Designation: D 4508 – 98

Standard Test Method for Chip Impact Strength of Plastics[1]

This standard is issued under the fixed designation D 4508; 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 The purpose of this test method is to provide an impact test that can be performed on small specimens of plastics of different thicknesses. This test method is especially suited for observing the effects of microcracks caused by weathering, or by exposure to solvents or other hostile environments, on the surface of plastic materials. It is not meant to be used as a replacement for any existing impact test, but can be used to measure impact on coupons machined from finished parts that cannot be tested by the drop-weight, Izod, or Charpy method because of shape or thickness limitations.

1.2 The chip-impact test is run on small, flat, unnotched specimens using a standard pendulum-impact device. The test places the impacted surface in tension and, for notch-sensitive materials, is extremely sensitive to the presence of surface microcracks. Thus, for plastics that develop surface cracks when exposed outdoors, the chip-impact test is a severe test of the weathered impact strength.

1.3 Round-robin testing has indicated that materials that break at total energy values of less than 0.17 joules (1.5 in.-lbf) have within-laboratory coefficients of variation of approximately 30 %. Therefore, such values are considered out of the normal testing range for this test.

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

1.5 There is no ISO equivalent to this test method.

1.6 *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.*

2. Referenced Documents

2.1 *ASTM Standards:*

D 256 Test Method for Determining the Pendulum Impact Resistance of Notched Specimens of Plastics[2]

D 618 Practice for Conditioning Plastics and Electrical Insulating Materials for Testing[2]

D 883 Terminology Relating to Plastics[2]

D 1600 Terminology for Abbreviated Terms Relating to Plastics[2]

D 4000 Classification System for Specifying Plastic Materials[3]

D 4066 Specification for Nylon Injection and Extrusion Materials[3]

E 380 Practice for Use of the International System of Units (SI) (the Modernized Metric System)[4]

E 691 Practice for Conducting an Interlaboratory Study to Determine the Precision of a Test Method[4]

3. Terminology

3.1 Definitions—For definitions of plastic terms see Terminology D 883 and for abbreviations see Terminology D 1600. There are no terms in this test method that require new or other-than-dictionary definitions.

4. Significance and Use

4.1 The chip-impact test is a variation of the Izod impact test described in Test Methods D 256.

4.2 The specimen geometry has been chosen to fit three basic criteria as follows:

4.2.1 The specimen is relatively thin and is struck on the broad surface so that the test result is sensitive to the condition of the surface,

4.2.2 The specimen is relatively small for efficient utilization of space in accelerated testing media or devices and to minimize amounts of material needed for testing, and

4.2.3 The specimen can be tested using a standard Izod pendulum tester.

4.3 It has been found that a 12.7-mm (0.500-in.) wide strip with a thickness in the range from 1.02 to 3.18 mm (0.040 to 0.125 in.) meets the above criteria. Much experimental work on 1.78-mm (0.070-in.) strips has demonstrated the utility of the chip-impact test to track weather aging of a variety of materials.

4.4 The distance (L) between clamping and impact points (striker height) will affect test results. Extensive experimental work has established that a ratio of $L = 2.182\ h$ (where L is the

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[2] *Annual Book of ASTM Standards*, Vol 08.01.

[3] *Annual Book of ASTM Standards*, Vol 08.02.

[4] *Annual Book of ASTM Standards*, Vol 14.02.

distance between clamping and impact points and *h* is the thickness of the specimen) will provide accurate and sensitive chip-impact values. Increasing this ratio (that is, raising the striker height for a given thickness) lowers chip-impact values and reduces sensitivity of the test. Decreasing the above ratio (that is, lowering the striker height for a given thickness) results in a shearing of the specimen rather than the desired bending and breaking.

4.5 In general, the chip-impact value during weathering varies according to specimen thickness, even after adjusting striker heights for constant deflection, as given in Table 1. The thickness of the specimen should always be reported, along with the test values, and comparisons should only be made among samples of similar thickness.

4.6 The standard Izod Methods A, C, D, and E require that the type of failure for each specimen be recorded as one of the four coded categories defined as follows:

C = *complete break*—a break in which 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 surface of the impact side and the opposite side.

