Designation: D 1004 – 94a

Standard Test Method for Initial Tear Resistance of Plastic Film and Sheeting[1]

This standard is issued under the fixed designation D 1004; 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 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. This test method 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 outset of tearing, is recorded as the tear resistance in newtons (or pounds-force).

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

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 cautionary statements are given in Note 2.

NOTE 1—There is no simular or equivalent ISO standard.

2. Referenced Documents

2.1 *ASTM Standards:*

D 374 Test Methods for Thickness of Solid Electrical Insulation[3]

D 618 Practice for Conditioning Plastics and Electrical Insulating Materials for Testing[4]

D 882 Test Methods for Tensile Properties of Thin Plastic Sheeting[4]

D 4000 Classification System for Specifying Plastic Materials[5]

E 4 Practices for Load Verification of Testing Machines[6]

E 691 Practice for Conducting an Interlaboratory Study to Determine the Precision of a Test Method[7]

3. Significance and Use

3.1 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.

3.2 The data of 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.

3.3 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.

3.4 For many materials, there 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 D 4000 lists the ASTM materials standards that currently exist.

4. Apparatus

4.1 *Testing Machines*—A power-driven machine of either of the two following types shall be used:

4.1.1 *Static Weighing—Constant Rate of Grip Separation Type*—Negligible movement of the upper jaw.

4.1.2 *Pendulum Weighing—Constant Rate of Powered-Grip*

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[1] This test method is under the jurisdiction of ASTM Committee D-20 on Plastics and is the direct responsibility of Subcommittee D20.10 on Mechanical Properties.

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An ISO equivalency statement has been added since the prior version of this test method.

[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] *Annual Book of ASTM Standards*, Vol 10.01.

[4] *Annual Book of ASTM Standards*, Vol 08.01.

[5] *Annual Book of ASTM Standards*, Vol 08.02.

[6] *Annual Book of ASTM Standards*, Vol 03.01.

[7] *Annual Book of ASTM Standards*, Vol 14.02.

Motion Type—Constant rate of lower jaw movement, variable upper jaw movement (Note 2). The machine shall conform to requirements given in the appropriate Method A or B of Test Methods D 882, except that cross-head rates of other than 51 mm (2 in.)/min are not required. Either maximum load indicating devices or recorders are permissible in the testing machine. The accuracy of the testing machine shall be verified in accordance with Practices E 4 (Note 3). The applied load, as indicated by a recorder, dial, or scale, shall be accurate to within ±2 %. If an indicating device is used, the indicator shall remain at the point of maximum load after rupture of the test specimen.

NOTE 2—If both jaws of the machine are power activated, the rate of jaw separation shall be nominally 51 mm (2 in.)/min.

NOTE 3—Experience has shown that many testing machines now in use are incapable of maintaining accuracy for as long as the periods between inspection recommended in Practices E 4. Hence, it is recommended that each machine be studied individually and verified as often as may be found necessary. It will frequently be necessary to perform this function daily.

4.2 *Grips*—A gripping system that minimizes both slippage and uneven stress distribution on the specimen shall be used.

NOTE 4—Grips lined with thin rubber. No. 80 emery cloth, or crocus cloth, have been successfully used. 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.

4.3 *Thickness Measuring Devices*—Suitable micrometers, or thickness gages, reading to 0.0025 mm (0.0001 in.) or less, shall be used for measuring the thickness of the specimens. The pressure exerted by the gage on the specimen being measured shall be between 0.159 and 0.186 MPa (23 and 27 psi) in accordance with Method C of Test Methods D 374.

4.4 *Die*[8]—A die having the dimensions shown in Fig. 1 shall be used to cut all specimens. The 90° angle should 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. Cutting may be facilitated by wetting the surface of the sample and the cutting edges of the die with water. The sample shall rest on the smooth, slightly yielding surface that will not injure the die blade. Light-weight cardboard or a piece of leather belting is suitable. Care should be taken that the cut edges of the specimen are perpendicular to its other surfaces and that the edges have a minimum of concavity.

4.5 *Conditioning Apparatus*—Apparatus for maintaining laboratory atmospheric conditions of 23 ± 1°C (73.4± 1.8°F) and 50 ± 2 % relative humidity for conditioning prior to and during testing shall be used in accordance with Procedure A of Practice D 618, unless otherwise specified.

5. Test Specimens

5.1 The test specimens shall conform to the dimensions shown in Fig. 1 and shall not vary by more than 0.5 % from these dimensions.

[8] Detail drawings of the die are available from ASTM Headquarters. Order Adjunct: ADJD1004.

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:

$$S_r = [[\Sigma(S_1)^2 + (S_2)^2 \ldots + (S_n)^2]/n]^{1/2}$$

[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

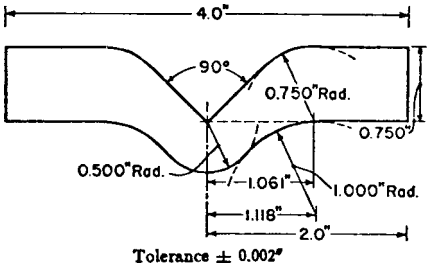
[A] S_r = within-laboratory standard deviation for the material stated. It is obtained by pooling the standard deviations of the test results from each laboratory:

$$S_r = [[\Sigma(S_1)^2 + (S_2)^2 \ldots + (S_n)^2]/n]^{1/2}$$

[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.



