Designation: F736 – 17

Standard Test Method for Impact Resistance of Monolithic Polycarbonate Sheet by Means of a Falling Weight[1]

This standard is issued under the fixed designation F736; 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 the energy required to initiate failure in monolithic polycarbonate sheet material under specified conditions of impact using a free falling weight.

1.2 Two specimen types are defined as follows:

1.2.1 *Type A* consists of a flat plate test specimen and employs a clamped ring support.

1.2.2 *Type B* consists of a simply supported three-point loaded beam specimen (Fig. 1) for use with material which can not be failed using the Type A specimen. For a maximum drop height of 6.096 m (20 ft) and a maximum drop weight of 22.68 kg (50 lb), virgin polycarbonate greater than 12.70 mm (½ in.) thick will require use of the Type B specimen.

NOTE 1—See also ASTM Methods: D1709, D2444 and D3029.

1.3 The values stated in SI units are to be regarded as standard. No other units of measurement are included in this standard.

1.3.1 *Exception*—The inch-pound units in parentheses are provided 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 and health practices and determine the applicability of regulatory limitations prior to use.* For specific hazard statement, See Section 7.

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

D790 Test Methods for Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials

3. Terminology

3.1 *Definitions of Terms Specific to This Standard:*

3.1.1 *failure (of test specimen)*—failure is signified by the presence of any crack or split in the impact-deformed area that was created by the impact of the falling weight and that can be seen by the naked eye.

4. Summary of Test Method

4.1 The test procedure to cause failure covers a range of impact energies and differs with respect to geometry and support of test specimen Type A and test specimen Type B. Guidelines are established to control drop heights, impact velocity, drop weights, impactor heads, impactor release, impactor rebound, impact location, and specimen configuration which are applicable to a falling weight impact tester designed to accommodate Type A or Type B test specimens, or both, fabricated from monolithic polycarbonate sheet material.

5. Significance and Use

5.1 This practice is applicable for qualitatively evaluating coated and uncoated monolithic polycarbonate sheet material, for monitoring process control, for screening studies, and as an aid in the prediction of hardware performance when exposed to impact service conditions.

5.2 A limitation of Type A specimen testing is that a thick sheet may not fail since the available impact energy is limited by the maximum drop height and falling weight capacity of the test apparatus. Use Specimen Type A for material less than 12.7 mm (0.50 in.) thick.

[1] This test method is under the jurisdiction of ASTM Committee F07 on Aerospace and Aircraft and is the direct responsibility of Subcommittee F07.08 on Transparent Enclosures and Materials.

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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.