NB = *non-break*—an incomplete break where the fracture extends less than 90 % of the distance between the impacted surface and the opposite side. Non-break data shall not be reported as a standard result, but may be used to establish a relative sensitivity to aging on a time basis.

4.6.1 Impact values cannot be directly compared for any two materials that experience different types of failure as defined in the method for this code.

4.7 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 a combination thereof, covered in the material specification shall take precedence over those mentioned in this test method. If there are no material specifications, then the default conditions apply.

TABLE 1 Striker Height Adjustment for Constant Deflection

h^A		L^B	
mm	in.	mm	in.
1.016	(0.040)	2.21	(0.09)
1.143	(0.045)	2.49	(0.10)
1.270	(0.050)	2.77	(0.11)
1.397	(0.055)	3.05	(0.12)
1.524	(0.060)	3.33	(0.13)
1.651	(0.065)	3.61	(0.14)
1.778	(0.070)	3.89	(0.15)
1.905	(0.075)	4.17	(0.16)
2.032	(0.080)	4.45	(0.18)
2.159	(0.085)	4.72	(0.19)
2.286	(0.090)	5.00	(0.20)
2.413	(0.095)	5.28	(0.21)
2.540	(0.100)	5.56	(0.22)
2.667	(0.105)	5.84	(0.23)
2.794	(0.110)	6.10	(0.24)
2.921	(0.115)	6.38	(0.25)
3.048	(0.120)	6.66	(0.26)
3.175	(0.125)	6.93	(0.27)

5. Apparatus

5.1 The apparatus shall be a cantilever beam (Izod-type) impact machine as described in the Annex and Test Methods D 256, Method A. The following modifications must be made to the specimen holder and impacting hammer (see Fig. 1). The specimen holder shall be constructed from a 12.7 by 12.7-mm (0.5 by 0.5-in.) steel bar, the front face of which shall be recessed 1.9 mm (0.075 in.) deep and 7.94 mm (0.312 in.) long from the top surface to accept the chip-impact specimen. Corresponding to this recessed area is an adjustable clamp to hold the specimen in place. This specimen holder is clamped into the standard Izod vise and adjusted to proper height based on specimen thickness. This adjustment is made by positioning the adjustment screw in the vertical portion of the specimen holder.

5.2 The chip-impact striker (see Fig. 2) has a flat face and bevelled bottom edge to facilitate clearance of specimens that do not completely break-off on impact (hinge or partial breaks). The standard Izod striker may also be used with no significant change in impact strength.

5.3 Calibration of the cantilever beam impact machine may be carried out as described in Test Methods D 256.

6. Test Specimen

6.1 The standard test specimen shall be 12.7 mm (0.5 in.) wide by 19.05 mm (0.750 in.) long by 1.02 to 3.175 mm (0.040 to 0.125 in.) in depth. The preferred depth is (1.778 mm (0.070 in.)). These may be cut from molded plaques, extruded sheets, or finished products and should be cut or milled to the proper 12.7-mm (0.5-in.) width. Smooth edges are necessary to minimize edge effects.

6.2 For determining the effect of aging or environmental exposure, cut the material to be tested into a convenient size for the exposure apparatus. Expose these sections for the required time in the desired environment. After exposure, cut each section into 12.7 by 19.05-mm (0.5 by 0.75-in.) chips for impacting testing. Test each chip by striking it on the exposed side.

