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.

Designation: D256 – 26

Standard Test Methods for Determining the Izod Pendulum Impact Resistance of Plastics[1]

This standard is issued under the fixed designation D256; 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.

This standard has been approved for use by agencies of the U.S. Department of Defense.

1. Scope*

1.1 These test methods cover the determination of the resistance of plastics to "standardized" (see Note 1) pendulum-type hammers, mounted in "standardized" machines, in breaking standard specimens with one pendulum swing (see Note 2). The standard tests for these test methods require specimens made with a milled notch (see Note 3). In Test Methods A and C, the notch produces a stress concentration that increases the probability of a brittle, rather than a ductile, fracture. Results are reported in terms of energy absorbed per unit of specimen width or per unit of cross-sectional area under the notch. (See Note 4.)

NOTE 1—The machines with their pendulum-type hammers 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. However, hammers of different initial energies (produced by varying their effective weights) 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 may exist. The specimens are "standardized" in that they are required to have one fixed length, one fixed depth, and one particular design of milled notch. The width of the specimens is permitted to vary between limits.

NOTE 2—Results generated using pendulums that utilize a load cell to record the impact force and thus impact energy, may not be equivalent to results that are generated using manually or digitally encoded testers that measure the energy remaining in the pendulum after impact.

NOTE 3—The notch in the Izod 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. However, because of differences in the elastic and viscoelastic properties of plastics, response to a given notch varies among materials.

NOTE 4—Caution must be exercised in interpreting the results of these standard test methods. The following testing parameters may affect test results significantly:

Method of fabrication, including but not limited to processing technology, molding conditions, mold design, and thermal treatments;
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 The test methods appear in the following order:

	Sections
Test Method A—Cantilever Beam Test	6 to 11
Test Method C—Cantilever Beam Test for Materials with Izod impact resistance of Less than 27 J/m (0.5 ft·lbf/in.)	12 to 17

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

1.4 *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 5—These test methods resemble ISO 180:1993 in regard to title only. The contents are significantly different.

1.5 *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

D883 Terminology Relating to Plastics

[1] These test methods are under the jurisdiction of ASTM Committee D20 on Plastics and are 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 www.astm.org/contact. 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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D3641 Practice for Injection Molding Test Specimens of Thermoplastic Molding and Extrusion Materials
D4066 Classification System for Nylon Injection and Extrusion Materials (PA)
D5947 Test Methods for Physical Dimensions of Solid Plastics Specimens
D6110 Test Method for Determining the Charpy Impact Resistance of Notched Specimens of Plastics
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

2.2 *ISO Standard:*
ISO 180:1993 Plastics—Determination of Izod Impact Strength of Rigid Materials[3]

3. Terminology

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

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *cantilever, n*—a projecting beam clamped at only one end.

3.2.2 *notch sensitivity, n*—a measure of the variation of impact energy as a function of notch radius.

4. Types of Tests

4.1 Two similar methods are presented in these test methods. (See Note 6.) These test methods use the same testing machine and specimen dimensions. There is no known means for correlating the results between test methods.

NOTE 6—Previous versions of this test method contained Test Method B for Charpy. It has been removed from this test method and has been published as D6110. Test Method D for Notch Radius Sensitivity and Test Method E for Cantilever Beam Reversed Notch have been moved into Appendixes.

4.1.1 In Test Method A, the specimen is held as a vertical cantilever beam and is broken by a single swing of the pendulum. The line of initial contact is at a fixed distance from the specimen clamp and from the centerline of the notch and on the same face as the notch.

4.1.2 Test Method C is similar to Test Method A, except for the addition of a procedure for determining the energy expended in tossing a portion of the specimen. The value reported is called the "estimated net Izod impact resistance." Test Method C is preferred over Test Method A for materials that have an Izod impact resistance of less than 27 J/m (0.5 ft·lbf/in.) under notch. (See Appendix X4 for optional units.) The differences between Test Methods A and C become unimportant for materials that have an Izod impact resistance higher than this value.

[3] Available from American National Standards Institute (ANSI), 1180 Avenue of the Americas, 10th Floor, New York, NY 10036, http://www.ansi.org.

5. Significance and Use

5.1 Before proceeding with these test methods, refer to the specification of the material being tested. Any test specimen preparation, conditioning, dimensions, and testing parameters covered in the materials specification shall take precedence over those mentioned in these test methods. If there is no material specification, then the default conditions apply.