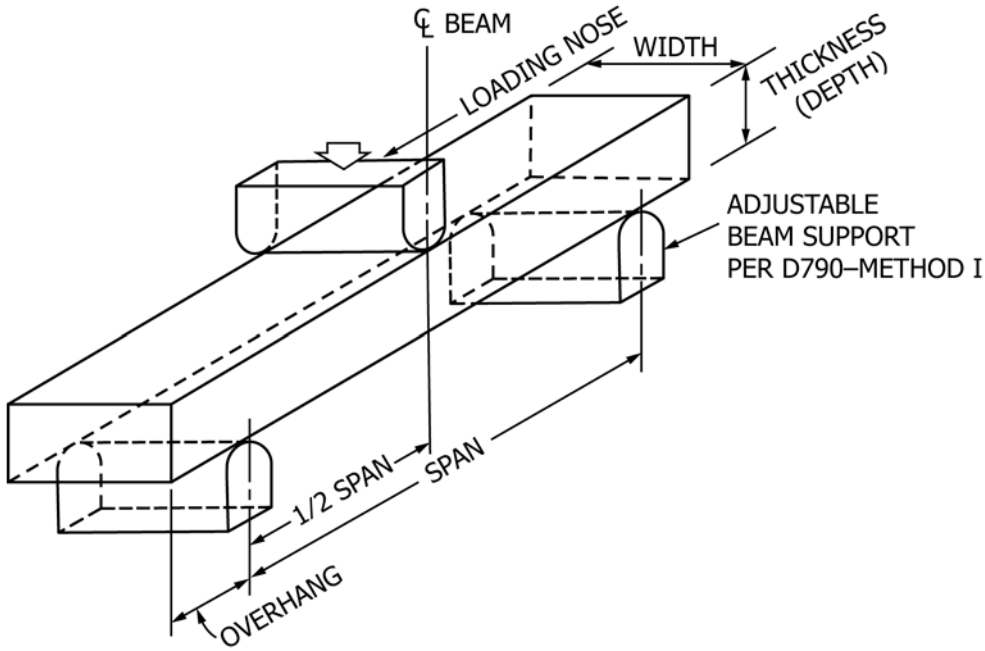


FIG. 1 Type B Specimen Geometry and Loading

5.3 Within the range of drop heights of this system, tests employing different velocities are not expected to produce different results. However, for a given series of tests, the drop height should be held constant so that velocity of impact (strain rate) will not be a variable.

5.4 As the polycarbonate specimen undergoes large plastic deformation under impact, the down (opposite impact) side is under tensile loading and most influential in initiating failure. For that reason, polycarbonate sheet coated on one side should be tested with the coated side down.

5.5 Direct comparison of specimen Type A and specimen Type B test results should not be attempted. For test programs that will require the comparison of interlaboratory test results the specimen type and the approximate drop height must be specified.

5.6 Monolithic polycarbonate sheet is notch sensitive. Data obtained from other test methods, particularly notched Izod/Charpy test results, and extremely high- or low-strain rate test results, should not be compared directly to data obtained from this method. It is noted that Type A specimens, free of flaws, have not experienced the characteristic ductile-to-brittle transition between thin, less than 3.18 mm (⅛ in.), and thick, greater than 7.94 mm (5⁄16 in.), sheet as reflected by other test methods.

6. Apparatus

6.1 *Impact Tester*—The apparatus shall be constructed as shown in Fig. 2. Although not specified, materials called out have been found to be satisfactory.

6.1.1 *Drop Height*—A lifting carrier shall be provided to raise or lower the falling weight impactor that will be adjustable within the range of 0.305 m (1 ft) to maximum drop height and measurable to the nearest 25.40 mm (1 in.).

6.1.2 *Drop Weight*—The falling weights shall be detachable, interchangeable, and variable in small known increments from a total of 0.45 kg (1 lb) to a maximum drop weight of 50 kg (110 lb).

6.1.3 *Impactor*—The loading nose to be used with Type A specimens is shown in Fig. 3; with Type B specimens as shown in Fig. 4. The impactor surface shall be free of nicks or other surface irregularities. The impactor geometry for Type B specimens corresponds to Test Method D790.

6.1.4 *Impact Location*—The center of mass of the falling weight shall be guided by a two cable system or other suitable means to repeatedly strike within 2.54 mm (0.10 in.) of the center of the specimen support fixture as measured in the plane of the specimen, in order to assure uniform, reproducible drops. Friction retarding the falling weight shall be minimal so that the impact velocity approaches

$$\sqrt{2gh}$$

where:

g = acceleration of gravity, and
h = drop height.

6.1.5 *Supports*—Clamp and support rings as shown in Fig. 5 and Table 1 shall be used to accommodate Type A plate specimens. Adjustable D790–Test Method 1 supports shall be used to accommodate the Type B simply supported beam specimens of 6 + 1 span-to-depth ratio. Specimens shall be supported so that the surface to be impacted is horizontal and at an angle of 90 (± 1)° (π/2 radians) with respect to the falling weight guides.

6.1.6 *Release*—An electromagnetic or mechanical releasing mechanism, capable of supporting the maximum falling weight, shall be used to assure uniform and reproducible drops.

