Designation: D 1938 – 9402

An American National Standard

Standard Test Method for Tear-Propagation Resistance (Trouser Tear) of Plastic Film and Thin Sheeting by a Single-Tear Method[1]

This standard is issued under the fixed designation D 1938; 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 force necessary to propagate a tear in plastic film and thin sheeting (thickness of 1 mm (0.04 in.) or less) by a single-tear method. The method is not applicable for film or sheeting material where brittle failures occur during testing.

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 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.

1.34 *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.*

NOTE 12—This standard and is similar to ISO 6383-1 a, but is not considered technically equivalent. However, the The specimen size is larger for ISO 6383-1 is larger, and the method specifies different test speeds.

2. Referenced Documents

2.1 *ASTM Standards:*

D 374 Test Methods for Thickness of Solid Electrical Insulation[2]

---

[1] This test method is under the jurisdiction of ASTM Committee D-20 on Plastics and is the direct responsibility of Subcommittee D20.109 on Mechanical Properties . Film and Sheeting.

Current edition approved Feb. 15, 1994. March 10, 2002. Published April 1994. May 2002. Originally published as D 1938 – 62 T. Last previous edition D 1938 – 934.

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

D 618 Practice for Conditioning Plastics and Electrical Insulating Materials for Testing[3]
D 882 Test Methods for Tensile Properties of Thin Plastic Sheeting[3]
D 883 Terminology Relating to Plastics[3]
D 4000 Classification System for Specifying Plastic Materials[4]
E 4 Practices for Load Verification of Testing Machines[5]
E 691 Practice for Conducting an Interlaboratory Study to Determine the Precision of a Test Method[6]
2.2 *ISO Standard:*
ISO 6383-1 Film and Sheeting—Determination of Tear Resistance Part 1 Trouser Tear Method[7]

3. Terminology

3.1 *Definitions:* ~~D~~ For definitions of terms ~~applying to~~ used in this test ~~method appear in~~ method, refer to Terminology D 883.

4. Summary of Test Method

4.1 The force to propagate a tear across a film or sheeting specimen is measured using a constant-rate-of-grip separation machine as described in ~~Method A of~~ Test Methods ~~D 882. The force necessary to propagate the tear~~ D 882 and is ~~interpreted~~ calculated from the load-time chart.

5. Significance and Use

5.1 This test method is of value in rating the tear-propagation ~~force~~ resistance of various plastic films and thin sheeting of comparable thickness. For highly extensible film or sheeting the deformation energy of the specimen legs is significantly greater than the tearing energy. The tear-propagation resistance in ~~h~~ slightly extensible or non-extensible film or sheeting is distinguished from the tear-propagation resistance in ~~slightly~~ highly extensible ~~or nonextensible~~ film or sheeting by the load-time or load-displacement data, (Fig. 1 and Fig. 2 ~~in 10.1~~). The tear-propagation force for slightly extensible or non-extensible material is determined from the average tear force versus the initial and ~~10.2, respectively.~~ peak force for a highly extensible material.

5.2 This test method should be used for specification acceptance testing only after it has been demonstrated that the data for the particular material are acceptably reproducible.

5.3 The data obtained by this test method furnish information for ranking the tear-propagation resistance of plastic films and sheeting of similar composition. Actual use performance may not necessarily correlate with data from this test method. Sets of data from specimens of dissimilar thickness are usually not comparable.

5.4 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.

6. Apparatus

6.1 *~~Film-Testing~~Testing Machine*~~, with~~—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*—Perferably, a set of self-aligning grips for holding the test specime-n between the fixed member and the movable member of the testing machine. The grips should minimize both slippage and uneven stress distribution.

[2] *Annual Book of ASTM Standards*, Vol 10.01.
[3] *Annual Book of ASTM Standards*, Vol 08.01.
[4] *Annual Book of ASTM Standards*, Vol 08.02.
[5] *Annual Book of ASTM Standards*, Vol 03.01.
[6] *Annual Book of ASTM Standards*, Vol 14.02.
[7] Available from American National Standards Institute, ~~11~~ 25 W. ~~42nd~~ 43rd St., ~~13th~~ 4th Floor, New York, NY 10036.

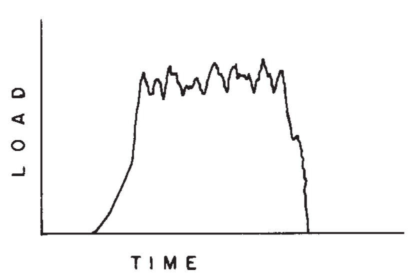

FIG. 1 Load-Time Chart for Low-Extensible Film

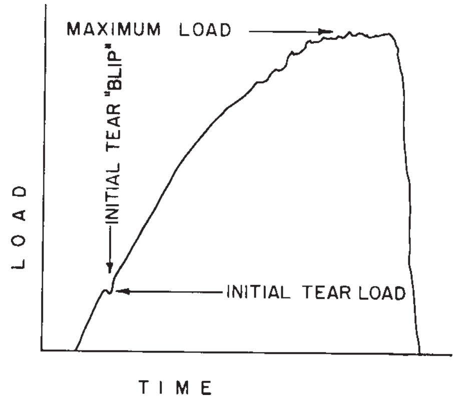

FIG. 2 Load-Time Chart for Highly Extensible Film

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 ~~can measure~~ 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 ~~to tear~~ so that the long axis of the test specimen~~. I~~ will coincide with the direction of the applied pull through the center line of the grip assembly. The specimens should be ~~equipped~~ aligned as perfectly as possible with ~~a device for recording~~ the ~~load carried by~~ direction of pull so that no rotary motion that may induce slippage will occur in the ~~specimen and~~ grips; there is a limit to the amount of misalignmepnt self-aligning grips will accommodatie.