5.2 The pendulum impact test indicates the energy to break standard test specimens of specified size under stipulated parameters of specimen mounting, notching, and pendulum velocity-at-impact.

5.3 The energy lost by the pendulum during the breakage of the specimen is the sum of the following:

5.3.1 Energy to initiate fracture of the specimen;

5.3.2 Energy to propagate the fracture across the specimen;

5.3.3 Energy to throw the free end (or ends) of the broken specimen ("toss correction");

5.3.4 Energy to bend the specimen;

5.3.5 Energy to produce vibration in the pendulum arm;

5.3.6 Energy to produce vibration or horizontal movement of the machine frame or base;

5.3.7 Energy to overcome friction in the pendulum bearing and in the indicating mechanism, and to overcome windage (pendulum air drag);

5.3.8 Energy to indent or deform plastically the specimen at the line of impact; and

5.3.9 Energy to overcome the friction caused by the rubbing of the striker (or other part of the pendulum) over the face of the bent specimen.

5.4 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 factors 5.3.1 and 5.3.3. The toss correction (see 5.3.3) has potential for representing a very large fraction of the total energy absorbed when testing relatively dense and brittle materials. Test Method C shall be used for materials that have an Izod impact resistance of less than 27 J/m (0.5 ft·lbf/in.). (See Appendix X4 for optional units.) The toss correction obtained in Test Method C is only an approximation of the toss error, since it is possible that the rotational and rectilinear velocities will not be the same during the re-toss of the specimen as for the original toss, and because it is also possible that stored stresses in the specimen were released as kinetic energy during the specimen fracture.

5.5 For tough, ductile, fiber filled, or cloth-laminated materials where the fracture propagation energy (see 5.3.2) is large compared to the fracture initiation energy (see 5.3.1), factors (see 5.3.2, 5.3.5, and 5.3.9) can become quite significant, even when the specimen is accurately machined and positioned and the machine is in good condition with adequate capacity. (See Note 7.) There is potential that bending (see 5.3.4) and indentation losses (see 5.3.8) will be appreciable when testing soft materials.

NOTE 7—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 design must ensure that the center of percussion be at the center of strike [illegible] striker

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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 striker is properly positioned.

5.6 In a well-designed machine of sufficient rigidity and mass, the losses due to factors 5.3.6 and 5.3.7 are expected to be very small. Vibrational losses (see 5.3.6) can be quite large when wide specimens of tough materials are tested in machines of insufficient mass, not securely fastened to a heavy base.

5.7 Some materials have a critical width, below which specimens will appear ductile, as evidenced by considerable drawing or necking down in the region behind the notch and by a relatively high-energy absorption, and above which they will appear brittle, as evidenced by little or no drawing down or necking and by a relatively low-energy absorption. Since these methods permit a variation in the width of the specimens, and since the width dictates, for many materials, whether a brittle, low-energy break or a ductile, high energy break will occur, it is necessary that the width be stated in the specification covering that material and that the width be reported along with the impact resistance. In view of the preceding, do not make comparisons between data from specimens having widths that differ by more than a few mils.

5.8 The type of failure for each specimen shall be recorded as one of the four categories listed as follows:

C =	*Complete Break*—A break where the specimen separates into two or more pieces.
H =	*Hinge Break*—An incomplete break, such that one part of the specimen cannot support itself above the horizontal when the other part is held vertically (less than 90° included angle).
P =	*Partial Break*—An incomplete break that does not meet the definition for a hinge break but has fractured at least 90 % of the distance between the vertex of the notch and the opposite side.
NB =	*Non-Break*—An incomplete break where the fracture extends less than 90 % of the distance between the vertex of the notch and the opposite side.

For tough materials, it is possible that the pendulum will not have the energy necessary to complete the breaking of the extreme fibers and toss the broken piece or pieces. Results obtained from "non-break" specimens shall be considered a departure from standard and shall not be reported as a standard result. Impact resistance cannot be directly compared for any two materials that experience different types of failure as defined in the test method by this code. Averages reported must likewise be derived from specimens contained within a single failure category. This letter code shall suffix 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 resistance for each type of failure, followed by the percent of the specimens failing in that manner and suffixed by the letter code.

5.9 The value of the impact methods 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, types of breaks, critical widths, or critical temperatures, it can be assumed 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. The order of toughness can even be reversed under different testing conditions.