7. Conditioning

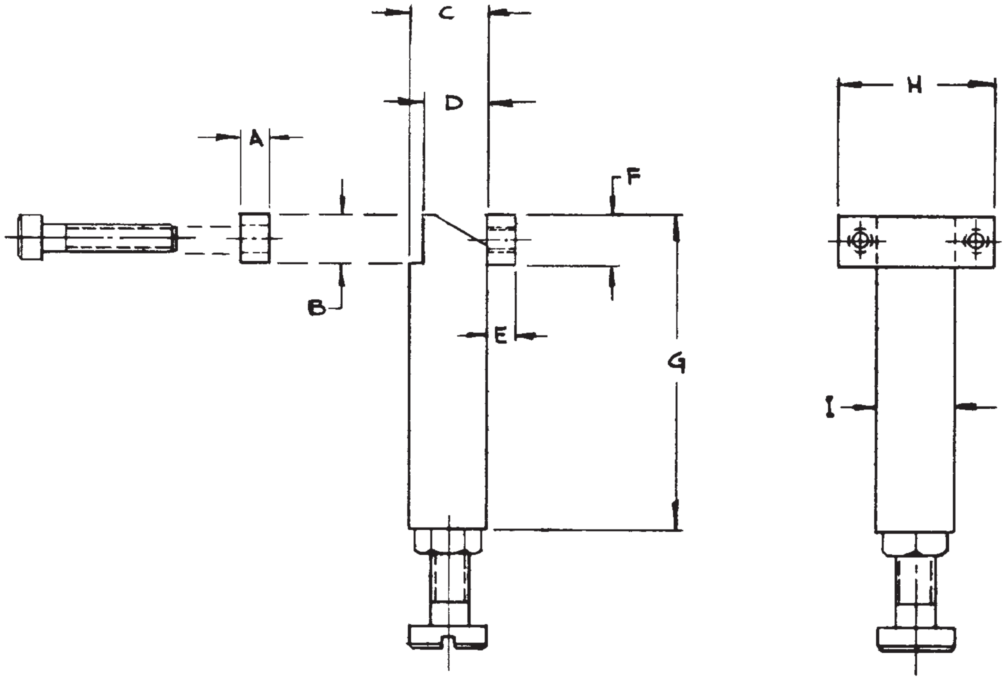
7.1 Condition the test specimens at 23 ± 2°C (73.4 ± 3.6°F) and 50 ± 5 % relative humidity for not less than 40 h prior to test, in accordance with Method A of Practice D 618, unless otherwise specified.

7.2 Conduct tests in the standard laboratory atmosphere of 23 ± 2°C (73.4 ± 3.6°F) and 50 ± 5 % relative humidity, unless otherwise specified.

7.3 Note that for some hygroscopic materials, such as nylons, the material specifications (for example, Specification D 4066) call for testing "dry as molded specimens." Such requirements take precedence over routine preconditioning to 50 % relative humidity and require sealing specimens in water vapor-impermeable containers as soon as molded or extruded, and not removing them until ready for testing.

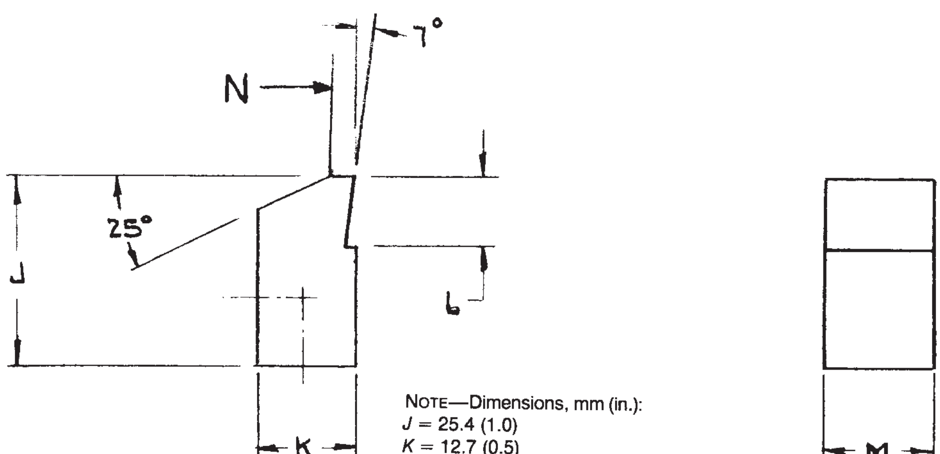
7.4 *Post-Conditioning of Specimens After Exposure to Hostile Environment*:

7.4.1 Specimens shall be conditioned in accordance with section 7.1 or 7.3 prior to subjecting the specimens to the hostile environment, unless otherwise specified.



