Designation: 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 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, health, and 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.*

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

3. Terminology

3.1 *Definitions*—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.

[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.

[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.

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

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:

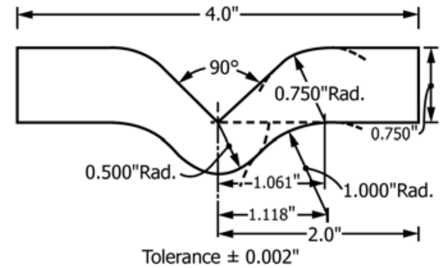
6.1.1 *Fixed Member*—A fixed or essentially stationary member carrying one grip.

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.



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

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*—If a die is used to cut 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. Cut edges of the specimen are to be perpendicular to its other surfaces and have a minimum of concavity.

7. Test Specimens

7.1 The test specimens shall be cut using a die or other appropriate method so that the resulting specimens conform to the dimensions shown in Fig. 1.

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.

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.

9.2 Measure the thickness of the specimen at several points in the notched area to the accuracy limits of the measuring devices specified in 6.2. Record the average thickness in microns (mil).

9.3 Place the specimen in the grips of the testing machine so that the long axis of the enlarged ends of the specimen is in line with the center line of the grip assembly.

9.4 After complete rupture of the specimen, the maximum tearing load in newtons (pounds-force), and the maximum extension in mm (in.) shall be recorded.

10. Calculation

10.1 Calculate the mean maximum resistance to tearing, and the maximum extension for all specimens tested in each principal direction of orientation. Record maximum tear resistance expressed in newtons (pounds-force) to three significant figures and maximum extension expressed in mm (in.) to two significant figures.

10.2 Calculate standard deviation.

11. Report

11.1 Report the following information:

11.1.1 Complete identification of the material tested, including type, source, manufacturer's code number, form, principal dimensions, previous history, and orientation of sample with respect to anisotropy, if any.

11.1.2 Average thickness of each test specimen and average thickness of all test specimens.

11.1.3 Type of testing machine used.

11.1.4 Number of specimens tested in each principal direction.

11.1.5 Average value of tear resistance calculated in newtons (pounds-force) and the maximum extension in mm (in.).

11.1.6 Standard deviation from the averaged values obtained for specimens tested in each principal direction.

12. Precision and Bias[4]

12.1 The precision of this test method is based on an interlaboratory study of ASTM D1004 Tear Resistance (Graves Tear) of Plastic Film and Sheeting, conducted between 1986 and 1990. Each of seven laboratories tested seven different materials. Every "test result" represents an average of 10 individual determinations, and all participants reported two test results for each material. Practice E691 was followed for the design and analysis of the data; the results are given in Table 1 and Table 2.(**Warning—**The data in Table 1 and Table 2 shall not be rigorously applied to acceptance or rejection of material, as those data are specific to the interlaboratory study and are not necessarily representative of other lots, conditions, materials, or laboratories. Users of this test method shall apply the principles outlined in Practice E691 to generate data specific to their laboratory and materials, or between specific laboratories.)

[4] Supporting data have been filed at ASTM International Headquarters and may be obtained by requesting Research Report RR:20-1177.

TABLE 1 Initial Tear Resistance (Graves Tear) Machine Direction

Material	Values Expressed in Units of Grams-Force				
	Average	S_r [A]	S_R [B]	r [C]	R [D]
LDPE—LD 104	314.6	31.98	55.79	89.53	156.2
LLDPE	384.9	7.80	41.73	21.84	116.8
Polystyrene	459.8	98.06	261.6	274.6	732.3
HDPE No. 2	474.0	19.82	55.42	55.51	155.2
Polypropylene	503.9	29.87	77.45	83.64	216.9
HDPE No. 1	570.9	36.35	78.20	101.8	219.0
Polyester	2494.0	6407.9	599.2	1142.0	1678.0

[A] S_r = within-laboratory standard deviation for the material stated. It is obtained by pooling the standard deviations of the test results from each laboratory.
[B] S_R = between-laboratories standard deviation for the material stated. It is a pooling of the amounts by which the average of the test results for each laboratory deviate from the overall average for that material.
[C] r = within-laboratory repeatability limit = 2.8 × S_r.
[D] R = between-laboratories reproducibility limit = 2.8 × S_R.

TABLE 2 Initial Tear Resistance (Graves Tear) Transverse Direction

Material	Values Expressed in Units of Grams–Force				
	Average	S_r [A]	S_R [B]	r [C]	R [D]
LDPE—LD 104	325.1	15.24	34.63	42.67	96.96
LLDPE	366.6	20.52	28.53	57.45	79.89
HDPE No. 2	411.1	31.70	82.06	88.76	229.8
Polypropylene	468.0	33.94	86.73	95.02	242.8
Polystyrene	481.4	101.7	263.7	284.7	738.2
HDPE No. 1	523.9	46.02	97.75	128.9	273.7
Polyester	2341.0	317.2	443.2	888.1	1241.0

[A] S_r = within-laboratory standard deviation for the material stated. It is obtained by pooling the standard deviations of the test results from each laboratory.
[B] S_R = between-laboratories standard deviation for the material stated. It is a pooling of the amounts by which the average of the test results for each laboratory deviate from the overall average for that material.
[C] r = within-laboratory repeatability limit = 2.8 × S_r.
[D] R = between-laboratories reproducibility limit = 2.8 × S_R.

13. Keywords

13.1 Graves; plastic film; tear; tear initiation; thin sheeting

SUMMARY OF CHANGES

Committee D20 has identified the location of selected changes to this standard since the last issue (D1004 - 13) that may impact the use of this standard. (January 15, 2021)

(1) Five-year review for content and removal of permissive language.
(2) Removed reference to ASTM Adjunct ADJD1004. Committee D20.19 has decided that it is no longer necessary. The detailed drawing of the test specimen is already included within the standard as Fig. 1.
(3) Revised and corrected Section 12, Precision and Bias, and removal of definitions.
(4) Revised to allow for specimen preparation methods other than die cutting.
(5) Removed conflicting dimensional tolerance information.
(6) Turned Note 3 into 6.1.3.3 per suggestion from last round of balloting.
(7) Verified Table 1 and Table 2 with the latest data available from the ASTM PTP.
(8) Updated Terminology, Section 3 with suggested D20 language from guidance document.
(9) Section 7—Turned Note 4 into 7.1.1 as it is mandatory and not informational.