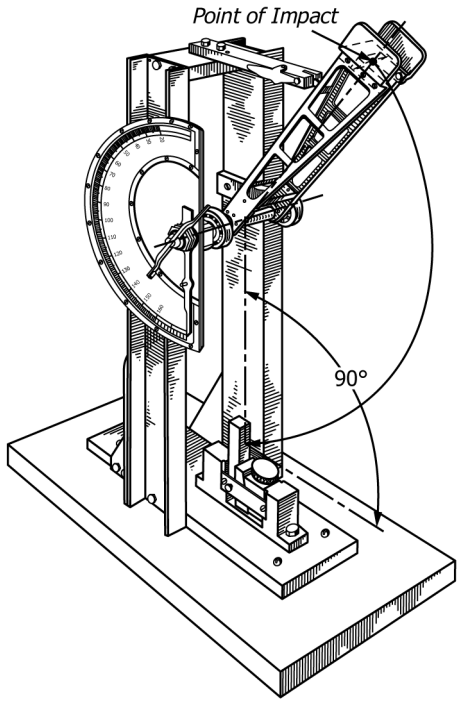


FIG. 1 Cantilever Beam (Izod-Type) Impact Machine

NOTE 8—A documented discrepancy exists between manual and digital impact testers, primarily with thermoset materials, including phenolics, having an impact value of less than 54 J/m (1 ft-lb/in.). Comparing data on the same material, tested on both manual and digital impact testers, may show the data from the digital tester to be significantly lower than data from a manual tester. In such cases a correlation study may be necessary to properly define the true relationship between the instruments.

TEST METHOD A—CANTILEVER BEAM TEST

6. Apparatus

6.1 The machine shall consist of a massive base on which is mounted a vise for holding the specimen and to which is connected, through a rigid frame and bearings, a pendulum-type hammer. (See 6.2.) The machine must also have a pendulum holding and releasing mechanism and a mechanism for indicating the breaking energy of the specimen.

6.2 Use the provided jig for positioning the specimen in the vise as well as graphs or tables to aid in the calculation of the correction for friction and windage. One type of machine is shown in Fig. 1. One design of specimen-positioning jig is illustrated in Fig. 2. Detailed requirements are given in subsequent paragraphs. General test methods for checking and calibrating the machine are given in Appendix X2. Consult the manufacturer for any additional instructions for adjusting a particular machine.

6.3 The pendulum shall consist of a single or multi-membered arm with a bearing on one end and a rigid,

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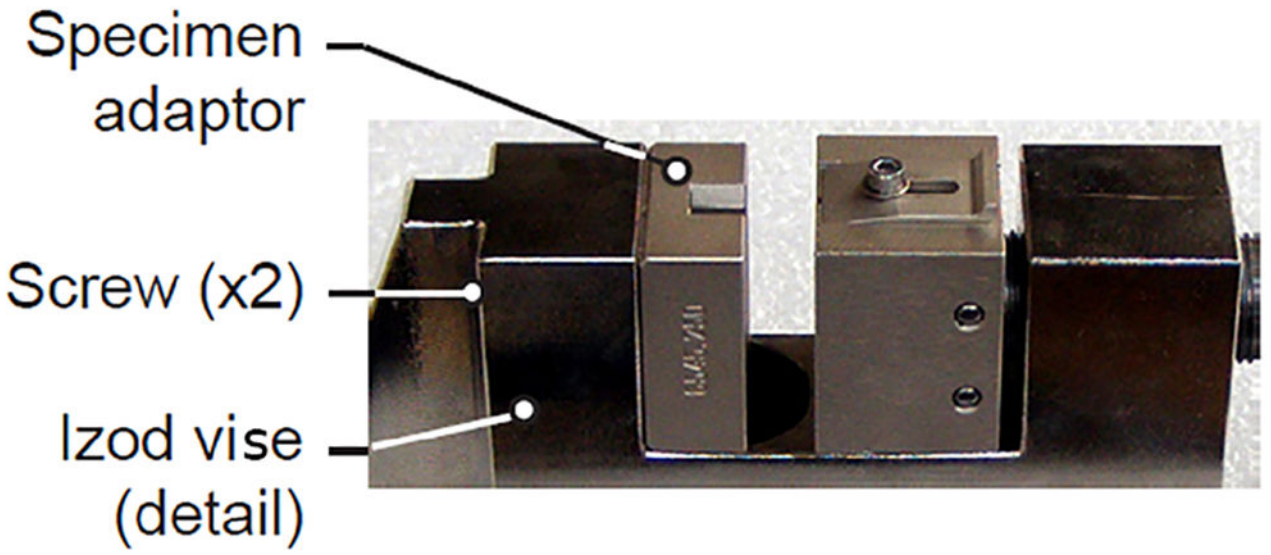


FIG. 2 Jig for Positioning Specimen for Clamping

containing the striker, on the other. 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 that are always included in the measured impact resistance. Both simple and compound pendulum designs comply with this test method.

