Designation: D3420 – 14

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 and health 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.

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

E177 Practice for Use of the Terms Precision and Bias in ASTM Test Methods

E691 Practice for Conducting an Interlaboratory Study to Determine the Precision of a Test Method

3. Terminology

3.1 *Definitions*—Definitions of terms relating to plastics not otherwise described in this test method shall be in accordance with Terminology D883.

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). 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.

[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.

Current edition approved Dec. 1, 2014. Published December 2014. Originally approved in 1975. Last previous edition approved in 2008 as D3420 – 08a. DOI: 10.1520/D3420-14.

[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**

5.3 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 X2. 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,*[3] 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 an impact head. The dimensions for the impact heads for Procedures A and B are as follows:

6.1.1 *Procedure A*—Hemispherical, 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)

[3] A tester of the Procedure A type is available from Testing Machines Inc. (TMI), 2 Fleetwood Court, Ronkonkoma, NY 11779. A tester of the Procedure B type is available from Thwing-Albert Instrument Co., 14 W. Collings Ave., West Berlin, NJ 08091.

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

6.3 *Specimen Cutter.*

7. Hazards

7.1 In Procedure A do not release the pendulum manually when the temperature chamber is in position unless the unit is plugged in and energized; otherwise the chamber doors will not open and will be struck by the pendulum ball. 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 *Procedure A:*

9.1.1 Level the instrument carefully, using the level located on the instrument (assuming the level has been properly mounted and calibrated).

9.1.2 Attach the largest weight (for example, "50 cm·kgf" or "5.0 J").

9.1.3 Adjust the auxiliary weights on the rear of the pendulum so the pendulum hangs vertically when free.

9.1.4 Set the pointer on Point *P* of the scale, and adjust the arm that moves the pointer so it just contacts the pointer in this position.

9.1.5 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. If this is not the case, the bearing likely needs cleaning.

9.1.6 Whenever the range of test is changed, the instrument must be reset so the "pointer pusher" is against the pointer with the pointer at *P* and the pendulum hanging freely. This is done by repositioning the auxiliary weights.

9.1.7 Select the energy range and attach the correct weights to the pendulum. Do not use a higher range than is necessary to ensure rupture of the film under test.

9.2 *Procedure B:*

9.2.1 Locate the instrument on a level surface.

9.2.2 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.

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

9.2.4 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. Any slippage that occurs can be detected by marking each specimen with a wax pencil near the clamp after it is installed in test position, and by observing the marking after the test for any change of location.

NOTE 3—A calibration discussion is given in Appendix X1 for the tester in Procedure A.

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 ±1°C (±1.8°F) and ±5 % 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 *Procedure A:*

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

11.1.2 Set the control switches properly.

NOTE 4—In the TMI instrument (Procedure A): power switch, ON; selector switch, MANUAL; temperature control switch (for ambient temperature), OFF.

11.1.3 Place a specimen in the specimen holder.

11.1.3.1 Turn the knob and pull it outward to remove pressure from the hinged plate of the specimen holder. Open the specimen holder, push the knob forward, and turn it to exert a gripping pressure on the specimen.

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

11.1.4 Set the pendulum to its latched position by raising it completely with the hand and then gently releasing it, making certain it engages the latch. This movement ensures the proper functioning of the relay which will open the temperature chamber doors at the proper instant during the test.

11.1.5 Place the specimen holder in the instrument and tighten it in place with the tightening knobs.

11.1.6 Set the movable pointer to *P* on the graduated scale.

11.1.7 For an ambient temperature test, the pendulum will release when the MANUAL button is pushed.

11.1.8 After the swing, determine if the film specimen ruptured. If not, record this fact. If so, read the position of the movable pointer on the appropriate scale (corresponding to the weights used) and record this value in joules or centimetres-kilograms-force.

NOTE 5—It is wise to make trial tests, especially for thicker specimens, by dropping the pendulum from a partial arc, so as to avoid damage to the pendulum (bending). If damage is suspected, the impact point shall be checked for proper centering by inserting a clear specimen in the holder and allowing the impact head to rest against it.

11.1.9 Remove the tested specimen and test the remaining specimens as described above.

11.2 *Procedure B:*

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

11.2.2 Place a specimen in the specimen holder.

11.2.3 Set the pendulum in its raised latched position. Zero the indicator and mark the specimen as described in 9.2.4.

11.2.4 Release the pendulum by pressing down firmly on the latch stop. 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.