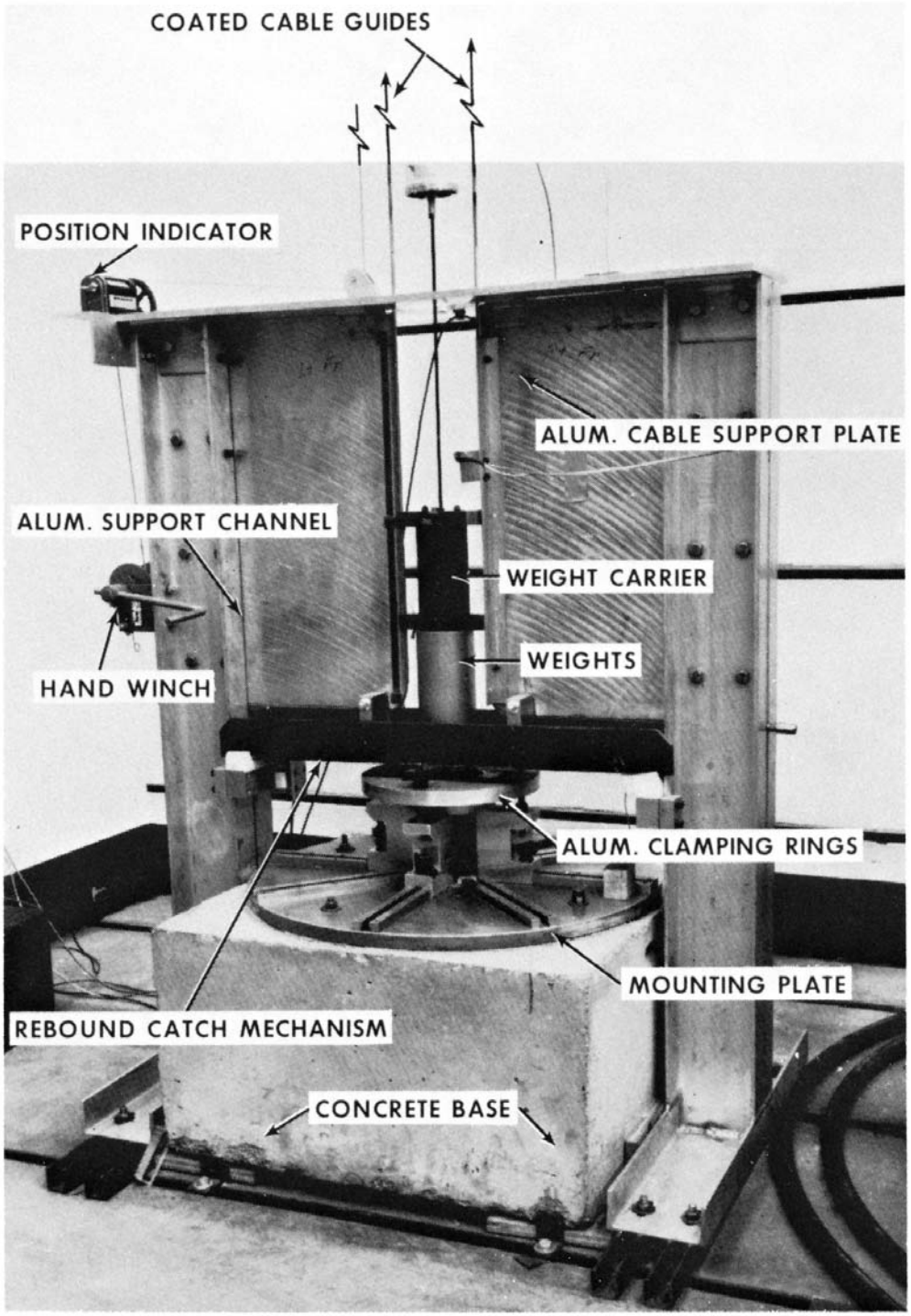


FIG. 2 Falling Weight Impact Tester

TABLE 1 Plate Support Ring Geometry

NOTE 1—Reference Fig. 5 for definition of "A" and "C."