NOTE 3—Grips lined with thin rubber have successfully been 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 ~~during~~ 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 250 mm (10 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 inertia lag at the specified rate of testing and shall indicate the load with an accuracy of ~~±2 % of the indicated value or better.~~ ±1 %. The accuracy of the testing machine shall be verified in accordance with Practices ~~E 4. A device shall be included to control~~ E 4.

6.1.6 *Crosshead Extension Indicator*—A suitable extension-indicating mechanism capable of showing the ~~grip-separation rate at 250 mm (10 in.)± 5 %/min.~~ amount of change in the separation of the grips (crosshead movement).

6.2 ~~*Thickness-Measuring Devices* ,~~Thickness—A micrometer as prescribed in ~~accordance with~~ Test Methods D 374 or an equivalent measuring device, reading to 0.0025 mm (0.0001 in.) or less. The pressure exerted by the gage on the specimen being measured shall not distort or deform the specimen. For thin films, ≤ 0.0025 mm (0.001 in.), or films which exhibit visual deformation during measurement, a ~~method~~ maximum pressure of ~~equivalent accuracy.~~ 70 kPa (10 psi) is recommended. For thicker or stiffer films, the pressure shall be between 160 and 185 kPa (23 and 27 psi).

6.3 ~~*Cutter*~~*Die*—A ~~sharp razor blade or~~ die having the ~~equivalent.~~

~~6.4 *Conditioning Apparatus*,~~ dimensions shown in ~~accordance with Procedure A~~ Fig. 3 shall be used to cut all specimens. The cutting edge of ~~Practice D 618.~~ 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. The sample shall rest on a smooth, slightly yielding surface that will not injure the die blade. Care should be taken that the cut edges of the specimen are parallel and perpendicular to the samples longitudinal and transverse directions.

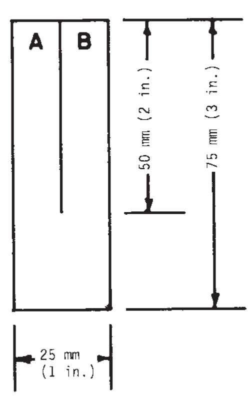

FIG. 3 Single-Tear Specimen

7. Test Specimens

7.1 The specimens shall ~~be of~~ conform to the ~~single-tear type~~ dimensions shown in Fig. 1 and shall ~~consist of strips 75 mm (3 in.) long~~ not vary by ~~25 mm (1 in.) wide and shall have a clean longitudinal slit 50 mm (2 in.) ±2 % long cut with a sharp razor blade (Fig. 3) or the equivalent.~~ more than 0.5 % from these dimensions.

NOTE ~~2~~4—The thickness of the test specimens shall be uniform to within 5 % of the thickness over the length of the unslit portion of the specimen.

7.2 Measure the thickness of the specimen below the slit (see Fig. 3) in several places and record it in millimetres to the nearest 0.0025 mm (0.0001 in.).

7.3 Cut enough specimens to provide a minimum of five tear-propagation force determinations each in the machine direction and in the transverse direction of the material being tested.

NOTE 5—This is required because the properties of anisotropic specimens vary with direction.

8. Conditioning

8.1 *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.

8.2 *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. In cases of disagreement, the tolerances shall be ±1°C (±1.8°F) and ±2 % relative humidity.

9. Procedure

9.1 Secure Tongue *A* (Fig. 3) in one grip and Tongue *B* in the other grip of the constant-rate-of-grip separation-testing machine, using an initial grip separation of 50 mm (2 in.). Align the specimen so that its major axis coincides with an imaginary line joining the centers of the grips.

9.2 Using a grip-separation speed of 250 mm (10 in.)/min, start the ~~machine,~~ instrument, and record the load ~~necessary to propagate~~ versus extension.

9.3 Continue the test until the tear has propagated through the entire unslit 25-mm (1-in.) portion.

9.~~3~~4 If the tear deviates from the center line to such an extent as to reach one of the edges of the specimen, note the deviation in the report.

9.5 Test not less than five specimens in each of the principal film or sheeting directions.

10. Calculation

10.1 For thin films and sheeting that have load-time charts characterized by Fig. 1, ~~obtain~~ calculate the average tear propagation force by averaging the load ~~indicated on the chart~~ over ~~the time period,~~ a 25.4 mm (1 in.) interval, disregarding the initial and final portions of the ~~curve. This can be done with an integrator or a planimeter. In some cases, a fairly accurate estimate can be made by eye.~~ curve.

