



# Standard Test Method for Tearing Strength of Fabrics by Trapezoid Procedure<sup>1</sup>

This standard is issued under the fixed designation D5587; 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 ( $\epsilon$ ) 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 textile fabrics by the trapezoid procedure using a recording constant-rate-of-extension-type (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-type (CRT) tensile testing machines continue to be used. Consequently, these test instruments may be used when agreed upon between the purchaser and the supplier. The conditions for use of the CRT-type tensile tester are included in [Appendix X1](#).

1.2 This test method applies to most fabrics including woven fabrics, air bag fabrics, blankets, napped fabrics, knitted fabrics, layered fabrics, pile, and nonwoven fabrics. The fabrics may be untreated, heavily sized, coated, resin-treated, or otherwise treated. Instructions are provided for testing specimens with or without wetting.

1.3 Tearing strength, as measured in this test method, requires that the tear be initiated before testing. The reported value obtained is not directly related to the force required to initiate or start a tear.

1.4 Two calculations for trapezoid tearing strength are provided: the single-peak force and the average of five highest peak forces.

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

1.6 *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.*

<sup>1</sup> This test method is under the jurisdiction of ASTM Committee D13 on Textiles and is the direct responsibility of Subcommittee D13.60 on Fabric Test Methods, Specific.

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## 2. Referenced Documents

### 2.1 *ASTM Standards*:<sup>2</sup>

- D76 Specification for Tensile Testing Machines for Textiles
- D123 Terminology Relating to Textiles
- D629 Test Methods for Quantitative Analysis of Textiles
- D1776 Practice for Conditioning and Testing Textiles
- D2904 Practice for Interlaboratory Testing of a Textile Test Method that Produces Normally Distributed Data (Withdrawn 2008)<sup>3</sup>
- D2906 Practice for Statements on Precision and Bias for Textiles (Withdrawn 2008)<sup>3</sup>
- D4850 Terminology Relating to Fabrics and Fabric Test Methods

## 3. Terminology

3.1 For all terminology relating to D13.59, Fabric Test methods, General, refer to Terminology [D4850](#).

3.1.1 The following terms are relevant to this standard: fabric, in textiles; peak force, in tear testing of fabrics; tearing force, in fabric; tearing strength, in fabrics; yarn distortion (see [Fig. 1](#)).

3.2 For all other terms related to textiles, refer to Terminology [D123](#).

## 4. Summary of Test Method

4.1 An outline of an isosceles trapezoid is marked on a rectangular specimen (see [Fig. 2](#)). The specimen is slit at the center of the smallest base of the trapezoid to start the tear. The nonparallel sides of the marked trapezoid are clamped in parallel clamps of a tensile testing machine. The separation of the clamps is increased continuously to apply a force to propagate the tear across the specimen. At the same time, the force developed is recorded. The force to continue the tear is calculated from autographic chart recorders or microprocessor data collection systems.

<sup>2</sup> For referenced ASTM standards, visit the ASTM website, [www.astm.org](http://www.astm.org), or contact ASTM Customer Service at [service@astm.org](mailto:service@astm.org). For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

<sup>3</sup> The last approved version of this historical standard is referenced on [www.astm.org](http://www.astm.org).

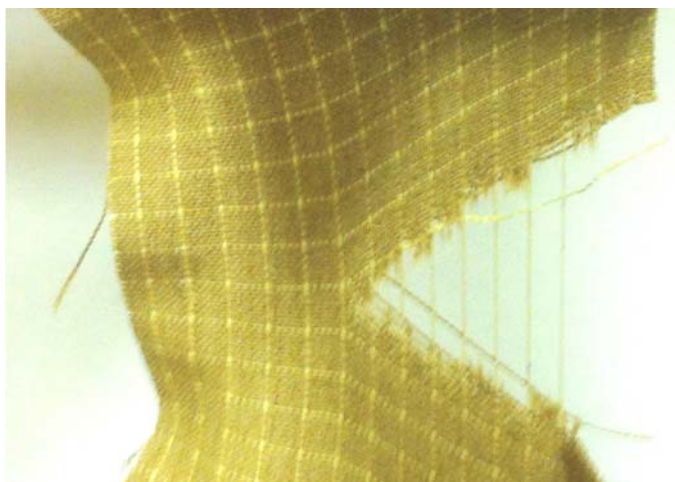


FIG. 1 Photograph Showing Yarn Distortion in a Modern Technical Type Fabric

## 5. Significance and Use

5.1 This test method is considered satisfactory for acceptance testing of commercial shipments because current estimates of between-laboratory precision are acceptable, and this test method is used extensively in the trade for acceptance testing.