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

11.2.6 Record the scale reading.

11.2.7 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 centimetres-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 centimetres-kilograms-force,

13.1.5 The average thickness in micrometres 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[4] on five materials in six laboratories, the within-laboratory standard

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

TABLE 1 Estimated Precision for Procedure B

Material	Film Thickness, mm	Film Thickness, (mil)	Impact Strength, J	Within-Laboratories, Vr, %	Between-Laboratories (Includes Within-Laboratories), VR, %
Low-density polyethylene[A]	0.03	(1.3)	0.41	9.4	9.4
Low-density polyethylene[A]	0.05	(2)	0.56	3.4	5.4
High-density polyethylene[A]	0.025	(1)	0.26	3.6	8.3
High-density polyethylene[A]	0.05	(2)	0.63	2.7	7.2
Linear low-density polyethylene[B]	0.025	(1)	0.41	9.4	12.0
Linear low-density polyethylene[B]	0.076	(3.5)	0.97	5.4	6.1
Polypropylene[C]	0.025	(1)	0.27	12.2	19.0
Polypropylene[C]	0.05	(2)	0.65	9.6	16.9

[A]For low-density polyethylene and high-density polyethylene over the impact range from 0.26 to 0.63 J.
[B]For linear low-density polyethylene over the impact range from 0.40 to 0.97 J.
[C]For polypropylene over the impact range from 0.27 to 0.65 J.

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[5] 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.

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

15. Keywords

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

APPENDIXES

(Nonmandatory Information)

X1. CALIBRATION[6]

X1.1 Scope

X1.1.1 This procedure covers the maintenance and calibration of the TMI Dynamic Ball Burst Tester.

NOTE X1.1—The TMI tester was used by the task group that developed Procedure A of this test method. For Procedure B calibration (Elmendorf), refer to Section 6 of Test Method D1922.

X1.2 Apparatus

X1.2.1 *Level.*

X1.2.2 *No. 10 Oil.*

X1.2.3 *Spirit Level Pendulum Attachment.*

X1.2.4 *Micrometer Device,* for locating the probe in the free-hanging position.

X1.2.5 *Plastic Specimen,* 0.25 to 0.37 mm (10 to 15 mils) in thickness, 102-mm (4-in.) square, or 102-mm diameter circular, with a bull's eye center and alignment rings marked on it for exact centering in the holder, and exact centering of the ball in the specimen holder opening.

X1.2.6 *Alcohol.*

X1.2.7 *Masking Tape.*

X1.2.8 *Metal Rule or Straightedge.*

X1.2.9 *Lathe,* or similar device to accomplish the procedure outlined in X1.4.1.12.

X1.2.10 *Black Felt-Tip Pen.*

X1.3 Maintenance

X1.3.1 Check regularly to be sure that the instrument is secured to a table so rigid that there is no perceptible movement of the table or instrument during the swing of the pendulum. Any movement of the instrument base during the swinging of the pendulum is a potential source of error. This must be accomplished in such a way that the instrument is leveled after securing.

X1.3.2 Place a drop of No. 10 oil on the specimen holder tightening screw and on each specimen holder clamp screw periodically (for example, monthly if used daily).

X1.3.3 Check the cleanliness of the entire instrument at least monthly and clean as required.

X1.4 Calibration Procedure

X1.4.1 Calibrate the instrument in accordance with X1.4.1.1 – X1.4.1.26 upon receipt of a new instrument, and once every three months thereafter.

[6] This Appendix is intended to be advisory only, since detailed calibration procedures will vary with manufacturer and also may differ according to the objectives of the user.

X1.4.1.1 Level the instrument very carefully by leveling the vertical uprights to be exactly vertical (plumb).

X1.4.1.2 If the spirit level on the instrument base does not show level, adjust it to show level by adding or removing shims until the bubble is centered.

X1.4.1.3 Remove the pendulum test range weights (if present) and the specimen holder.

X1.4.1.4 Set the HOT-COLD switch at OFF, the MANUAL-AUTO switch at MANUAL, and the POWER switch at ON.

X1.4.1.5 Holding the pendulum, depress the MANUAL button and lower the pendulum slowly to its free-hanging rest position.

X1.4.1.6 Tape the chamber doors open or tie back (or block open) the door solenoid plunger so the doors remain open. Set the POWER switch at OFF.

X1.4.1.7 Inspect the pendulum bearings. If the bearings appear dirty or sticky, remove the bearings, clean them with alcohol, dry them thoroughly (a syringe is useful in blowing the solvent from the bearings), and replace them in the instrument.

X1.4.1.8 Check the amount of end play in the pendulum shaft. Remove or add shims as required at the rear end of the shaft to obtain end play within 0.13 mm (0.005 in.).

X1.4.1.9 Attach the spirit level pendulum attachment to the lower portion of the pendulum upright. Adjust to center the bubble (if required) by repositioning the weights. Tighten the weights and tape a small note to these weights indicating they are not to be removed.

X1.4.1.10 Set the POWER switch at ON and raise the pendulum to its latched position.

X1.4.1.11 Place the plastic specimen (X1.2.5) in the specimen holder, aligning it carefully so the bull's eye is at the exact center of the specimen holder opening, and lock it in place. Place the specimen holder in the instrument and lock it in place with the two locking screws.

X1.4.1.12 Remove the pendulum ball from the pendulum and chuck it in a lathe or other device for rotating it on its axis. With the ball rotating, blacken the entire face of the ball with a black felt-tip pen with the exception of a small dot at the exact center. Replace the ball on the pendulum.