Tolerance ± 0.002°
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

5.2 Single specimens shall be used. Where orientation effects are significant and are to be evaluated, duplicate sets of

specimens shall be prepared so that their direction of tear is respectively parallel with and normal to the direction of maximum orientation. The direction of maximum orientation may be established for transparent materials by examination of the film or sheeting between crossed Polaroids.

5.3 At least 10 specimens shall be tested for each sample, in the case of isotropic materials.

5.4 Twenty specimens, 10 parallel with and 10 normal to the principal axis of anisotropic or maximum orientation, shall be tested for each sample, in the case of anisotropic material.

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

5.6 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 5—For certain materials whose properties vary considerably throughout film or sheeting, as many as 50 specimens cut from random portions of the sheet must be tested if reliable tear resistance data is desired.

6. Conditioning

6.1 *Conditioning*—Condition the test specimens at 23 ± 2°C (73.4 ± 3.6°F) and 50 ± 5 % relative humidity for not less than 40 h prior to test in accordance with Procedure A of Practice D 618, for those tests where conditioning is required. In cases of disagreement, the tolerances shall be± 1°C (±1.8°F) and ±2 % relative humidity.

6.2 *Test Conditions*—Conduct tests in the standard laboratory atmosphere of 23 ± 2°C (73.4 ± 3.6°F) and 50 ± 5 % relative humidity, unless otherwise specified in the test methods or in this test method. In cases of disagreements, the tolerances shall be± 1°C (±1.8°F) and ±2 % relative humidity.

7. Speed of Testing

7.1 A 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 and shall be uniform at all times.

NOTE 6—In this test method, resistance to tear is calculated from the maximum load recorded or indicated by the testing machine. In testing most plastics, this maximum load is generated at the outset of tearing across the 13-mm (0.5-in.) testing width of the specimen. Hence, the accuracy of the initial advance of the chart pen or dial from its origin is of utmost importance. The testing speed of 51 mm (2 in.)/min is sufficiently slow to make it virtually certain that the recorder pen or dial response is not exceeded. The response of the testing machine recorder pen shall be checked prior to testing specimens.

8. Procedure

8.1 Measure the thickness of the specimen at several points to the accuracy limits of the measuring devices specified in 4.3. Record the average thickness in inches.

8.2 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 points of attachment of the grips to the machine.

8.3 Apply the load at 51-mm (2-in.)/min rate of grip separation. After complete rupture of the specimen, the maximum tearing load in pounds shall be noted from the dial scale or recorder chart and recorded.

9. Calculation

9.1 Calculate the average resistance to tearing from all specimens tested in each principal direction of orientation. Record data as pounds of tearing resistance.

NOTE 7—Resistance to tear may be expressed in pounds per mil of specimen thickness where correlation for the particular material being tested has been established. However, it should be realized that comparison between films of dissimilar thickness may not be valid.

9.2 Calculate standard deviation (estimated) as follows, or, by any mathematically equivalent expression. Report to two significant figures.

$$s = \sqrt{\Sigma(X^2 - n\bar{X}^2)/(n-1)} \quad (1)$$

where:

s = estimated standard deviation,
X = value of a single observation,
n = number of observations, and
$\bar{X}$ = arithmetic mean of the set of observations.

10. Report

10.1 Report the following information:

10.1.1 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.

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

10.1.3 Type of testing machine used.

10.1.4 Number of specimens tested in each principal direction.

10.1.5 Average value of tear strength calculated in newtons (or pounds-force).

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

11. Precision and Bias [9]

11.1 Table 1 and Table 2 are based on a round robin conducted between 1986 and 1990 in accordance with Practice E 691, involving seven materials tested by seven laboratories. For each material, all the samples were prepared at one source, and randomized sections of film were sent to each of the laboratories which prepared the test specimens and tested them. Each "test result" was the average of ten determinations. Each laboratory obtained two test results for each material.

NOTE 8—**Caution:** The following explanations of *r* and *R* (11.2-11.2.3) are only intended to present a meaningful way of considering the approximate precision of this test method. The data in Table 1 and Table 2 should not be rigorously applied to acceptance or rejection of material, as those data are specific to the round robin and may not be representative of other lots, conditions, materials, or laboratories. Users of this test method should apply the principles outlined in Practice E 691 to generate

[9] Supporting data are available from ASTM Headquarters. Request RR:20-1177.

data specific to their laboratory and materials, or between specific laboratories. The principles of 11.2-11.2.3 would then be valid for such data.

11.2 *Concept of r and R*—If S_r and S_R have been calculated from a large enough body of data and for test results that were the result of testing ten specimens:

11.2.1 *Repeatability Limit, r*—(Comparing two test results for the same material, obtained by the same operator using the same equipment on the same day.) The two test results should be judged not equivalent if they differ by more than the "*r*" value for that material.

11.2.2 *Reproducibility Limit, R*—(Comparing two test results for the same material, obtained by different operators using different equipment in different laboratories.) The two test results should be judged not equivalent if they differ by more than the " *R*" value for that material.

11.2.3 Any judgment in accordance with 11.2.1 or 11.2.2 would have an approximate 95 % (0.95) probability of being correct.

11.3 There are no recognized standards to estimate bias of this test method.

12. Keywords

12.1 Graves; plastic film; tear; thin sheeting