Designation: D 5733 – 99

Standard Test Method for Tearing Strength of Nonwoven Fabrics by the Trapezoid Procedure[1]

This standard is issued under the fixed designation D 5733; 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 measurement of the tearing strength of nonwoven fabrics by the trapezoid procedure using a recording constant-rate-of-extension (CRE) tensile testing machine.

1.1.1 The CRE-type tensile testing machine has become the preferred test apparatus for determining trapezoid tearing strength. It is recognized that some constant-rate-of-traverse (CRT) tensile testing machines continue to be used. As a consequence, these test instruments may be used when agreed upon between the purchaser and the supplier. The conditions for the CRT-type tensile tester as used with this test are included in Appendix X1.

1.2 This test method applies to most nonwoven fabrics including those that are treated or untreated, heavily sized, coated, or resin-treated. This test method may not be useful for highloft nonwoven fabrics.

1.3 Trapezoid tear strength as measured in this test method is the maximum tearing force required to continue or propagate a tear started previously in the specimen. The reported value is not directly related to the force required to initiate or start a tear.

1.4 The values stated in SI units are to be regarded as the standard. The inch-pound units given in parentheses may be approximate.

1.5 *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.*

2. Referenced Documents

2.1 *ASTM Standards:*

D 76 Specification for Tensile Testing Machines for Textiles[2]

D 123 Terminology Relating to Textiles[2]

D 1776 Practice for Conditioning Textiles for Testing[2]

D 2904 Practice for Interlaboratory Testing of a Textile Test Method That Produces Normally Distributed Data[2]

D 4848 Terminology of Force, Deformation, and Related Properties of Textiles[3]

3. Terminology

3.1 *Definitions of Terms Specific to This Standard:*

3.1.1 *lengthwise direction*, *n—in textiles*, the direction in a machine-made fabric parallel to the direction of movement the fabric followed in the manufacturing machine.

3.1.1.1 *Discussion*—For nonwovens, an easily distinguishable pattern for orientation may not be apparent, especially if removed from the roll. Care should be taken to maintain the directionality by clearly marking the direction.

3.1.2 *nonwoven fabric*, *n*—a textile structure produced by bonding or interlocking of fibers, or both, accomplished by mechanical, chemical, thermal, or solvent means, or combination thereof.

3.1.3 *tearing force*, *n*—the average force required to continue a tear previously started in a fabric.

3.1.3.1 *Discussion*—For nonwovens, the tearing force is recorded as the maximum force required to continue a tear previously started in a fabric. The tearing force may appear as a single peak or a series of peaks on a force-extension curve, depending on the nature of the material. Typically for nonwoven fabrics, if a small decrease in force occurs at a time when the applied force is increasing, it is not considered as a peak unless the indicated force exceeds the force required to break, individually or collectively, the fibers, fiber bonds, or fiber interlocks. Lower shifts corresponding to fiber movement do not qualify as peaks since the fibers, fiber bonds, or fiber interlocks are not broken. The trapezoid tearing force may be calculated from a single-peak or multiple-peak force-extension curve.

3.1.4 *tearing strength*, *n*—the force required either to start or to continue or propagate a tear in a fabric followed in the manufacturing process.

3.1.5 *widthwise direction*, *n—in textiles*, the direction in a machine-made fabric perpendicular to the direction of movement the fabric followed in the manufacturing machine.

[1] This test method is under the jurisdiction of ASTM Committee D13 on Textiles and is the direct responsibility of Subcommittee D13.90 on Executive.

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[2] *Annual Book of ASTM Standards*, Vol 07.01.

[3] *Annual Book of ASTM Standards*, Vol 07.02.

3.2 *Definitions*—For definitions of other terms related to force and deformation of textiles used in this test method, refer to Terminology D 4848. For definitions of other textile terms, refer to Terminology D 123.

4. Summary of Test Method

4.1 An outline of an isosceles trapezoid is marked on a rectangular specimen cut for the determination of tearing strength (see Fig. 1). The specimen is slit at the center of the smallest base of the trapezoid to start the tear. The nonparallel sides of the trapezoid marked on the specimen are clamped in parallel jaws of a tensile testing machine. The separation of the jaws is continuously increased to apply a force to propagate the tear across the specimen. At the same time, the force developed is recorded. The maximum force to continue the tear is calculated from autographic chart recorders, or microprocessor data collection systems.

5. Significance and Use

5.1 This test method is used in the trade for acceptance testing of commercial shipments of nonwoven fabrics, however, caution is advised since information about between-laboratory precision is incomplete. Comparative tests as directed in 5.1.1 may be advisable.

5.1.1 In case of a dispute arising from differences in reported test results when using this test method for acceptance testing of commercial shipments, the purchaser and the supplier should conduct comparative tests to determine if there is a statistical bias between their laboratories. Competent statistical assistance is recommended for the investigation of bias. As a minimum, the two parties should take a group of test specimens that are as homogeneous as possible and that are from a lot of material of the type in question. Test specimens should then be randomly assigned in equal numbers to each laboratory for testing. The average results from the two laboratories should be compared using the appropriate Student's *t*-test and an acceptable probability level chosen by the two parties before testing is begun. If a bias is found, either its cause must be found and corrected or the purchaser and the supplier must agree to interpret future test results in view of the known bias.