X1.4.1.13 Set the POWER switch at ON. Holding the pendulum, depress the MANUAL button and lower the pendulum slowly and carefully to its free hanging rest position. *Do not allow the pendulum to strike the specimen.* Release the MANUAL button and set the POWER switch at OFF.

X1.4.1.14 Look through the opening at the top of the specimen chamber and note the location of the pendulum ball in relation to the specimen holder opening. The pendulum must be positioned so the exact center of the ball is aligned with the exact center of the specimen holder opening. Adjust as required. If any adjustment is made, repeat X1.4.1.9.

X1.4.1.15 Set the POWER switch at ON and raise the pendulum to its latched position.

X1.4.1.16 Remove the specimen holder from the instrument and remove the plastic specimen from the holder.

X1.4.1.17 Determine the zero point of the micrometer device, that is, the plane of the inside surface of the upper section of the specimen holder.

(a) Open the specimen holder and insert the micrometer device in the outer portion of the upper section of the specimen holder so the measurement tip extends inward toward the rubber side.

(b) Place a straightedge across the center of the specimen holder hole and adjust the micrometer so it just makes contact with the straightedge. Observe and record the micrometer reading. This is the zero point.

X1.4.1.18 Close and lock the specimen holder and replace it in the instrument. Tighten the two locking screws.

X1.4.1.19 Set the POWER switch at ON. Holding the pendulum, depress the MANUAL button and lower the pendulum slowly and carefully to its free-hanging rest position. Release the MANUAL button and set the POWER switch at OFF.

X1.4.1.20 Set the micrometer device (X1.2.4) at the zero point determined in X1.4.1.17 and, reaching carefully through the upper chamber door opening, place it in position in the specimen holder opening.

X1.4.1.21 With the pendulum hanging motionless, turn the micrometer down until the measuring tip just makes contact with the pendulum ball. This is observed by watching the spirit level on the pendulum attachment (X1.2.3). Turn the micrometer down until the bubble just begins to make the slightest movement. Remove the micrometer device and read and record the micrometer reading.

X1.4.1.22 Subtract the micrometer reading (determined in X1.4.1.21) from the micrometer reading obtained in X1.4.1.17. This value (obtained by the above subtraction) must be 0.076 ± 0.025 mm (3.0 ± 1.0 mil). (This means that with a 0.076-mm (3.0-mil) specimen in the specimen holder, the pendulum ball will just make contact with the specimen surface.) Other values are used for other thicknesses.

(a) If the above value is out of tolerance, add shims or remove material from the rear of the ball as required to obtain the proper measurement. If any adjustment is made, repeat X1.4.1.20 – X1.4.1.22. Repeat until measurements are within tolerance.

X1.4.1.23 Check the pointer for freedom of operation. If the pointer does not move freely, or chatters or grabs, clean the area of the hub under the pointer with alcohol and dry it thoroughly. Adjust the tension of the pointer on the hub so the pointer moves freely, but does not fall back from a maximum reading.

X1.4.1.24 Line up the pointer with *P* on the dial. Set the pointer sweep arm so that it just contacts the pointer. Tighten the set screws on the sweep arm.

X1.4.1.25 Remove the spirit level pendulum attachment from the pendulum.

X1.4.1.26 Untape the chamber doors or untie the door solenoid plunger. Set the POWER switch at ON and raise the pendulum to its latched position. Set the POWER switch at OFF.

X1.4.1.27 Check the level of the instrument by observing the spirit level (and adjust, with the leveling legs, if necessary) prior to each use and *monthly* as part of the regular maintenance schedule.

X2. IMPACT VALUES BY FOUR TEST METHODS

Material[A]	D3420 Procedure A[B]	D3420 Procedure B[C]	D1709 (Method A)		D4272	
	J	J	g	J	ft·lb·f	J
PP, 1 mil	0.30	0.27	[D]	[D]	0.07[E]	0.09[E]
PP, 2 mil	0.95	0.65	75[F]	0.49[F]	5.17[E]	7.01[E]
LLDPE, 1 mil	0.52	0.41	47[G]	0.30[G]	0.36[H]	0.49[H]
LLDPE, 3.5 mil	1.43	0.97	309[I]	2.00[I]	2.46[H]	3.34[H]

[A] LLDPE (linear low-density polyethylene).
[B] Four laboratories, two sets of data each.
[C] Eight laboratories, two sets of data each.
[D] Minimum weight of the tester was too heavy.
[E] One laboratory, one set of data.
[F] Three laboratories, one set of data each.
[G] Two laboratories, one set of data each.
[H] Two laboratories, one set of data each.
[I] Five laboratories, one set of data each.

SUMMARY OF CHANGES

Committee D20 has identified the location of selected changes to this standard since the last issue (D3420 - 08a) that may impact the use of this standard. (December 1, 2014)

(1) Revised 6.1.3.

(2) Revised Section 10.