6.4 The striker of the pendulum shall be hardened steel and shall be a 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. The line of contact of the striker shall be located at the center of percussion of the pendulum within ±2.54 mm (±0.100 in.) (See Note 9.) 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 in contact with the specimen during the break.

NOTE 9—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:

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

where:

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

6.5 The position of the pendulum holding and releasing mechanism shall be such that the vertical height of fall of the striker shall be 610 ± 2 mm (24.0 ± 0.1 in.). This will produce a velocity of the striker at the moment of impact of approximately 3.5 m (11.4 ft)/s. (See Note 10.) The mechanism shall be so constructed and operated that it will release the pendulum without imparting acceleration or vibration to it.

NOTE 10—

$$V = (2gh)^{0.5}$$

where:

- V = velocity of the striker at the moment of impact (m/s),
- g = local gravitational acceleration (m/s^2), and
- h = vertical height of fall of the striker (m).

This assumes no windage or friction.

6.6 The effective length of the pendulum shall be between 0.33 and 0.40 m (12.8 and 16.0 in.) so that the required elevation of the striker is obtained by raising the pendulum to an angle between 60 and 30° above the horizontal.

6.7 The machine shall be provided with a basic pendulum capable of delivering an energy of 2.7 ± 0.14 J (2.00 ± 0.10 ft·lbf). This pendulum shall be used with all specimens that extract less than 85 % of this energy. For specimens that require more energy to break, heavier pendulums shall be provided, either as separate interchangeable pendulums or one basic pendulum designed to allow rigid attachment of extra pairs of equal calibrated weights to opposite sides of the pendulum. It is imperative that the extra weights shall not significantly change the position of the center of percussion or the free-hanging rest point of the pendulum (that would consequently take the machine outside of the allowable calibration tolerances). A range of pendulums having energies from 2.7 to 21.7 J (2 to 16 ft·lbf) has been found to be sufficient for use with most plastic specimens and machines. A series of pendulums such that each has twice the energy of the next will be found convenient. Each pendulum shall have an energy within ±0.5 % of its nominal capacity.

6.8 A vise shall be provided 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 (see Fig.

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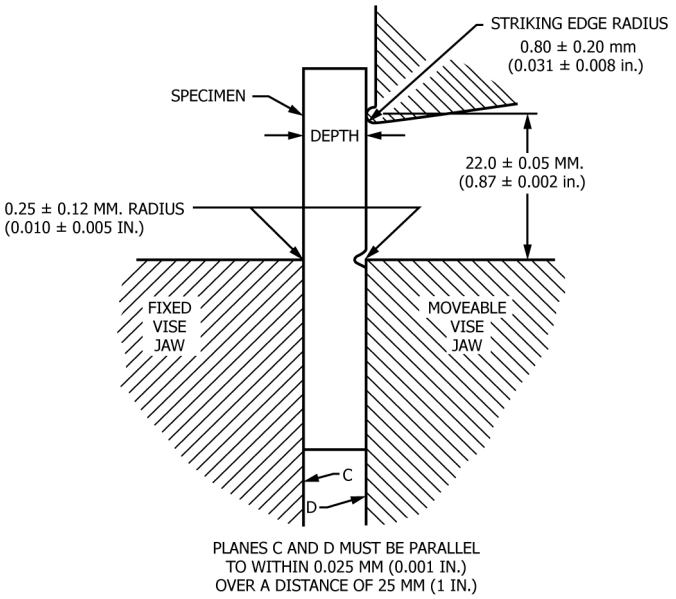


FIG. 3 Relationship of Vise, Specimen, and Striking Edge to Each Other for Izod Test Methods A and C

3.) This top plane shall bisect the angle of the notch with a tolerance of 0.12 mm (0.005 in.). Correct positioning of the specimen is generally done with a jig furnished with the machine. The top edges of the fixed and moveable jaws shall have a radius of 0.25 ± 0.12 mm (0.010 ± 0.005 in.). For specimens whose thickness approaches the lower limiting value of 3.00 mm (0.118 in.), means shall be provided to prevent the lower half of the specimen from moving during the clamping or testing operations (see Fig. 2 and Note 11.)

