Designation: ~~D1004 – 13~~ D1004 – 21

Standard Test Method for Tear Resistance (Graves Tear) of Plastic Film and Sheeting[1]

This standard is issued under the fixed designation D1004; 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 U.S. Department of Defense.

1. Scope*

1.1 This test method[2] covers the determination of the tear resistance of flexible plastic film and sheeting at very low rates of loading, 51 mm (2 in.)/min. and is designed to measure the force to initiate tearing. The specimen geometry of this test method produces a stress concentration in a small area of the specimen. The maximum stress, usually found near the onset of tearing, is recorded as the tear resistance in newtons (or pounds-force). The method is not applicable for film or sheeting material where brittle failures occur during testing or where maximum extension is greater than 101.6 mm (4 in.).

1.1.1 Although resistance to tear can be expressed in newtons per microns, (pounds-force per mil) of specimen thickness, this is only advisable where correlation for the particular material being tested has been established. In most cases, comparison between films of dissimilar thickness is not valid.

NOTE 1—Film has been arbitrarily defined as sheeting having nominal thickness not greater than 0.25 mm (0.010 in.).

1.2 *Constant-Rate-of-Grip Separation Test*—This test method employs a constant rate of separation of the grips holding the test specimen.

1.2.1 Specimen extension ~~may~~shall be measured in this test method by grip separation.

1.3 The values stated in SI units are to be regarded as the standard. The values given 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~~ safety, health, and ~~health~~environmental practices and determine the applicability of regulatory limitations prior to use.*

NOTE 2—There is no known ISO equivalent to this standard.

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.*

[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] The following reference may be of interest in connection with this test method: Graves, F. L., "The Evaluation of Tear Resistance in Elastomers," *India Rubber World*, Vol 111, No. 3, December 1944, pp. 305–308.

***A Summary of Changes section appears at the end of this standard**

2. Referenced Documents

2.1 *ASTM Standards:*[3]

D618 Practice for Conditioning Plastics for Testing
D882 Test Method for Tensile Properties of Thin Plastic Sheeting
D883 Terminology Relating to Plastics
D4000 Classification System for Specifying Plastic Materials
D5947 Test Methods for Physical Dimensions of Solid Plastics Specimens
D6988 Guide for Determination of Thickness of Plastic Film Test Specimens
E4 Practices for Force Verification of Testing Machines
E456 Terminology Relating to Quality and Statistics
E691 Practice for Conducting an Interlaboratory Study to Determine the Precision of a Test Method
E2935 Practice for Conducting Equivalence Tests for Comparing Testing Processes
~~2.2 *ASTM Adjuncts:*~~
~~Die Drawings[4]~~

3. Terminology

3.1 ~~*Definitions:*~~ *Definitions—*
~~Definitions of terms applying to this test method appear in~~ Terms used in this standard are defined in accordance with Terminology D883, unless otherwise specified. For terms relating to precision and bias and associated issues, the terms used in this standard are defined in accordance with Terminology E456.

4. Summary of Test Method

4.1 The force to initiate tearing across a specific geometry of a film or sheeting specimen is measured using a constant-rate-of-grip separation machine. The force necessary to initiate the tear is calculated from the load-time or load-displacement data.

5. Significance and Use

5.1 Tear resistance of plastic film or sheeting is a complex function of its ultimate resistance to rupture. The specimen geometry and speed of testing in this test method are controlled to produce tearing in a small area of stress concentration at rates far below those usually encountered in service. Experience has shown the test to have its best reliability for materials which do not have brittle failure or do not elongate greater than two hundred percent during testing.

5.2 The data from this test method furnish comparative information for ranking the tearing resistance of plastic specimens of similar composition. Actual use performance in tearing of some plastics may not necessarily correlate with data from this test method.

5.3 The resistance to tear of plastic film and sheeting, while partly dependent upon thickness, has no simple correlation with specimen thickness. Hence, tearing forces measured in newtons (or pounds-force) cannot be normalized over a wide range of specimen thickness without producing misleading data as to the actual tearing resistance of the material. Data from this test method are comparable only from specimens, which vary by no more than ±10 % from the nominal or average thickness of all specimens tested. Therefore, the tearing resistance is expressed in maximum newtons (or pounds-force) of force to tear the specimen.

5.4 The tear resistance of plastic film may be a specification that requires the use of this test method, but with some procedural modifications that take precedence when adhering to the specification. Therefore, it is advisable to refer to that material specification before using this test method. Table 1 of Classification System D4000 lists the ASTM materials standards that currently exist.

6. Apparatus

6.1 *Testing Machine*—A testing machine of the constant rate-of crosshead-movement type and comprising essentially the following:

[3] 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.

6.1.1 *Fixed Member*—A fixed or essentially stationary member carrying one grip.

6.1.2 *Movable Member*—A movable member carrying a second grip.

6.1.3 *Grips*—Preferably, a set of self-aligning grips for holding the test specimen between the fixed member and the movable member of the testing machine. The grips should minimize both slippage and uneven stress distribution.

6.1.3.1 Fixed grips are rigidly attached to the fixed and movable members of the testing machine. Fixed grips may be used if extreme care is taken to ensure that the test specimen is inserted and clamped so that the long axis of the test specimen coincides with the direction of pull through the center line of the grip assembly.

6.1.3.2 Self-aligning grips are attached to the fixed and movable member of the testing machine in such a manner that they will move freely into alignment as soon as any load is applied so that the long axis of the test specimen will coincide with the direction of the applied pull through the center line of the grip assembly.