5.2 If there are differences of practical significance between test results for two laboratories (or more), comparative test should be performed to determine if there is a statistical bias between them, using competent statistical assistance. As a minimum, use the samples for such a comparative test that are as homogeneous as possible, drawn from the same lot of material as the samples that resulted in disparate results during initial testing. Randomly assign the samples in equal numbers to each laboratory. The test results from the laboratories involved should be compared using a statistical test for unpaired data, at a probability level chosen prior to the testing series. If bias is found, either its cause must be found and corrected, or future test results for that material must be adjusted in consideration of the known bias.

5.3 The trapezoid tear 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.

5.4 Depending on the nature of the specimen, the data recording devices will show the tearing force in the form of a peak or peaks. The highest peaks appear to reflect the strength of the yarn components, individually or in combination, needed to stop a tear in fabrics of the same construction. The valleys recorded between the peaks have no specific significance. The minimum tearing force, however, is indicated to be above the lowest valleys.

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

a result of being gripped in the clamps. In some cases, due to fabric constructions, individual yarns may not rupture but show a high peak and yarn distortion within the test specimen. Wherever possible, this shall be prevented. If you have tried all of these steps and yarn distortion still occurs, this must be included in the report.

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. There may be no overall correlation, however, between the results obtained with the CRT-type machine and the CRE-type 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-type machine shall prevail.

## 6. Apparatus

6.1 *Tensile Testing Machine*<sup>4</sup>, of the CRE-type conforming to the requirements of Specification D76 with autographic recorder, or automatic microprocessor data gathering system.

6.2 *Clamps*, having all clamping surfaces parallel, and capable of preventing slipping of the fabric specimen during a test, and measuring at least 50 by 75 mm (at least 2 by 3 in.), with the longer dimension perpendicular to the direction of application of the force.

6.2.1 Hydraulic or pneumatic clamping systems with a minimum of 50 by 75-mm (at least 2 by 3-in.) rubber, metal, or padded/coated clamps faces shall be used. The faces shall have an appropriate clamping force at the clamp faces depending on the type of fabric under test. The pressure should be sufficient to prevent slippage of the fabric specimen from the clamps during the test, while ensuring the specimen is not damaged at the clamps edge. For certain industrial type fabrics a gripping force at the clamps of 13 to 14 kN (2900 to 3111 lbf) is recommended. Manual clamping is permitted providing no fabric specimen slippage in the clamp is observed. When using manual clamping, use of torque wrench or other tool is recommended to consistently achieve 2900-3111 lbf.

6.2.2 For some fabrics, to prevent fabric slippage or yarn distortion from the clamp when using clamp faces other than serrated, such as rubber faced clamps, the clamps faces may be covered with a No. 80 to 120 medium grit emery cloth. Secure the emery cloth to the clamps faces with pressure-sensitive tape. Other techniques may also be used such as resins if necessary. If fabric slippage or yarn distortion continues to occur, then serrated or interlocking clamps faces should be used.

6.3 *Cutting Die or Template*, having essentially the shape and dimensions shown in Fig. 2.

## 7. Sampling and Test Specimens

7.1 *Lot Sample*—As a lot sample for acceptance testing, randomly select the number of rolls or pieces of fabric directed in an applicable material specification or other agreement between the purchaser and the supplier. Consider the rolls or

<sup>4</sup> Apparatus and accessories are commercially available.

