INTERNATIONAL

Designation: D3420 − 21

Standard Test Method for Pendulum Impact Resistance of Plastic Film[1]

This standard is issued under the fixed designation D3420; 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 resistance of film to impact-puncture penetration. Knowledge of how the impact energy is absorbed by the specimen while it is deforming under the impact loading, and the behavior of the specimen after yielding, is not provided by this test. No provision is made for nonambient temperatures in this test method.

1.2 The values stated in SI units are to be regarded as the standard.

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.* Specific hazards statements are given in Section 7.

NOTE 1—There is no known ISO equivalent to this standard.

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]

D618 Practice for Conditioning Plastics for Testing
D883 Terminology Relating to Plastics
D1709 Test Methods for Impact Resistance of Plastic Film by the Free-Falling Dart Method
D1922 Test Method for Propagation Tear Resistance of Plastic Film and Thin Sheeting by Pendulum Method
D4272 Test Method for Total Energy Impact of Plastic Films by Dart Drop
D6988 Guide for Determination of Thickness of Plastic Film Test Specimens
E456 Terminology Relating to Quality and Statistics
E691 Practice for Conducting an Interlaboratory Study to Determine the Precision of a Test Method

3. Terminology

3.1 *Definitions*—For definition of terms used in this test method and associated with plastics issues refer to the terminology contained in D883. 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 *failure completion energy*—the energy necessary to initiate failure plus the energy necessary to cause complete rupture to the test specimen.

3.2.2 *failure initiated energy*—the energy necessary to begin failure of the test specimen.

3.2.3 *pendulum impact resistance*—the resistance to failure of plastic film is measured by loss in mechanical work capacity due to the expenditure of kinetic energy by a pendulum.

4. Summary of Test Method

4.1 The energy necessary to burst and penetrate the center of a specimen, mounted between two plates with a circular aperture, is measured by the loss in mechanical work-capacity due to the expenditure of kinetic energy by a pendulum, the rounded probe of which passes through the test specimen. Corrections for "toss factor" or kinetic energy imparted to the puncture fragment of the test specimen are not made, as only tiny masses are involved. The pendulum head hits the specimen with a maximum velocity of about 74 m/min and a maximum energy of about 5 J (50 cm·kgf).

5. Significance and Use

5.1 Like other techniques to measure toughness, this test method provides a means to determine parameters of a material at strain rates closer to some end-use applications than provided by low-speed uniaxial tensile tests. Dynamic tensile behavior of a film is important, particularly when the film is used as a packaging material. The same uncertainties about correlations with thickness that apply to other impact tests also apply to this test (see section 3.4 of Test Methods D1709).

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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 D20.19 on Film, Sheeting, and Molded Products.

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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**

Hence, no provision for rationalizing to unit thickness is provided. Also, no provision is made for testing at non-ambient temperatures.

5.2 This test method includes two procedures, similar except with regard to sample size: Procedure A for 60-mm diameter and Procedure B for 89-mm diameter (commonly called the "Spencer"). The data have not been shown relatable to each other.

5.3 Several impact test methods are used for film. It is sometimes desirable to know the relationships among test results derived by different methods. A study was conducted in which four films made from two resins (polypropylene and linear low-density polyethylene), with two film thicknesses for each resin, were impacted using Test Methods D1709 (Method A), Test Method D3420 (Procedures A and B), and Test Method D4272. The test results are shown in Appendix X1. Differences in results between Test Methods D1709 and D4272 are expected since Test Methods D1709 represents failure initiated energy while Test Method D4272 is initiation plus completion energy. Some films have shown consistency when the initiation energy was the same as the total energy. This statement and the test data also appear in the significance and appendixes sections of Test Methods of D1709 and D4272.

6. Apparatus

6.1 *Tester,* having a heavy base plate (to be bolted down when the higher energy ranges are used), housing, and frame upon which is located a free-swinging pendulum with a hemispherical impact head. The dimensions for the impact heads for Procedures A and B are as follows:

6.1.1 *Procedure A*—Having a smooth surface of 12.7-mm (0.5-in.) radius and 25.4-mm (1.0-in.) diameter, which when released from the starting position punctures the material. The specimen is clamped between two plates with a circular aperture of 60 ± 0.3-mm (2.362 ± 0.012-in.) diameter in the center.

6.1.2 *Procedure B*—Having a smooth surface of 12.7-mm (0.5-in.) radius, and 19.0-mm (0.75-in.) diameter, which when released from the starting position punctures the material. The specimen is clamped between two plates with a circular aperture of 89 ± 0.5 mm (3.50 ± 0.02 in.). Several types of clamps are available on the Spencer testers: a slip-ring type, manual-tightening type with O-ring, and air-operated type with O-ring. The O-ring type, either manual or air-operated, is recommended to minimize slippage of the test specimen. The air-operated O-ring clamp shall be the referee-type.

6.1.3 *Calibrated Dial or Digital Readout,* to record the energy necessary to burst and penetrate the specimen (a scale and pointer with indicating follower and attachable auxiliary weights to give suitable energy scales). Four energy scales have been found suitable, 0.5, 1.0, 2.5, and 5.0 J (5, 10, 25, and 50 cm·kgf), for Procedure A through the use of attachable auxiliary weights. For Procedure B, a modified Elmendorf tester having a capacity of 1600 gf (3200 gf with auxiliary weight) is normally used. Pendulums of 200, 400, and 800 gf are also available. Equivalent energy capacities for these force capacities are as follows:

gf	J (cm·kgf)
200	0.169 (1.7)
400	0.338 (3.4)
800	0.675 (6.8)
1600	1.35 (13.5)
3200	2.70 (27)

6.2 *Micrometer,* reading to ±0.00025 mm (±0.00001 in.) for measuring specimen thickness.

