required by this test method. Table 1 of Classification **D4000** lists the ASTM materials standards that currently exist. If there is no material specification, then the requirements of this test method apply.

5.2 The pendulum impact test indicates the energy to break standard test specimens of specified size under stipulated conditions of specimen mounting, notching (stress concentration), and pendulum velocity at impact.

5.3 For this test method, the energy lost by the pendulum during the breakage of the specimen is the sum of the energies required to initiate fracture of the specimen; to propagate the fracture across the specimen; to throw the free ends of the broken specimen (toss energy); to bend the specimen; to produce vibration in the pendulum arm; to produce vibration or horizontal movement of the machine frame or base; to overcome friction in the pendulum bearing and in the indicating mechanism, and to overcome windage (pendulum air drag); to indent or deform, plastically, the specimen at the line of impact; and to overcome the friction caused by the rubbing of the striking nose over the face of the bent specimen.

NOTE 5—The toss energy, or the energy used to throw the free ends of the broken specimen, is suspected to represent a very large fraction of the total energy absorbed when testing relatively dense and brittle materials. No procedure has been established for estimating the toss energy for the Charpy method.

5.4 For tough, ductile, fiber-filled, or cloth-laminated materials, the fracture propagation energy is usually large compared to the fracture initiation energy. When testing these materials, energy losses due to fracture propagation, vibration, friction between the striking nose and the specimen has the potential to become quite significant, even when the specimen is accurately machined and positioned, and the machine is in good condition with adequate capacity (see **Note 6**). Significant energy losses due to bending and indentation when testing soft materials have also been observed.

NOTE 6—Although the frame and the base of the machine must 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 its striking nose. Locating the striking nose precisely at the center of percussion reduces the vibration of the pendulum arm when used with brittle specimens. 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 vibration and friction in the pendulum bearing and in the indicating mechanism will be very small. Vibrational losses are observed when wide specimens of tough materials are tested in machines of insufficient mass, or in machines that are not securely fastened to a heavy base.

5.6 Since this test method permits a variation in the width of the specimens and since the width dictates, for many materials, whether a brittle, low-energy break (as evidenced by little or no

drawing down or necking and by a relatively low energy absorption) or a ductile, high-energy break (as evidenced by considerable drawing or necking down in the region behind the notch and by a relatively high energy absorption) will occur, it is necessary that the width be stated in the specification covering that material and that the width be stated along with the impact value.

5.7 This test method requires that the specimen break completely. Results obtained when testing materials with a pendulum that does not have sufficient energy to complete the breaking of the extreme fibers and toss the broken pieces shall be considered a departure from standard and shall not be reported as a standard result. Impact values cannot be directly compared for any two materials that experience different types of failure.

5.8 The value of this impact test method lies mainly in the areas of quality control and materials specification. If two groups of specimens of supposedly the same material show significantly different energy absorptions, critical widths, or critical temperatures, it is permitted to assume that they were made of different materials or were exposed to different processing or conditioning environments. 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.

6. Apparatus

6.1 *Pendulum Impact Machine*—The machine shall consist of a massive base on which are mounted a pair of supports for holding the specimen and to which is connected, through a rigid frame and bearings, one of a number of pendulum-type hammers having an initial energy suitable for use with the particular specimen to be tested (or one basic pendulum designed to accept add-on weights), plus a pendulum holding and releasing mechanism and a mechanism for indicating the breaking energy of the specimen. The specimen anvil, pendulum, and frame shall be sufficiently rigid to maintain correct alignment of the striking edge and specimen, both at the moment of impact and during the propagation of the fracture, and to minimize energy losses due to vibration. The base shall be sufficiently massive so that the impact will not cause it to move. The machine shall be designed, constructed, and maintained so that energy losses due to pendulum air drag (windage), friction in the pendulum bearings, and friction and inertia in the indicating mechanism are held to a minimum.

6.1.1 *Pendulum*—The simple pendulum shall consist of a single or multi-membered 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 simple pendulum is 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 energy losses, which are always included in the measured impact value. A machine with a simple pendulum design is illustrated in **Fig. 1**. Instruments with a compound-pendulum design also have been found to be acceptable for use. A compound-pendulum design is illustrated in **Fig. 2**.