5.2 The trapezoid tear method is a test that produces tension along a reasonably defined course such that the tear propagates across the width of the specimen. It is useful for estimating the relative tear resistance of different fabrics or different directions in the same fabric.

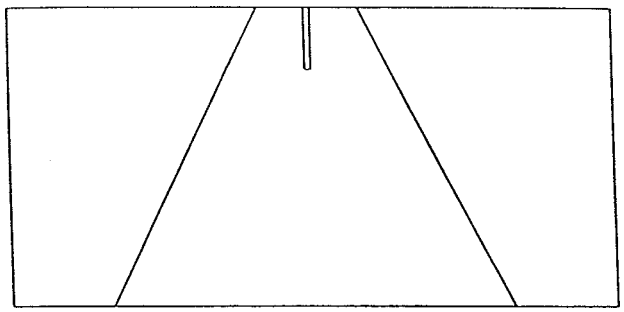


FIG. 1 Diagram of Marked Trapezoid Specimen

5.3 For nonwoven fabrics, because the individual fibers are more or less randomly oriented and capable of some reorientation in the direction of the applied force, the maximum trapezoid tearing strength is reached when the resistance to further reorientation is greater than the force required to rupture one or more fibers or the fiber interlocking, simultaneously. The tearing strength is determined primarily by the bonding or interlocking of fibers in the structure.

5.4 Depending on the nature of the specimen, the data recording devices usually will show the tearing force in the form of single peak. The highest peak appears to reflect the strength combination needed to stop a tear in a fabric of the same construction.

5.5 Most nonwoven fabrics can be tested by this test method. Some modification of clamping techniques may be necessary for a given fabric, depending upon its structure. Special adaptation may be necessary with strong fabrics, or fabrics made from glass fibers, to prevent them from slipping in the clamps or being damaged as a result of being gripped in the clamps.

5.6 The CRE-type is the preferred tensile testing machine. This test method allows the use of the CRT-type tensile machine when agreed upon between the purchaser and the supplier. However, there may be no overall correlation between the results obtained with the CRT machine and the CRE machine. Consequently, these two tensile testers cannot be used interchangeably unless the degree of quantitative correlation has been established between the purchaser and the supplier. In any event, the CRE machine shall prevail.

6. Apparatus

6.1 *Tensile Testing Machine*, of the constant-rate-of-extension (CRE) type conforming to the requirements of Specification D 76 with autographic recorder, or automatic microprocessor data gathering systems.

6.2 *Clamps*, having all gripping surfaces parallel, flat, and capable of preventing slipping of the specimen during a test, and measuring 50 by no less than 75 mm (2 by no less than 3 in.), with the longer dimension perpendicular to the direction of application of the force.

6.2.1 The use of hydraulic pneumatic clamping systems with a minimum of 50 by 75-mm (2 by 3-in.) serrated or rubber jaw faces having a clamping force at the grip faces of 13 to 14 kN (2900 to 3111 lbf) is recommended. Manual clamping is permitted providing no slippage of the specimen is observed.

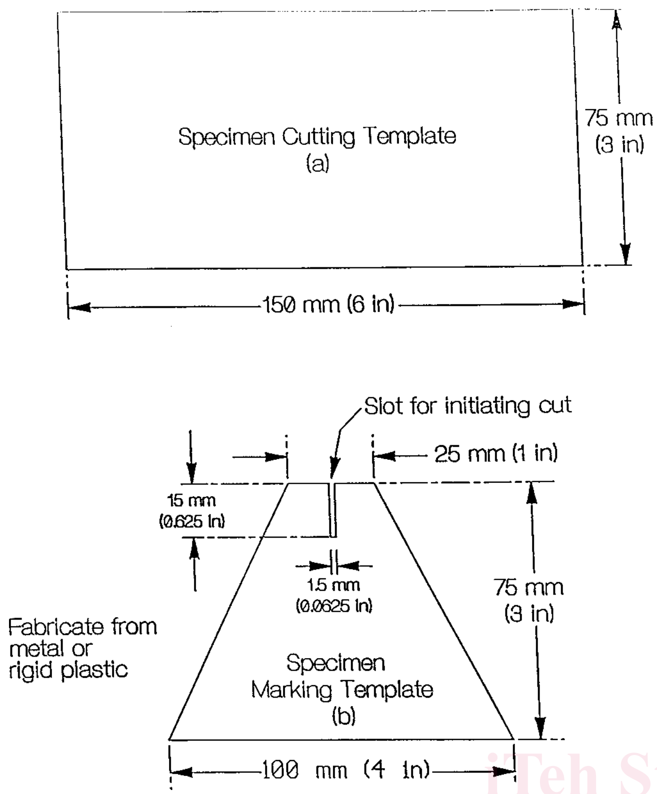
6.2.2 For some materials, to prevent slippage when using jaw faces other than serrated, such as rubber-faced jaws, they may be covered with a No. 80 to 120 medium-grit emery cloth. Secure the emery cloth to the jaw faces with pressuresensitive tape.

