Designation: D 1709 – 09

Standard Test Methods for Impact Resistance of Plastic Film by the Free-Falling Dart Method[1]

This standard is issued under the fixed designation D 1709; 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 Department of Defense.

1. Scope*

1.1 These test methods cover the determination of the energy that causes plastic film to fail under specified conditions of impact of a free-falling dart. This energy is expressed in terms of the weight (mass) of the missile falling from a specified height which would result in 50 % failure of specimens tested.

1.2 Two test methods are described:

1.2.1 *Test Method A* employs a dart with a 38.10 ± 0.13-mm (1.500 ± 0.005-in.) diameter hemispherical head dropped from a height of 0.66 ± 0.01 m (26.0 ± 0.4 in.). This test method may be used for films whose impact resistances require masses of about 50 g or less to about 2 kg to fracture them.

1.2.2 *Test Method B* employs a dart with a 50.80 ± 0.13-mm (2.000 ± 0.005-in.) diameter hemispherical head dropped from a height of 1.50 ± 0.03 m (60.0 + 0.25, −1.70 in.). Its range of applicability is from about 0.3 kg to about 2 kg.

1.3 Two testing techniques are described:

1.3.1 The standard technique is the staircase method. By this technique, a uniform missile weight increment is employed during test and the missile weight is decreased or increased by the uniform increment after test of each specimen, depending upon the result (fail or not fail) observed for the specimen.

1.3.2 The alternative technique provides for testing specimens in successive groups of ten. One missile weight is employed for each group and missile weight is varied in uniform increments from group to group.

1.3.3 The staircase technique and the alternative technique give equivalent results both as to the values of impact failure weight which are obtained and as to the precisions with which they are determined.

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

NOTE 1—Tests on materials that do not break, for any reason, are not considered to be valid. It has been noted that certain materials may stretch so far as to bottom out at the base of certain test instruments without actually rupturing. Subcommittee D20.19 is currently considering methods for testing these materials. Anyone interested in participating in a Task Group should contact the Chairman of Subcommittee D20.19 through ASTM International Headquarters.

1.5 *This standard does not purport to address 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.*

NOTE 2—Film has been arbitrarily defined as sheeting having nominal thickness not greater than 0.25 µm (0.010 in.).

NOTE 3—This test method is technically equivalent to ISO 7765-1: 1988, with the exception of a larger tolerance on the drop height in Test Method B. Also, the ISO method does not allow the alternative testing technique described in Section 11 of this test method.

2. Referenced Documents

2.1 *ASTM Standards:*[2]

D 618 Practice for Conditioning Plastics for Testing
D 883 Terminology Relating to Plastics
D 1248 Specification for Polyethylene Plastics Extrusion Materials for Wire and Cable
D 3420 Test Method for Pendulum Impact Resistance of Plastic Film
D 4272 Test Method for Total Energy Impact of Plastic Films By Dart Drop
D 6988 Guide for Determination of Thickness of Plastic Film Test Specimens
E 177 Practice for Use of the Terms Precision and Bias in ASTM Test Methods
E 691 Practice for Conducting an Interlaboratory Study to Determine the Precision of a Test Method

[1] These test methods are under the jurisdiction of ASTM Committee D20 on Plastics and are the direct responsibility of Subcommittee D20.19 on Film and Sheeting.

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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.**

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2.2 *ISO Standard:*

ISO 7765:1988 Plastic Film and Sheeting—Determination of Impact Resistance by the Free Falling Dart Method—Part 1: Staircase Method[3]

3. Terminology

3.1 *Definitions*—For definitions related to plastics, see Terminology D 883.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *failure*—any break through the film that can be observed readily by feeling or by viewing the specimen under backlighted condition.

3.2.2 *impact failure weight*—that missile weight, estimated statistically, at which 50 % of the specimens would fail in the specified test.

3.2.3 *missile weight*—the weight (mass) of the dart plus the total value of incremental weights attached *plus* the locking collar.

4. Significance and Use

4.1 Test Methods A and B are used to establish the weight of the dart when 50 % of the specimens fail under the conditions specified. Data obtained by one test method cannot be compared directly with the other test method nor with those obtained from tests employing different conditions of missile velocity, impinging surface diameter, effective specimen diameter, and thickness. The values obtained by these test variables are highly dependent on the method of film fabrication.

4.2 The results obtained by Test Methods A and B are greatly influenced by the quality of film under test. The confidence limits of data obtained by this procedure can, therefore, vary significantly, depending on the sample quality, uniformity of film gage, die marks, contaminants, etc. (see Section 15).

4.3 Test Methods A and B have been found useful for specification purposes. Correlation between test results and field performance can usually be established.

4.4 The impact resistance of plastic film, while partly dependent on thickness, has no simple correlation with sample thickness. Hence, impact values cannot be normalized over a range of thickness without producing misleading data as to the actual impact resistance of the material. Data from these test methods are comparable only for specimens that vary by no more than ±25 % from the nominal or average thickness of the specimens tested.