Ring Size	"A"	"C"	Span
	mm (in.)	mm (in.)	mm (in.)
1	88.9 (3.50)	127.0 (5.00)	101.6 (4.00)
2	114.3 (4.50)	157.5 (6.20)	127.0 (5.00)
3	190.5 (7.50)	254.0 (10.00)	203.2 (8.00)
4	292.1 (11.50)	381.0 (15.00)	304.8 (12.00)

6.1.7 *Rebound Catcher*—Means must be provided to catch the weight if it rebounds to prevent restriking the specimen and causing further damage.

6.1.8 *Energy Absorber*—An energy absorbent material must be provided beneath the specimen to prevent damage to the fixture when the impactor penetrates the specimen.

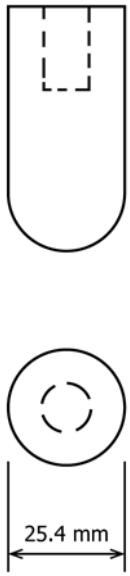
7. Hazards

7.1 To reduce a hazard to the test operator or witness, or both, a protective enclosure shall be placed around the test specimen impact area to contain any flying particles which may be generated during the test. No further adjustments to the specimen shall be made after positioning the falling weight at the selected drop height.

8. Test Specimens

8.1 All specimens must be initially without flaws unless the flaws constitute variables under study. Type B specimens must be free of machining stresses. Edge stresses associated with standard shop practice do not affect the test results for Type A specimens. If no combination of falling weight/drop height is available that will give satisfactory results using Type A specimens because of high impact resistance, the use of Type B specimens shall be used to produce failure at a lower energy level.

8.1.1 *Type A*—Flat plates shall be round or square and have the physical dimensions specified in Table 2. These dimensions provide adequate edge distance for clamping on the plate support rings.



NOTE 1—All loading surfaces to have surface roughness of 1.5–3.0 µm (64–128 µin.).

FIG. 3 Impactor Loading Nose—Type A Plate Specimen (Stainless Steel)

TABLE 2 Type A Specimen Geometry[A]

Specimen Thickness	Span[B] ("A" + 2R)	Diameter or Width	Span/Thickness
mm (in.)	mm (in.)	mm (in.)	
3.175 (0.125)– 7.94 (0.3125)	101.6 (4.00)	127.0 (5.00)	32–12.8
7.95 (0.3130)–12.80 (0.5040)	127.0 (5.00)	157.5 (6.20)	16–9.9
12.81 (0.5045)–19.30 (0.760)	203.2 (8.00)	254.0 (10.00)	15.9–10.5
19.31 (0.765)–32.00 (1.26)	304.8 (12.00)	381.0 (15.00)	15.8–9.5

[A] Specified specimen thicknesses are nominal thicknesses. Tolerances on actual material thickness could cause specimens from a given group to fall in more than one thickness range. This should not be permitted. All specimens having the same nominal thickness should be tested at the same span.
[B] Reference Fig. 5.

8.1.2 *Type B*—For beam specimens greater than 12.7 mm (0.50 in.) thick the support span shall be six times the thickness of the beam, the specimen width shall be two times the thickness, not to exceed 50.80 mm (2.00 in.), and the overhang on each end shall be four times the thickness to prevent the specimen from slipping through the supports.

NOTE 2—Type A plate specimens shall be machined, or bandsawed carefully to avoid inducing failure from edge effects. Type B beam specimens must have deburred finish-machined edges that are free of stress risers.