~~NOTE 3—The specimens should be aligned as perfectly as possible with the direction of pull so that no rotary motion that may induce slippage will occur in the grips; there is a limit to the amount of misalignment self-aligning grips will accommodate.~~

6.1.3.3 The specimens are to be aligned as perfectly as possible with the direction of pull so that no rotary motion could induce slippage in the grips; there is a limit to the amount of misalignment self-aligning grips will accommodate.

NOTE 3—Grips lined with thin rubber have been used successfully. Grips may be of the self-tightening type. In cases where specimens frequently fail at the edge of the grips, the radius of curvature of the edges of the grips may be increased slightly at the point where they come in contact with the specimen.

6.1.4 *Drive Mechanism*—A drive mechanism capable of separating the movable member (grip) from the stationary member (grip) at a controlled velocity of 51 mm (2 in.) ± 5 %/min.

6.1.5 *Load Indicator*—A suitable load-indicating mechanism capable of showing the total tensile load carried by the test specimen held by the grips. The testing machine shall be essentially free from inertial lag at the specified rate of testing and shall indicate the load with an accuracy of ±1 %. The accuracy of the testing machine shall be verified in accordance with Practices E4.

6.1.6 *Crosshead Extension Indicator*—A suitable extension-indicating mechanism capable of showing the amount of change in the separation of the grips (crosshead movement).

6.2 *Thickness*—Measure the specimen thickness in accordance with Test Methods D5947 or Guide D6988 as appropriate.

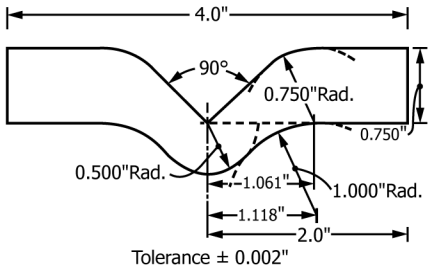
6.3 ~~*Die*~~*Die*—~~—A die having the dimensions shown in~~If a die is used to cut specimens, ~~Fig. 1 shall be used to cut all specimens.~~it shall conform to the dimensions shown in Fig. 1. The 90° angle shall be honed sharp with no radius or have a minimum practical radius. The cutting edge of the die shall have a 5° negative rake, and shall be kept sharp and free from nicks to avoid leaving ragged edges on the specimen. Wetting the surface of the sample and the cutting edges of the die with water may facilitate cutting. The sample shall rest on the smooth, slightly yielding surface that will not damage the die blade. Lightweight cardboard or a piece of leather belting is suitable. ~~Care should be taken that the cut~~ Cut edges of the specimen are to be perpendicular to its other surfaces and ~~that the edges~~ have a minimum of concavity.

7. Test Specimens

7.1 The test specimens shall be cut ~~out with a die conforming to the dimensions shown in~~using a die or other appropriate method so that ~~Fig. 1 and shall not vary by more than 0.5 %~~the resulting specimens conform to the dimensions shown in Fig. 1~~from these dimensions. The cutting edges of the die shall be kept sharp and free of all nicks to avoid leaving ragged edges on the specimens.~~.

~~NOTE 5—Caution should be used to ensure all samples are the same dimension if multiple specimens are cut at one time by stacking (layering) film.~~

7.1.1 The cutting method used shall ensure all samples are the same dimension if multiple specimens are cut at one time by stacking (layering) film.



Tolerance ± 0.5°

Table of Metric Equivalents

in.	mm
4.0	101.60
0.750	19.05
1.061	26.95
1.000	25.40
1.118	28.40
2.0	50.80
0.002	0.051
0.500	12.70

FIG. 1 Die for Tear Test Specimen

7.2 Machine direction specimens are cut perpendicular to the machine direction and transverse direction specimens are cut perpendicular to the transverse direction.

7.3 At least ten specimens shall be tested for each sample, in the case of isotropic materials.

7.4 Test a minimum of ten specimens each in the machine direction and in the transverse direction for each anisotropic test sample.

7.5 Data from specimens which break at some obvious flaw or which break in or at the edges of the grips shall be discarded and additional specimens tested, unless such failures constitute a variable whose effect is being studied.

7.6 Data from specimens which deviate markedly from the mean value of all tests shall be rejected if the deviation of the doubtful value is more than five times the standard deviation from the mean value obtained by excluding the doubtful results.

NOTE 4—For certain materials whose properties vary considerably throughout the film or sheeting, as many as 50 specimens cut from random portions of the sheet must be tested if reliable tear resistance data are desired.

8. Conditioning

8.1 *Conditioning*—Condition the test specimens at 23 ± 2°C (73.4 ± 3.6°F) and 50 ± 10 % relative humidity for not less than 40 h prior to test in accordance with Procedure A of Practice D618, for those tests where conditioning is required. In cases of disagreement, the tolerances shall be ±1°C (±1.8°F) and ±5 % relative humidity.

8.2 *Test Conditions*—Conduct tests in the standard laboratory atmosphere of 23 ± 2°C (73.4 ± 3.6°F) and 50 ± 10 % relative humidity, unless otherwise specified in the applicable ASTM material specification. In cases of disagreements, the tolerances shall be ±1°C (±1.8°F) and ±5 % relative humidity.

9. Procedure

9.1 An initial jaw separation of 25.4 mm (1 in.) shall be used. The rate of travel of the power activated grip shall be 51-mm (2-in.)/min.

NOTE 5—In this test method, resistance to tear is calculated from the maximum load recorded. In testing most plastics, this maximum load is generated at the onset of tearing across the 13-mm (0.5-in.) testing width of the specimen.