10.2 For thin films and sheeting that have load-time ~~charts~~ data characterized by Fig. 2, obtain and report the initial force to continue the propagation of the ~~slit and~~ slit, the maximum ~~force from~~ force, and the ~~chart. The initial force may be more readily detected by placing a dot approximately 3 mm (⅛ in.) in a diameter at the base of the razor-blade slit with a china-marking wax pencil. As the load is applied to the sample, observe the dot area. When the load is just sufficient to begin the~~ extension ~~of the slit, introduce a "blip" on the chart (see Fig. 2) by pushing the appropriate button on the recorder or the equivalent to mark this point. The~~ at maximum ~~load is the highest reading on the chart.~~ force. Report both the initial ~~load and~~ load, the maximum load, and extension at maximum load.

10.3 For each series of tests, report the mean of all values obtained to three significant figures and as the mean value of the particular property.

10.4 Calculate the estimated standard deviation ~~as follows~~ and report load to three significant ~~figures:~~

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

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

figures and extension to two significant figures.

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, orientation of samples with respect to principal directions of the material, etc., 11.1.2 Average thickness of test specimens,

11.1.3 Number of samples tested,

11.1.4 Date of test, and

11.1.5 Mean of the five average tear-propagation determinations, usually in newtons (or pounds-force), for the materials described in 10.1; and the mean of the five initial tear-propagation forces and forces, the mean of the five maximum tear-propagation forces, usually in newtons (or pounds-force), and the extension to maximum force, in mm (in.) for materials described in 10.2. In each case, report the standard deviation of the above sets of data. In the cases where the specimens tear to one side, so state, and report note this together with the values obtained.

12. Precision and Bias

12.1 *Precision*:

12.1.1 Table 1 and Table 2 are based on a round robin[8] conducted between 1986 and 1990 in accordance with Practice E 691 – 87, 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 five determinations. Each laboratory obtained two test results for each material.

NOTE 3— 6—**Caution:** The following explanations of *r* and *R* (12.1.2-12.1.2.3) are intended only 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 – 87 to generate data specific to their laboratory and materials, or between specific laboratories. The principles of 12.1.2-12.1.2.3 would then be valid for such data.

12.1.2 *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 five specimens, the following applies:

12.1.2.1 *Repeatability Limit, r*—In 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.

12.1.2.2 *Reproducibility Limit, R*—In 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.

12.1.2.3 Any judgment in accordance with 12.1.2.1 or 12.1.2.2 would have an approximate 95 % (0.95) probability of being correct.

12.2 *Bias*—There are no recognized standards to estimate the bias of this test method.

13. Keywords

13.1 plastic film; single tear; tear; tear-propagation; thin sheeting; trouser

[8] Supporting data on precision are available from ASTM Headquarters. Request RR: D20-1177.

TABLE 1 Tear Propagation Resistance (Trouser Tear) Machine Direction (Values Expressed in Units of Grams-Force)

Material	Average	S_r[A]	S_R[B]	r[C]	R[D]
Polystyrene	5.04	1.54	3.47	4.32	9.72
Polyester	32.75	7.08	7.08	19.81	19.81
Polypropylene	70.77	20.52	38.05	57.45	106.6
HDPE No. 2	127.3	48.04	56.49	134.59	158.2
LDPE—LD 104	228.3	33.98	33.98	95.14	95.14
LLDPE	337.1	30.95	42.74	86.66	119.7
HDPE No. 1	482.9	49.04	106.0	137.3	296.9

[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, as follows:

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

[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 Tear Propagation Resistance (Trouser Tear) Transverse Direction (Values Expressed in Units of Grams-Force)

Material	Average	S_r[A]	S_R[B]	r[C]	R[D]
Polystyrene	3.86	0.46	3.08	1.28	8.63
Polyester	32.47	1.74	3.68	4.86	10.31
LDPE—LD 104	278.6	12.21	30.29	34.18	84.40
Polypropylene	326.2	49.67	124.9	139.1	349.7
LLDPE	372.5	26.69	31.68	74.74	88.70
HDPE No. 2	452.6	24.68	31.28	69.10	87.59
HDPE No. 1	549.7	64.10	105.4	179.5	295.0

[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, as follows:

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

[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.

SUMMARY OF CHANGES

This section identifies the location of selected changes to this test method. For the convenience of the user, Committee D20 has highlighted those changes that may impact the use of this test method. This section may also include descriptions of the changes or reasons for the changes, or both.

D 1938 – 02:
(*1*) The title was revised.
(*2*) The scope was revised.
(*3*) Note 1 was added.
(*4*) Paragraph 1.2 was added.
(*5*) ISO equivalency statement changed and renumbered at Note 2.
(*6*) Paragraphs 4.1 and 5.1 were modified.
(*7*) Section 6 was revised.
(*8*) Paragraph 7.1 was revised.
(*9*) Section 9 was revised.
(*10*) Section 10 was revised.
(*11*) Subcommittee jurisdiction was changed.