NOTE—Dimensions, mm (in):
A = 4.7625 (0.1875)
B = 7.9375 (0.3125)
C = 12.700 (0.500)
D = 10.795 (0.425)
E = 4.7625 (0.1875)
F = 7.9375 (0.3125)
G = 50.8 (2.0)
H = 25.4 (1.0)
I = 12.7 (0.5)

FIG. 1 Specimen Holder



NOTE—Dimensions, mm (in.):
J = 25.4 (1.0)
K = 12.7 (0.5)
L = 9.525 (0.375)
M = 14.2875 (0.5625)
N = 3.2 (0.125)

FIG. 2 Striker

7.4.2 The post-conditioning of specimens which have been exposed to hostile environments requires careful consideration. The ultimate purpose of the exposure and test must be considered. The post-conditioning requirements for the specimen shall be agreed upon by seller and purchaser for the purpose of referee testing. One cannot expect comparable results unless all details of sampling, specimen preparation, specimen conditioning, and exposures as well as testing conditions are identical in all laboratories trying to make a comparison or settle a disagreement. Specimens subjected to high temperatures, accelerated weathering, outdoor weathering, radiation, or other exposure not involving submersion in liquid shall be allowed to return to the standard laboratory atmosphere before testing. If the original unexposed specimens used as references were tested at a temperature other than the standard laboratory temperature then the specimens subjected to the hostile environment must be allowed to reach thermal equilibrium at the test temperature before testing.

NOTE 1—For hygroscopic materials such as nylons that have data based on "dry as molded" conditioning, returning the exposed specimens to the same conditions as the original specimen may introduce new (negative) effects on the test specimen, for example, by drying in oven (heat/crystallinity) or over chemical desiccant. For these materials, condition the exposed sample and a "control" sample at the standard laboratory atmosphere prior to testing.

7.4.3 Specimens that have been immersed in a hostile liquid environment require special handling. The liquid may evaporate from the specimen while exposed to the standard laboratory atmosphere so all specimens must remain in the liquid until ready to test. The liquid temperature and specimen must both be at standard laboratory temperature. If the original unexposed specimens used as references were tested at a temperature other than the standard laboratory temperature the liquid and specimens subjected to the hostile environment must then be allowed to reach thermal equilibrium at the test temperature prior to testing.

8. Procedure

8.1 For evaluation purposes within a laboratory, make four individual determinations on each sample to be tested. For comparing data between laboratories, make ten individual determinations of each sample to be tested. Each group shall consist of specimens of one nominal thickness only. In the case of specimens cut from sheets that are suspected of being anisotropic, prepare and test specimens from each principal direction (lengthwise and crosswise to the direction of anisotropy).

8.2 Estimate the breaking energy for the specimen and select a pendulum of suitable energy. Use the lightest standard pendulum that is expected to break each specimen in the group with a loss of not more than 85 % of its energy (Note 1). Check the machine with the proper pendulum in place for conformity with the requirements of Section 1.5 of Test Methods D 256 before starting the test (see Appendix XI of Test Methods D 256).

NOTE 2—Ideally an impact test would be conducted at a constant test velocity. In a pendulum-type test the velocity decreases as the fracture progresses. For specimens that have an impact energy approaching the capacity of the pendulum, there is insufficient energy to complete the break and toss. By avoiding the higher 15 % scale energy readings, the velocity of the pendulum will not be reduced below 1.34 m/s (4.4 ft/s). On the other hand, the use of too heavy a pendulum would reduce the sensitivity of the reading.

8.3 Before testing the specimens, perform the following operations on the machine:

8.3.1 With the excess energy-indicating pointer in its normal starting position, but without a specimen in the vise, release the pendulum from its normal starting position and note the position the pointer attains after the swing as one reading of Factor A.

8.3.2 Without resetting the pointer, raise the pendulum and release again. The pointer should move up the scale an additional amount. Repeat until a swing causes no additional movement of the pointer and note the final reading as one reading of Factor B.