6.3 *Cutting Die or Template*, having essentially the shape and dimensions with tolerances of ± 0.5 % shown in Fig. 2(*a*).

6.4 *Trapezoidal-Shaped Template*, having dimensions with tolerances of ± 0.5 % as shown in Fig. 2(*b*).

7. Sampling and Test Specimens

7.1 *Lot Sample*—As a lot sample for acceptance testing, take at random the number of rolls, or pieces, of nonwoven fabric directed in an applicable material specification or other



NOTE 1—All tolerances ± 0.5 %.

FIG. 2 Templates for Cutting (a) and Marking (b) Trapezoid Test Specimens

agreement between the purchaser and the supplier. Consider the rolls, or pieces, of nonwoven fabric to be the primary sampling units. In the absence of such an agreement, take the number of nonwoven fabric rolls specified in Table 1.

NOTE 1—An adequate specification or other agreement between the purchaser and the supplier requires taking into account the variability between rolls or pieces of fabric and between specimens from a swatch from a roll or pieces of fabric to provide a sampling plan with a meaningful producer's risk, consumer's risk, acceptable quality level, and limiting quality level.

7.2 *Laboratory Sample*—For the laboratory sample, take a sample extending the width of the fabric and approximately 1 m (1 yd) along the machine direction from each roll, or piece, in the lot sample. For rolls of fabric, take a sample that will exclude fabric from the outer wrap of the roll or the inner wrap around the core.

7.3 *Test Specimens*—From each laboratory sampling unit, take five specimens from the lengthwise direction and five specimens from the widthwise direction, for each test condition described in 8.1-8.3 as, applicable to a material specification or contract order. Use the cutting die or template described in 6.3 and shown in Fig. 2. Mark each specimen with an isosceles trapezoid template (see Figs. 1 and 2). Make a preliminary cut 15 mm (0.625 in.) long at the center of the 25-mm (1-in.) edge, as shown in Figs. 1 and 2.

7.3.1 *Direction of Test*—Consider the short direction as the direction of test.

7.3.2 *Cutting Test Specimens*—Take the specimens for the measurement of the lengthwise direction from different positions across the fabric width. Take the specimens for the measurement of the widthwise direction from different positions along the length of the fabric. Cut the specimens to be used for the measurement of the lengthwise direction with the shorter dimension parallel to the lengthwise direction. Cut the specimens to be used for the measurement of the widthwise direction with the shorter dimension parallel to the widthwise direction. When specimens are to be tested wet, take the specimens from areas adjacent to the dry test specimens. Label to maintain specimen identity.

7.3.2.1 Cut specimens representing a broad distribution across the width of the laboratory sample and no nearer the edge than one tenth its width. Ensure specimens are free of folds, creases, or wrinkles. Avoid getting oil, water, grease, and so forth, on the specimens when handling.

7.3.2.2 Refer to Fig. 3 for illustration of the relationship of specimen orientation with respect to test direction.

TABLE 1 Number of Rolls, or Pieces, of Nonwoven Fabric in the Lot Sample

Number of Rolls, Pieces in Lot, Inclusive	Number of Rolls or Pieces in Lot, Sample
1 to 3	all
4 to 24	4
25 to 50	5
over 50	10 % to a maximum of ten rolls or pieces

8. Preparation of Apparatus

8.1 Set the distance between the clamps at the start of the test at 25 ± 1 mm (1 ± 0.05 in.). Select the full-scale force range of the testing machine such that the maximum force occurs between 15 and 85 % of full-scale force.

8.2 Set the testing speed to 300 ± 10 mm (12± 0.5 in./min).

8.3 Verify calibration of the tensile testing machine as directed in the manufacturer's instructions or Specification D 76.

8.4 When using microprocessor automatic data gathering systems, set the appropriate parameters as defined in the manufacturer's instructions.

9. Conditioning

9.1 *Condition 1, Unspecified Testing Conditioning*—No conditioning is required unless otherwise specified in a material specification or contract order.

9.2 *Condition 2, Standard Testing Conditioning*:

9.2.1 When specified, precondition the specimens by bringing them to approximate moisture equilibrium in the standard atmosphere for preconditioning textiles as directed in Practice D 1776.

9.2.2 After preconditioning, bring the test specimens to moisture equilibrium for testing in the standard atmosphere for testing textiles as directed in Practice D 1776 or, if applicable, in the specified atmosphere in which the testing is to be performed.

9.3 *Condition 3, Wet Specimen Conditioning Testing*:

9.3.1 Place the specimens in a container and submerge in distilled or deionized water at ambient temperature until thoroughly soaked (see 9.3.1.1).