NOTE 11—Some plastics are sensitive to clamping pressure; therefore, cooperating laboratories should agree upon some means of standardizing the clamping force. One method is using a torque wrench on the screw of the specimen vise. If the faces of the vise or specimen are not flat and parallel, a greater sensitivity to clamping pressure may be evident. See the calibration procedure in Appendix X2 for adjustment and correction instructions for faulty instruments.

6.9 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 (0.87 ± 0.002 in.) above the top surface of the vise.

6.10 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 10.3 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 12.)

NOTE 12—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.

6.11 The vise, pendulum, and frame shall be sufficiently rigid to maintain correct alignment of the hammer 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 that the impact will not cause it to move. The machine shall be so designed, constructed, and maintained 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.

6.12 A check of the calibration of an impact machine is difficult to make under dynamic conditions. The basic parameters are normally checked under static conditions; if the machine passes the static tests, then it is assumed to be accurate. The calibration procedure in Appendix X2 provides a method to establish the accuracy of the equipment. However, for some machine designs it might be necessary to change the recommended method of obtaining the required calibration measurements. Other methods of performing the required checks are acceptable, provided that they can be shown to result in an equivalent accuracy. Appendix X1 also describes a dynamic test for checking certain features of the machine and specimen.

6.13 *Micrometers*—Apparatus for measurement of the width of the specimen shall comply with the requirements of Test Methods D5947. Apparatus for the measurement of the depth of plastic material remaining in the specimen under the notch shall comply with requirements of Test Methods D5947, provided however that the one anvil or presser foot shall be a tapered blade conforming to the dimensions given in Fig. 4. The opposing anvil or presser foot shall be flat and conforming to Test Methods D5947.

7. Test Specimens

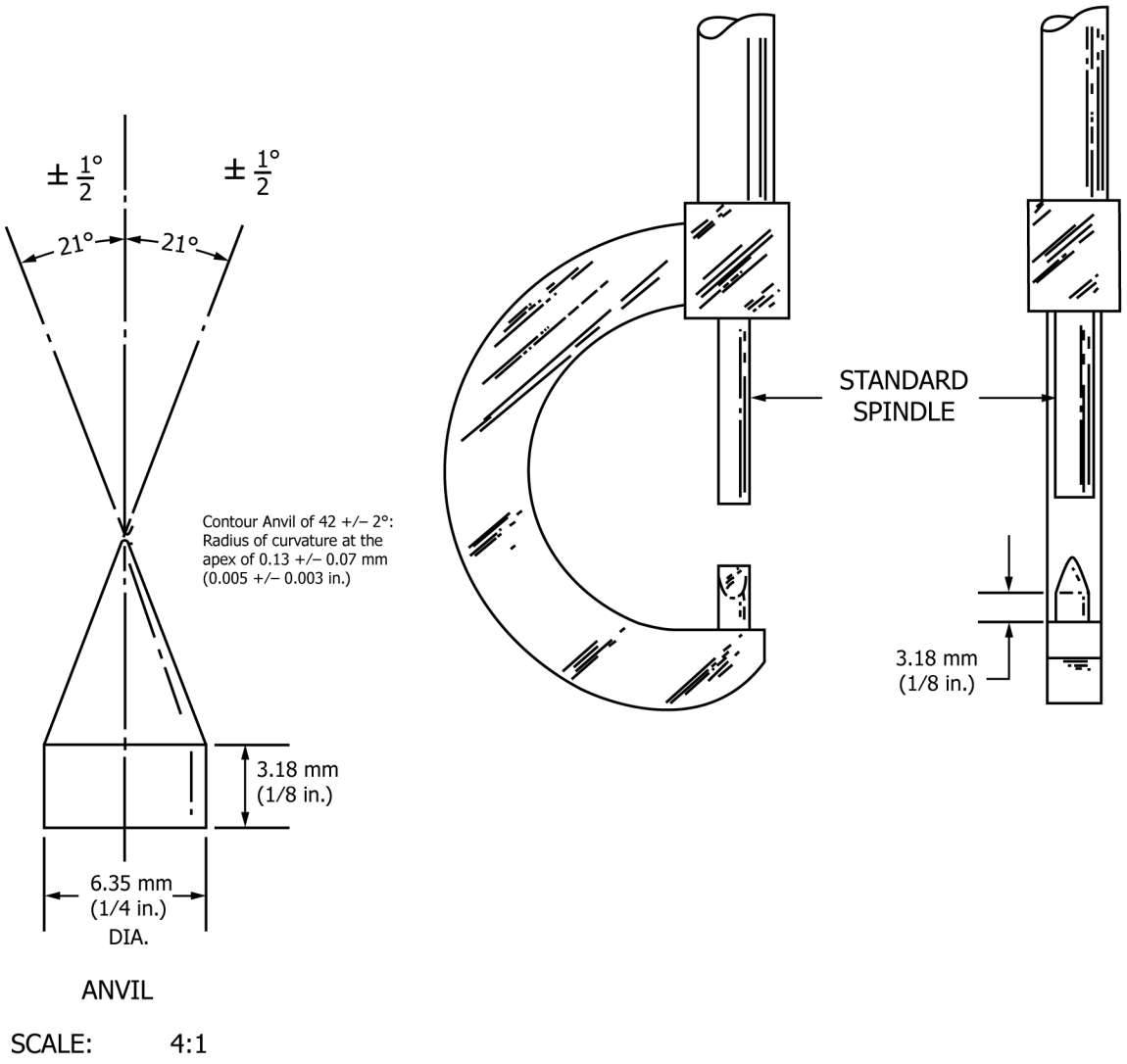
7.1 The test specimens shall conform to the dimensions and geometry of Fig. 5, except as modified in accordance with 7.2, 7.3, 7.4, and 7.5. To ensure the correct contour and conditions of the specified notch, all specimens shall be notched as directed in Section 8.