4.5 Several impact test methods are used for film. It is sometimes desirable to know the relationships among test results derived by different test 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 D 1709 (Method A), D 3420 (Procedures A and B), and D 4272. The test results are shown in the Appendix. Differences in results between Test Methods D 1709 and D 4272 may be expected since Test Methods D 1709 represents failure initiated energy, while Test Method D 4272 is initiation plus completion energy. Some films may show consistency when the initiation energy is the same as the total energy. This statement and the test data also appear in the significance sections and appendixes of Test Methods D 3420 and D 4272.

5. Apparatus

5.1 The apparatus shall be constructed essentially as shown in Fig. 1, using the following components common to both test methods:

5.1.1 *Dart Well*—If the dart impact machine utilizes an enclosed dart well, it must contain a single unobstructed vent with a minimum area of 625 mm^2 (~1 $in.^2$) to provide adequate venting.

NOTE 4—Some dart impact machine designs utilize enclosed dart wells that do not permit adequate venting to the atmosphere during impact. Data have shown that this has a significant effect on the observed impact value, especially with films that exhibit high elongation during testing, resulting in atypically high impact values.

NOTE 5—The use of smaller, multiple vents is permitted if it can be demonstrated that the venting efficiency is comparable and has no statistically significant effect on the values obtained.

5.1.2 *Specimen Clamp*—A two-piece annular specimen clamp having an inside diameter of 125 ± 2.0 mm (5.0 + 0.0, −0.15 in.) and conforming to the following requirements:

5.1.2.1 The lower or stationary half of the clamp shall be mounted rigidly so that the plane of the specimen is horizontal.

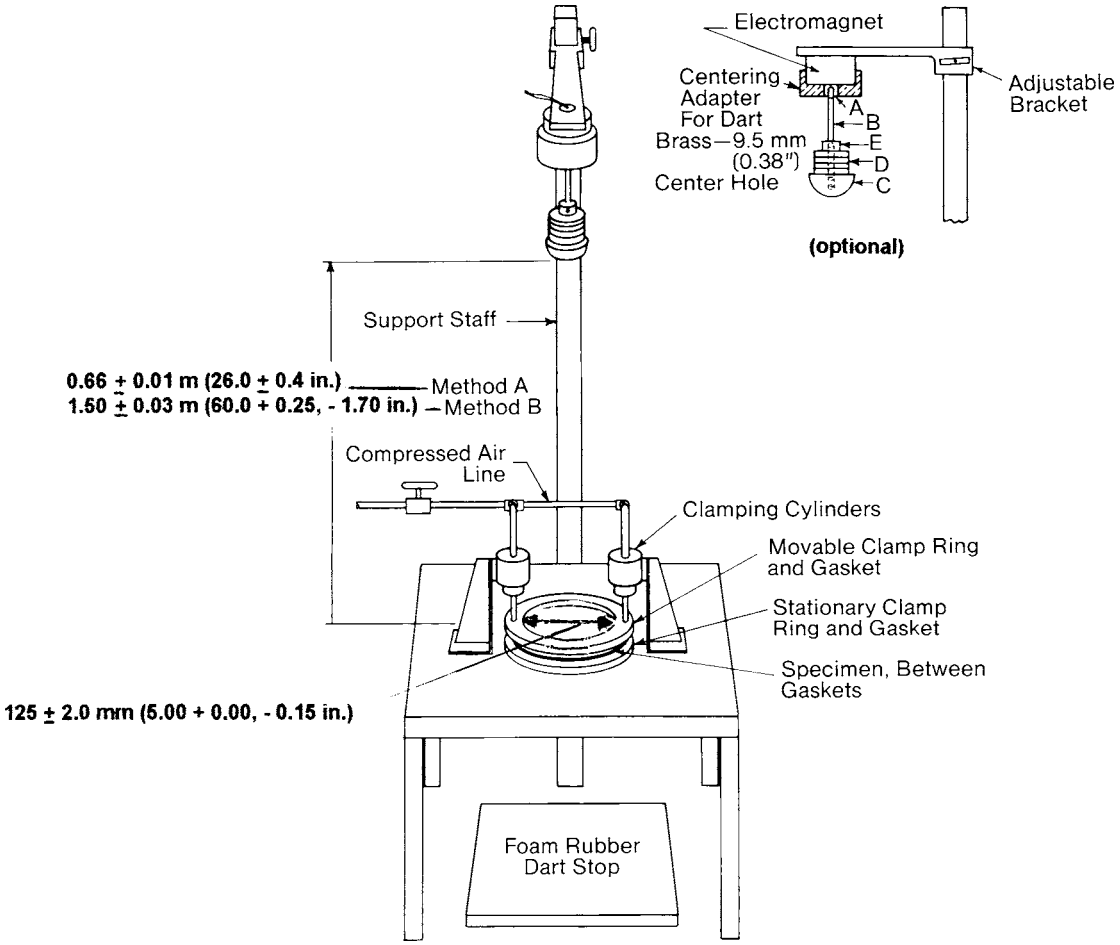
5.1.2.2 The upper or movable part of the clamp shall be designed to maintain positive and plane contact with the lower part of the clamp when in position. The clamps shall be provided with suitable means of maintaining sufficient contact to hold the film sample firmly in place during the test. Pneumatically operated clamps have been successfully employed.