8.3.3 Repeat the above two operations several times and calculate and record the average A and B readings.

NOTE 3—Factor B is an indication of the energy lost by the pendulum to friction in the pendulum bearings and to windage. The difference, A − B, is an indication of the energy lost to friction and inertia in the excess energy-indicating mechanism. However, the actual corrections will be smaller than these factors, since in an actual test the energy absorbed by the specimen prevents the pendulum from making a full swing. Therefore, the indicated breaking strength of the specimen must be included in the calculation of the machine correction before using it in 8.6. These A and B values also provide an indication of the condition of the machine. If they indicate excessive friction, the machine shall be adjusted before starting a test.

8.4 Check the specimens for conformity with the requirements of Section 6. Measure the thickness of each specimen with a micrometer caliper to the nearest 0.025 mm (0.001 in.) and record its average width, along with its identifying markings.

8.4.1 Set the clearance height of the striker (*L*) above the clamping device based on the specimen thickness (see Table 1). This adjustment is made by raising or lowering the vertical adjustment screw in the specimen holder (Fig. 1).

8.5 Position the specimen precisely and rigidly, but do not use excessive force in clamping (Note 3) in the vise. In the case of surface-treated or weathered specimens, pay special attention to ensure that the "exposed surface" of the specimen is the impacted surface. Release the pendulum and note and record the amount of energy required to break the specimen, together with a description of the appearance of the broken specimen.

NOTE 4—Some plastics are sensitive to clamping pressure. Therefore, laboratories comparing chip-impact test results should agree upon some means of standardizing the clamping force, such as a torque wrench on the screws of the specimen holder.

8.6 Calculate the machine correction from the indicated breaking strength of the specimen and Factors A and B, using tables or the graph described in Appendix X2 of Test Methods D 256. Subtract the correction so calculated from the indicated breaking strength of the specimen. Compare the net value so found with the energy requirement of the pendulum specified (8.2 and Note 2). If a pendulum of improper energy was used, discard the result and make additional tests on new specimens with the proper hammer.

8.7 Calculate chip-impact strength by the following formula:

$$\text{Chip-impact strength } (\text{ft} \cdot \text{lbf/in.}^2) = (E - C/12\ wh)$$

where:

E = inch-pound on tester scale,

C = correction from 8.6,
w = width of specimen, and
h = depth of specimen.

8.8 Calculate the average impact strength of the group of specimens. However, only values of specimens having the same nominal depth and type of break may be averaged. When required, also calculate the standard deviation of the group of values.

8.9 There are two methods of comparing the chip-impact values of specimens that have been environmentally exposed with corresponding specimens that have not been exposed.

8.9.1 Plot a graph of average chip-impact values as ordinates versus length of aging times as abscissae. Such a plot clearly indicates the change in chip-impact strength as a function of environmental aging, and allows the type of failure for each individual data point to be reported on the graph.

8.9.2 Calculate percent chip-impact strength retained for a given material at a specific aging time by the following:

$$\text{Chip}-\text{impact strength retained, \%} = (\text{Average chip}-\text{impact strength after aging}/\text{Average chip}-\text{impact strength before aging})\times 100$$

9. Report

9.1 Report the following information:

9.1.1 Complete identification of the material tested, including type, source, manufacturer's code number, and previous history.

9.1.2 A statement of how the specimens were prepared, the testing conditions used and, for sheet materials, the direction of testing with respect to anisotropy, if any.

9.1.3 The capacity of the pendulum in joules, or foot-pounds-force, or inch-pounds-force.

9.1.4 The nominal thickness of the specimens.

9.1.5 The total number of specimens tested per sample of material (that is, four, ten, or more).

9.1.6 The number of those specimens that resulted in failures conforming to each of the category requirements of 4.6.

9.1.7 The average chip-impact strength in foot-pounds-force per square inch of the specimens of 9.1.6 for each failure category.

9.1.8 If required, the standard deviation of the values of the impact strength of the specimens of 9.1.6.

9.1.9 The percent of specimens failing in each category suffixed by the corresponding letter code.

10. Precision and Bias

10.1 Table 2 is based on a round robin conducted in 1983, in accordance with Practice E 691 – 87, involving six materials, tested by nine laboratories. For each material, all the samples were prepared by a single laboratory. Each test result was the average of ten individual determinations. Each laboratory obtained two test results for each material on both unaged and aged stages.[5]

[5] Supporting data are available from ASTM Headquarters. Request RR: D 20 - 1117.