7.1.1 Studies have shown that, for some materials, the location of the notch on the specimen and the length of the impacted end can have a slight effect on the measured impact resistance. Therefore, unless otherwise specified, care must be taken to ensure that the specimen conforms to the dimensions shown in Fig. 5 and that it is positioned as shown in Fig. 3.

7.2 Molded specimens shall have a width between 3.0 and 12.7 mm (0.118 and 0.500 in.). Use the specimen width as specified in the material specification or as agreed upon between the supplier and the customer. All specimens having one dimension less than 12.7 mm (0.500 in.) shall have the

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NOTE 1—These views not to scale.
NOTE 2—Micrometer to be satin-chrome finished with friction thimble.
NOTE 3—Special anvil for micrometer caliper 0 to 25.4 mm range (50.8 mm frame) (0 to 1 in. range (2-in. frame)).
NOTE 4—Anvil to be oriented with respect to frame as shown.
NOTE 5—Anvil and spindle to have hardened surfaces.
NOTE 6—Range: 0 to 25.4 mm (0 to 1 in. in thousandths of an inch).
NOTE 7—Adjustment must be at zero when spindle and anvil are in contact.

FIG. 4 Early (ca. 1970) Version of a Notch-Depth Micrometer

notch cut on the shorter side. Otherwise, all compression-molded specimens shall be notched on the side parallel to the direction of application of molding pressure. (See Fig. 5.)

NOTE 13—While subsection 7.5 requires perpendicular pairs of plane parallel surfaces, the common practice has been to accept the non-parallel drafted surfaces formed when directly injection molding specimens for Izod testing. Users must be aware that employing a trapezoidal section rather than a rectangular section may lead to data shifts and scatter. Unequal stress, created by clamping in the fracture region and dynamic twisting, caused by uneven striking of the specimen are prone to occur when the faces of the specimen are not parallel. Interlaboratory comparisons must clearly spell out the specimen preparation conditions.

7.2.1 Extreme care must be used in handling specimens less than 6.35 mm (0.250 in.) wide. Such specimens must be accurately positioned and supported to prevent twist or lateral buckling during the test. Some materials, furthermore, are very sensitive to clamping pressure (see Note 11).

7.2.2 A critical investigation of the mechanics of impact testing has shown that tests made upon specimens under 6.35 mm (0.250 in.) wide absorb more energy due to crushing, bending, and twisting than do wider specimens. Therefore, specimens 6.35 mm (0.250 in.) or over in width are recommended. The responsibility for determining the minimum

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