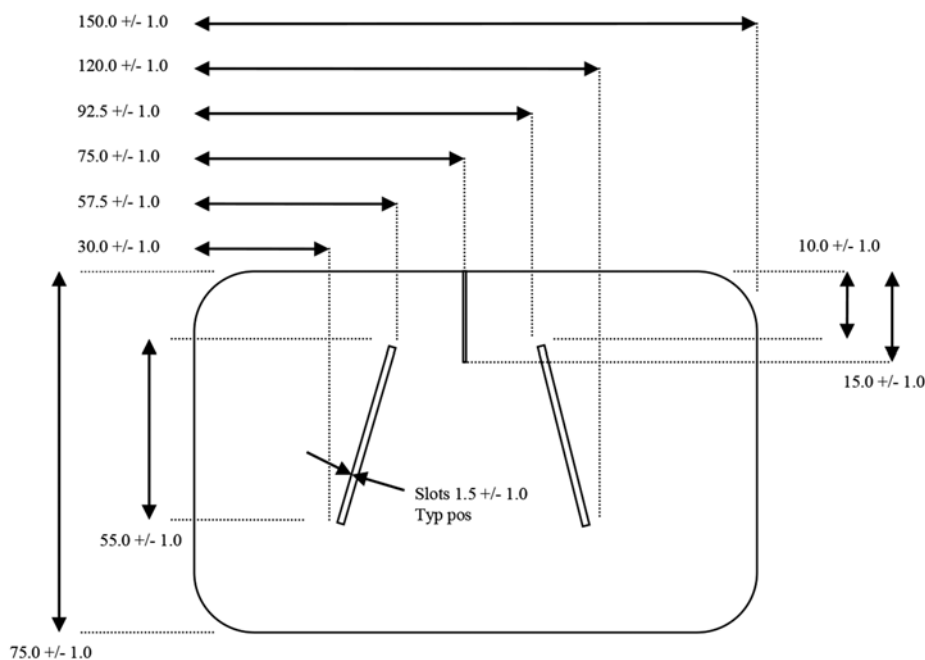


FIG. 2 Templates for Cutting and Marking Trapezoid Test Specimens (mm)

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

| Number of Rolls or 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 10 rolls or pieces |

pieces of fabric to be the primary sampling units. In the absence of such an agreement, take the number of 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 piece 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 acceptance testing, take a swatch 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 of the roll of fabric.

7.2.1 *Stretch Fabrics*—For fabrics with stretch yarns, laboratory samples shall be allowed to relax lying flat for 24 h in the conditioned atmosphere outlined in Section 9. Once relaxed, samples are to be marked and cut as described above.

7.3 *Test Specimens*—From each laboratory sampling unit, take five specimens from the machine direction and five specimens from the cross-machine direction, for each test condition described in 9.1 and 9.2, as applicable to a material specification or contract order.

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

7.3.2 *Cutting Test Specimens*—Take the specimens to be used for the measurement of machine direction with the longer dimension parallel to the machine direction. Take the specimens to be used for the measurement of the cross-machine direction with the longer dimension parallel to the cross-machine 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 In cutting the woven fabric specimens, take care to align the yarns running in the short direction parallel with the die such that when the slit is cut, the subsequent tear will take place between these yarns and not across them. This precaution is most important when testing bowed fabrics.

7.3.2.2 Cut specimens representing a broad distribution across the width and length, preferably along the diagonal 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.

7.3.2.3 Use the cutting die or template described in 6.3 and shown in Fig. 2. Mark each specimen with an isosceles trapezoid template (see Fig. 2). Make a preliminary cut 15 mm (0.625 in.) long at the center of the 25-mm (1-in.) edge, as shown in Fig. 2.

NOTE 2—Tests were carried out in 2007 to evaluate whether the specimen size and clamps separation could be increased to facilitate easier loading of the specimen. It was found that this caused a difference in the final results depending on the fabric type. Therefore, it is not possible to increase the specimen size.

## 8. Preparation of Test Apparatus and Calibration

8.1 Set the distance between the clamps at the start of the test at  $25 \pm 1$  mm ( $1 \pm 0.05$  in.).

8.2 Select the full-scale force range of the testing machine such that the maximum force occurs between 15 and 85 % of full-scale force.

8.3 Set the testing speed to  $300 \pm 10$  mm ( $12 \pm 0.5$  in./min).

8.4 Verify calibration of the tensile testing machine as specified in the manufacturer's instructions and Specification D76.

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

## 9. Conditioning

### 9.1 Condition 1, for Standard Testing:

9.1.1 Precondition the specimens by bringing them to approximate moisture equilibrium in the standard atmosphere for preconditioning textiles as specified in Practice D1776, unless otherwise specified in a material specification or contract order.

9.1.2 After preconditioning, bring the test specimens to moisture equilibrium for testing in the standard atmosphere for testing textiles as specified in Practice D1776 or, if applicable, in the specified atmosphere in which the testing is to be performed, unless otherwise directed in a material specification or contract order.

### 9.2 Condition 2, for Wet Specimen Testing:

9.2.1 Submerge the specimen in a container of distilled or deionized water at ambient temperature until thoroughly soaked.

9.2.1.1 The time of immersion must be sufficient to wet out the specimens, as indicated by no significant change in tearing force followed by longer periods of immersion. For most fabrics, this time period will be approximately 1 h. For fabrics not readily wet out with water, such as those treated with water-repellent or water-resistant materials, add a 0.1% solution of a nonionic wetting agent to the water bath.

9.2.2 When a desizing treatment is to be performed prior to wet testing, use one of the treatments specified in Test Methods D629. If desized specimens are to be tested wet, follow the steps in and 9.2.1.1. If desized specimens are to be tested in the conditioned state, follow the steps in 9.1.1 and 9.1.2.

9.2.2.1 The time of immersion must be sufficient to wet out the specimens, as indicated by no significant change in tearing force followed by longer periods of immersion. For most fabrics this time period will be about 1 h. For fabrics not readily wet out with water, such as those treated with water-repellent or water-resistant materials, add a 0.1 % solution of a nonionic wetting agent to the water bath.