5.1.2.3 Rubber-like gaskets may be affixed to the specimen contact surfaces of both clamps to provide a cushion which minimizes thickness variation effects. Rubber gasketing 3.0 ± 1 mm (0.125 + 0.025, −0.04 in.) thick, of 50 to 60 Shore A durometer hardness, 125 ± 2.0 mm (5.00 + 0.00, −0.15 in.) in inside diameter and 150 ± 3.0 mm (6.0 + 0.02, −0.2 in.) in outside diameter has been found satisfactory for this purpose.

5.1.2.4 Slippage of films greater than 0.10 mm (0.004 in.) in thickness may be minimized or eliminated by securing crocus cloth or 50D garnet abrasive paper to the gaskets with double sensitive tape so that the abrasive surface is in direct contact with the film. There should be sufficient clamping force to eliminate detectable slippage. Other means of reducing slippage such as additional clamping devices or positive clamping surfaces may be used provided that the film is not weakened at the inside wall of the specimen clamps and that the effective diameter of 125 ± 2.0 mm (5.00 + 0.00, −0.15 in.) of the film is not changed.

5.1.3 *Dart Release Mechanism*, capable of supporting a 2-kg weight shall be used for supporting and releasing the dart assembly. It shall be equipped with a centering device, such as a removable plumb bob, to ensure a reproducible drop. Either an electromagnetic- or pneumatic-operated release mechanism may be used.

[3] Available from American National Standards Institute (ANSI), 25 W. 43rd St., 4th Floor, New York, NY 10036, http://www.ansi.org.



NOTE 1—Values for tolerances in SI units are to be regarded as standard. The numbers in parentheses reflect the allowable tolerance range of older equipment and are only provided for information and, in many cases, do not correspond directly to the tolerances in SI units. The differences are not expected to have a significant effect on the results but the dimensions in SI units shall be used in cases of dispute.

NOTE 2—Legend Dart Assembly:

A. Steel shaft tip 6.5 ± 1 mm (0.25 + 0.04, –0.03 in.) OD by 12.5 ± 0.2 mm (0.50 + 0.00, –0.02 in.) long.

B. Dart shaft: 6.5 ± 1 mm (0.25 + 0.04, –0.03 in.) OD and at least 115 mm (4.5 in.) long: ¼ –20 thd. (N.C.) 12.5 ± 0.2 mm (0.50 + 0.00, –0.02 in.) long on bottom: No. 5–40 thd. (N.F.) for steel tip.

C. Hemispherical head: Method A—38.10 ± 0.13–mm (1.500 ± 0.005–in.) in diameter. Method B—50.80 ± 0.13–mm (2.000 ± 0.005 in.) in diameter.

D. Removable weights.

E. Collar and screw.

FIG. 1 Apparatus for Free-Falling Dart Impact Test for Plastic Film

5.1.4 *Positioning Device*—The apparatus shall be able to drop the dart from heights of 0.66 ± 0.01 m (26.0 ± 0.4 in.) for Test Method A and 1.50 ± 0.03 m (60.0 + 0.25, –1.70 in.) for Test Method B. The distance between the impinging surface of the dart head and the surface of the test specimen is considered to be the drop height. The dart shall be positioned vertically above the center of the test specimen.

5.1.5 *Micrometer, or other suitable thickness gauge*, for measuring specimen thickness in accordance with Guide D 6988.

5.1.6 *Cushioning and Shielding Devices*, to protect personnel and to avoid damaging the impinging surface of the dart. These devices shall not interfere with the dart or the specimen prior to penetrating the specimen.

5.1.7 *Collar* with inside diameter of approximately 7 mm (0.28 in.) and with set screw for securing collar to dart shaft.

5.2 *Darts* for Test Methods A and B shall have hemispherical heads, each fitted with a 6.5 ± 1-mm (0.25 + 0.04, –0.03-in.) diameter shaft at least 115 mm (4.5 in.) long to accommodate removable incremental weights. Each dart weight shall be known to ±0.5 % relative. Dart head surfaces shall be free of nicks, scratches, or other irregularities. The shaft shall be attached to the center of the flat surface of the head with its longitudinal axis perpendicular to the surface. If an electromagnet is used, the shaft shall be made of material that is not magnetic and shall have a steel tip 125 ± 0.2 mm (0.50 + 0.00, –0.02 in.) long at the end held by the electromagnet.

5.2.1 For Test Method A, the dart head shall be 38.10 ± 0.13–mm (1.500 ± 0.005–in.) in diameter. It may be constructed of smooth, polished aluminum, phenolic, or other low-density material of similar hardness.