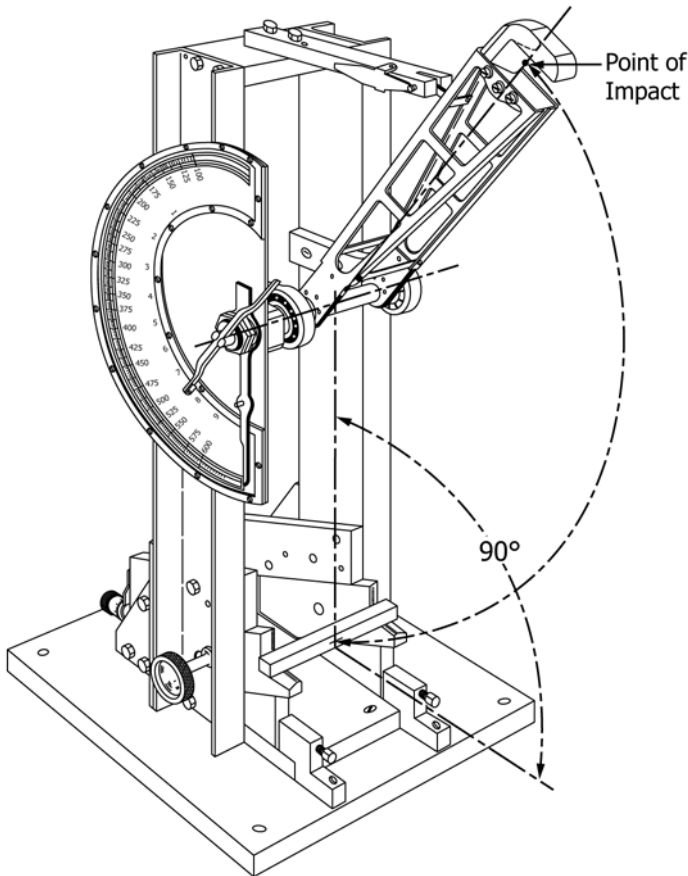


FIG. 1 Simple Beam (Charpy-Type) Impact Machine

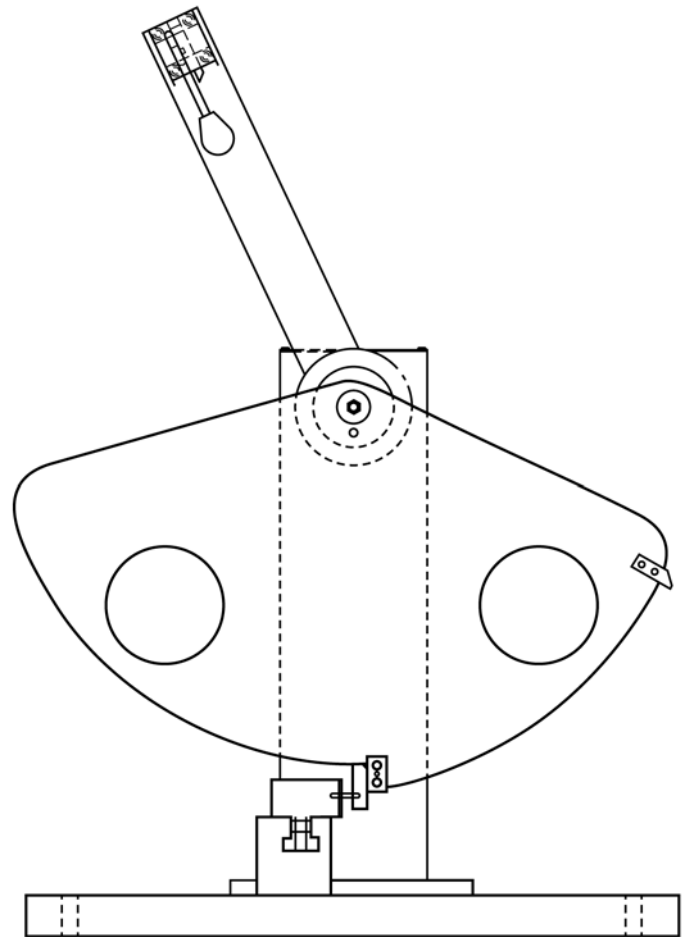


FIG. 2 Example of Compound-Pendulum-Type Machine

6.1.1.1 The machine shall be provided with a basic pendulum capable of delivering an energy of 2.7 ± 0.14 J (2.0 ± 0.10 ft-lbf). This pendulum shall be used for specimens that extract less than 85 % of this energy when breaking a specimen. Heavier pendulums or additional weights designed to attach to the basic pendulum shall be provided for specimens that require more energy to break. A series of pendulums such that each has twice the energy of the next lighter one has been found convenient.

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

6.1.2 *Striking Edge*—The striking edge (nose) of the pendulum shall be made of hardened steel, tapered to have an included angle of $45 \pm 2^\circ$ and shall be rounded to a radius of 3.17 ± 0.12 mm (0.125 ± 0.005 in.). The pendulum shall be aligned in such a way that when it is in its free hanging position, the center of percussion of the pendulum shall lie within ± 2.54 mm (0.10 in.) of the middle of the line of contact made by the striking nose upon the face of a standard specimen of square cross section. The distance from the axis of support to the center of percussion is determined experimentally from the period of motion of small amplitude oscillations of the pendulum by means of the following equation:

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

where:

- L = distance from the axis of support to the center of percussion, m,
- g = local gravitational acceleration (known to an accuracy of one part in one thousand), m/s^2
- π = 3.1416 ($4\pi^2 = 39.48$), and
- p = period, in s, of a single complete swing (to and fro) determined from at least 20 consecutive and uninterrupted swings. The angle of swing shall be less than 5° each side of center.

6.1.3 *Pendulum Holding and Releasing Mechanism*—The mechanism shall be designed, constructed, and operated so that it will release the pendulum without imparting acceleration or vibration to the pendulum. The position of the pendulum holding and releasing mechanism shall be 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 (11.4 ft)/s as determined by the following equation:

$$v = \sqrt{2gh} \quad (2)$$

where:

- v = velocity of the striking nose at the moment of impact,
- g = local gravitational acceleration, and
- h = vertical height of fall of the striking nose.