9. Conditioning

9.1 Unless otherwise specified, condition the test specimens in accordance with Procedure A of Practice D618.

10. Procedure

10.1 Measure and record the thickness and geometry of each specimen.

10.2 Choose a specimen at random from the sample.

10.3 Lightly clamp (20 in.-lbs) plate specimens.

10.4 Adjust the falling weight to that weight which is expected to cause failure.

10.5 Position the falling weight at the proper height to provide the predicted failure energy at impact.

10.6 Release the weight to strike the center of the specimen. If rebound occurs, prevent the impactor from restriking the specimen.

10.7 Examine the specimen to determine if it failed. Test each specimen only once. If over (full penetration) or under the threshold of failure, remove or add an increment of weight as derived from results observed from the specimen tested immediately prior and repeat the test procedure.

10.8 Use a sufficient number of specimens to determine the threshold of failure, using trial and error test runs. Test six replicates at failure energy so that at least two, and not more than four, of the samples tested fail at the given energy level.

10.9 Exercise care to avoid accidental exposure of polycarbonate test samples to toluene, MEK vapors, and other harmful solvents. Degradation can occur with no visual evidence of damage.

11. Calculation

11.1 The energy required to produce failure, expressed in Joules (foot-pounds), is obtained by multiplying the falling weight in Newtons (pounds) by the drop height in meters (feet).

12. Report

12.1 The report shall include the following:

12.1.1 Complete identification of the material,

12.1.2 Type of specimen (either A or B),

12.1.3 Specimen fabrication procedure,

12.1.4 Thickness for Type A specimen, and thickness and width for Type B specimen,

12.1.5 Number of test specimens employed to determine threshold of failure,

12.1.6 Test conditions and material history,

12.1.7 Failure energy,

12.1.8 Drop height,

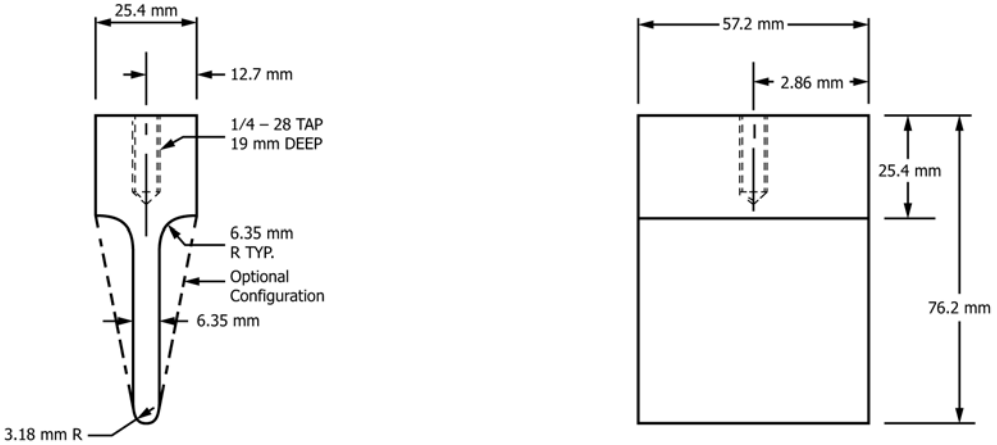
12.1.9 Drop weight,

12.1.10 Failure mode (ductile deformation, penetration, or brittle fracture),

12.1.11 Replicate data,

12.1.12 Deviation(s) from test procedure, and

12.1.13 Date of test.



NOTE 1—All loading surfaces to have surface roughness of 1.5–3.0 μm (64—128 μin.).