6.3 *Specimen Cutter.*

7. Hazards

7.1 In either procedure, be sure that the hands are kept out of the pendulum path when it is in the cocked position.

8. Test Specimens

8.1 Obtain samples that are of uniform thickness and consistency, flat, free of defects, and representative of the material to be tested.

NOTE 2—Although the scope of this test method is for films [sheeting ≤0.25 mm (≤10 mils)], samples up to 0.40 mm (15 mils) have been tested, representing the upper limit imposed by the design of the clamp, without damage to the pendulum.

8.2 From throughout the sample, cut at least five specimens, 100-mm (4-in.) diameter circular, or 100 by 100-mm (4 by 4-in.) square or larger if clamps require.

9. Preparation of Apparatus

9.1 Locate the instrument on a level surface and level the instrument carefully.

9.2 Make the necessary adjustments to ensure the pendulum hangs vertically when free.

9.3 Zero the instrument in accordance with Test Method D1922 if the instrument has a pointer, or refer to the manufacturer's recommendations if it has a digital readout.

9.3.1 *Analog Instruments*—Release the pendulum from its latched position and allow to swing freely (with no sample). The pointer shall come to within one scale division of the zero point.

NOTE 3—If the pointer does not come to within one scale division of the zero point the bearing likely needs cleaning.

9.4 Verify the scale in accordance with Test Method D1922 or refer to the manufacturer's recommendations.

9.5 Select the weight so that the scale readings do not fall on the extreme ends of the range when testing specimens.

9.6 Slippage of the specimen in the clamp when it is struck by the impact head is a recognized cause for testing error. The condition of the clamp and its operation must be inspected and prepared to minimize slippage.

NOTE 4—It is possible to detect slippage by marking each specimen with a wax pencil near the clamp after it is installed in test position and observing the marking after the test for any change of location.

10. Conditioning

10.1 *Conditioning*—Condition the test specimens in accordance with Procedure A of Practice D618 unless otherwise specified by agreement or the relevant ASTM material specification. In cases of disagreement, the tolerances shall be ±2°C (±1.8°F) and ±10 % relative humidity.

10.2 *Test Conditions*—Conduct the tests at 23 ± 2°C (73.4 ± 3.6°F) and 50 ± 10 % relative humidity unless otherwise specified by agreement or the relevant ASTM material specification. In cases of disagreement, the tolerances shall be ±1°C (±1.8°F) and ±5 % relative humidity.

11. Procedure

11.1 Determine the thickness of the specimens to the nearest 0.00025 mm (0.01 mil), in accordance with Test Methods D6988.

11.2 Place a specimen in the specimen holder and secure.

11.2.1 If the specimen has excessive curl, tape it in position in the specimen holder.

11.3 Set the pendulum in its raised latched position.

11.4 If required by the instrument design, place the specimen holder in the instrument and tighten it in place with the tightening knobs.

11.5 Zero the indicator and mark the specimen as described in 9.6.

11.5.1 When using an analog instrument, set the movable pointer to the starting position on the graduated scale.

11.6 Release the pendulum. Be sure the pendulum completely clears the stop as it swings, or it will be impeded and give a false reading. The impact head shall pass completely through the specimen. If it does not, a weight shall be added to the pendulum to provide more energy, or a thinner specimen shall be used.

11.7 Catch the pendulum with the hand on its return swing and reset it in the raised latched position.

11.8 Record the scale reading.

11.9 Remove the ruptured test specimen from the clamp. Observe the tested specimen for slippage. If slippage has occurred, the test shall be repeated using a new specimen. Test the remaining specimens as described above.

12. Calculation

12.1 For each specimen tested, calculate impact energy as follows:

12.1.1 *For Procedure A:*

$$E = \frac{(\text{scale reading in cm·kgf})}{10.2} \quad (1)$$

where E equals energy to rupture, J.

12.1.2 *For Procedure B:*

$$E = (R/100) \times C \quad (2)$$

where:

E = energy to rupture, J,
C = apparatus capacity, J (0.17, 0.34, 0.67, 1.35, or 2.7 J), and
R = scale reading on the 0 to 100 scale.

13. Report

13.1 Report the following information:

13.1.1 Complete identification of the sample,

13.1.2 The capacity of the pendulum in joules (or centimeters-kilogram-force) and procedure used (A or B, differing in sample size (see 5.2)),

13.1.3 Total number of specimens tested per sample,

13.1.4 The average impact strength in joules or centimeters-kilograms-force,

13.1.5 The average thickness in micrometers or mils,

13.1.6 If required, the calculated standard deviation of the values of the impact strengths of the specimens of 13.1.3, and

13.1.7 Temperature of specimen environment, degrees Celsius.

14. Precision and Bias

14.1 For Procedure A, for round-robin results[3] on five materials in six laboratories, the within-laboratory standard deviation is estimated to be 0.11 J (1.1 cm·kgf), and the between-laboratory standard deviation (including within-laboratory standard deviation) 0.16 J (1.6 cm·kgf).

14.2 For Procedure B, round-robin studies[4] were conducted using two films of different thicknesses made from each of four materials: a low-density polyethylene, a high density polyethylene, a linear-low density polyethylene, and a polypropylene. Nine laboratories were involved. The precision of the test method, as defined in Practice E691, is shown for the materials in Table 1.

15. Keywords

15.1 film; impact; impact resistance; pendulum; pendulum impact

[3] The summary report of this work may be obtained from ASTM Headquarters. Request RR:D20-1082.

[4] Supporting data are available from ASTM Headquarters. Request RR:D20-1092.