NOTE 5—**Caution:** The following explanation of r and R (10.2 through 10.2.3) are only intended to present a meaningful way of considering the approximate precision of this test method. The data in 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 Practice E 691 - 87 to generate data specific to their laboratory and materials, or between specific laboratories. The principles of 10.2 through 10.2.3 would then be valid.

10.2 *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 from testing 10 specimens:

10.2.1 *Repeatability Limit, r*—In comparing two averages (of ten specimens each) for the same material, obtained on the same equipment by the same operator on the same day, the averages should be judged not equivalent if they differ by more than the *r* shown in Table 2A for that material and condition.

10.2.1.1 Use Table 2B to compare averages of four determinations.

10.2.2 *Reproducibility Limit, R*—In comparing two averages (of ten specimens each) for the same material, obtained on different equipment by different operators on different days, the averages should be judged not equivalent if they differ by more than the *R* for the material and the condition.

10.2.3 Any judgment in accordance with 10.2.1 or 10.2.2 would have an approximate 95 % (0.95) probability of being correct.

10.3 *Bias*—There are no recognized standards by which to estimate bias of this test method.

11. Keywords

11.1 breaking energy; cantilever impact; chip impact strength; impact plastics; impact testing; microcracks; pendulum; plastics; small specimen impact; weathered impact strength

TABLE 2 Round-Robin Precision Data—Chip-Impact Strength ($ft \cdot lbf/in.^2$) Unaged

A. For 10 Determinations per Sample (see 8.1)

Material	Nominal Thickness	Mean	S_r	S_R	r	R	Type of Break
PS	0.070 in.	5.1	0.24	0.53	0.68	1.50	P
AES[A]	0.070 in.	23.7	0.99	3.5	2.80	9.82	H
ABS	0.070 in.	23.6	1.04	2.7	2.94	7.64	H
ABS[B]	0.125 in.	31.2	1.04	8.5	2.94	23.94	H

B. For 4 Determinations per Sample (see 8.1)

Material	Nominal Thickness	Mean	S_R	I_R
PS	0.070 in.	5.1	0.38	1.08
AES[A]	0.070 in.	23.7	1.55	4.39
ABS	0.070 in.	23.6	2.05	5.79
ABS[BCDEF]	0.125 in.	31.2	1.65	4.67

[A] Acrylonitrile-ethylene propylene-styrene.
[B] Some laboratories unable to adjust striker height for 0.125-in. thick specimens because of impact machine geometry.
[C] S_r is the within-laboratory standard deviation of the average.
[D] S_R is the between-laboratories standard deviation of the average.
[E] r is the within-laboratory Repeatability Limit = 2.8 S_r.
[F] R is the between-laboratories Reproducibility Limit = 2.8 S_R.

APPENDIX

(Nonmandatory Information)

X1. DETERMINATION OF STRIKER HEIGHT ADJUSTMENT FOR CONSTANT DEFLECTION

X1.1 The formula to determine *L*, the distance from the specimen holder to the striker for constant deflection (as listed in Table 1), is based on the formula for deflection of a cantilever beam:

X1.1.1

$$a=\frac{4WL^3}{bh^3E}$$

where:

a = deflection,
L = distance from holder to impact point,
b = width of specimen,
h = depth of beam,
E = Young's modulus, and
W = applied force.

X1.1.2 Since:

$$a=\frac{4W}{bE}$$

is a constant, then

$$\frac{L^3}{h^3} \text{ or } \frac{\mathrm{L}}{\mathrm{h}}$$

becomes the relationship on which Table 1 is based.

X1.1.3 The L = 2.182h ratio mentioned in 4.4 was arrived at through experimental trials as the ratio of L/h that would result from impacting a bar of the dimension 6.35 by 12.7 by 63.5 mm (0.250 by 0.50 by 2.5 in.) in a cantilever-beam impact tester with a striker height, L, of 22.0 mm (0.866 in.). \