FIG. 4 Impactor Loading Nose—Type B Beam Specimen (Stainless Steel)

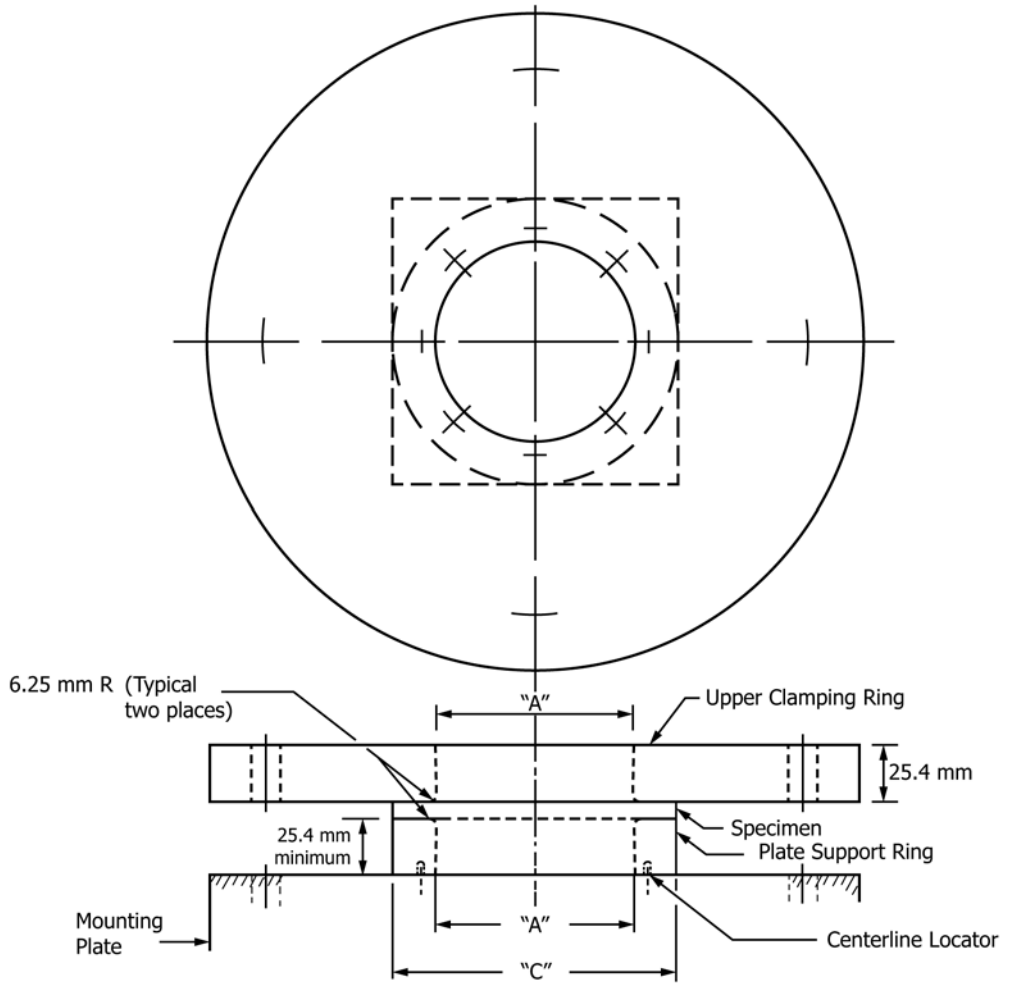
13. Precision and Bias

13.1 *Precision*—This test method does not yet contain a numerical precision statement. However, limited data from one laboratory indicates repeatability to approximately ± 5 % for either specimen Type A or Type B for material exhibiting ductile behavior. The precision of this test method is under investigation by a task group of Subcommittee F07.08 via an interlaboratory study. Anyone wishing to participate in this work may contact the Chairman, Subcommittee F07.08, ASTM, 100 Barr Harbor Drive, West Conshohocken, PA, 19428.

13.2 *Bias*—The procedure in this test method for measuring resistance to a falling weight has no bias because the value for resistance to a falling weight is defined only in terms of this test method.

14. Keywords

14.1 falling weight; impact resistance; polycarbonate



NOTE 1—Reference Table 1 for dimensions "A" and "C".

NOTE 2—All loading surfaces to have surface roughness of 1.5–3.0 μm (64–128 μin.).

FIG. 5 Clamping and Support Rings—Type A Plate Specimen