## 10. Procedure

10.1 Test the conditioned specimens in the standard atmosphere for testing textiles as described in Practice D1776, unless otherwise specified in a material specification or contract order.

10.2 Carefully position the specimen in the upper clamps of the machine, aligning the lower edge of the clamps face with line A on the specimen. Carefully position the lower half of the specimen into the lower clamps aligning line B with the upper

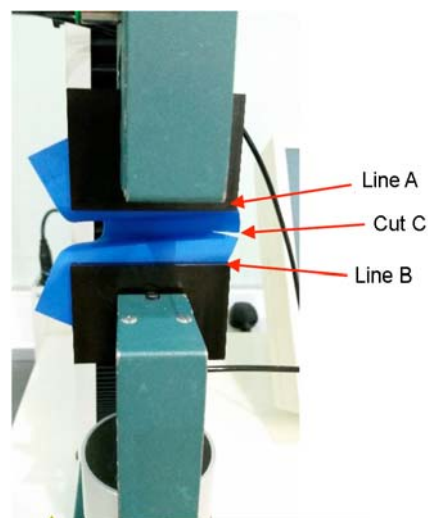


FIG. 3 Positioning Specimen in Clamps

edge of the bottom clamps face. Fold the excess fabric between the upper and lower clamps, ensuring cut C is halfway between the clamps (see Fig. 3).

10.2.1 For wet testing, remove a specimen from the water, and immediately mount it on the testing machine in the normal setup. Perform the test within 2 min after removal of the specimen from the water. If more than 2 min elapse between taking the wet specimen from the water bath and starting the tension testing machine, discard the specimen and take another.

10.3 Start the machine and record the tearing force on the recording device. After a nominal take-up load of 0.5 N (0.1 lbf) has been reached, start recording the tearing force (see Note 4). The tearing force may increase to a simple maximum value or may show several maxima and minima, as shown in Fig. 4.

10.4 Stop the crosshead motion after a total tear of approximately 75 mm (3 in.) or the fabric has torn completely, and return the crosshead to its starting position.

10.4.1 If a fabric slips from the clamps or if 25 % or more of the specimens break at a point within 5 mm (0.25 in.) of the edge of the clamps constituting an invalid test, then to prevent or reduce these problems the fabric may be coated under the clamps face area, if necessary, or the clamps face may be modified such as being serrated or interlocking profile. If any of these modifications are used, state the method of modification in the report.

NOTE 3—Slippage of the fabric specimen from the clamps must be prevented. However, due to dense fabric constructions, weave derivations, yarn strengths, or combinations of spun and filament yarns, individual yarn distortion (bunching) within some fabrics from the clamps may not be avoided even with the clamps modifications. In these instances the high peaks should be included in the calculation and a comment must be made in the test report stating that the steps mentioned above were taken to reduce the individual yarns from distorting/slipping from the clamps, but that despite this such yarn distortion did occur.

NOTE 4—Use of take-up force is to ensure that you get a consistent starting point for each graph, allowing for slight variations in mounting of the individual specimens that may occur. Care should be taken when mounting specimens that they are not tensioned or stressed.

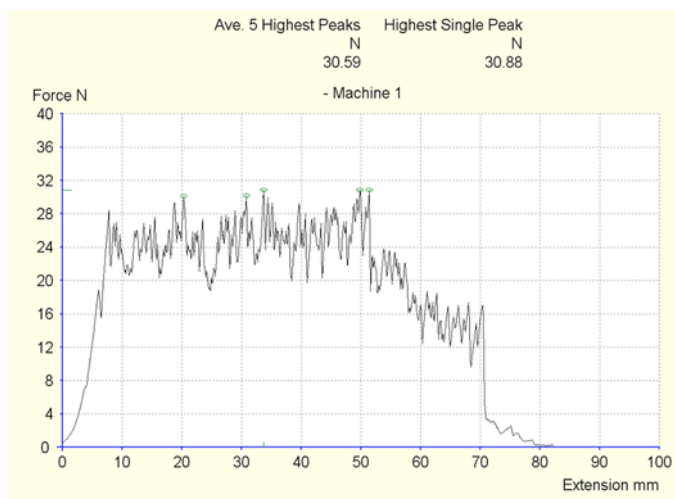


FIG. 4 Typical Trapezoid Tearing Force-Extension Curves for Individual Specimens

10.4.2 If 25 % or more of the specimens break at a point within 5 mm (0.25 in.) of the edge of the clamps after making the modifications in 10.4.1, consider the fabric untearable by this test method.

10.4.3 Record if the tear occurs crosswise to the direction of applied force.

10.5 Remove the tested specimen and continue as directed in 10.2 – 10.5 until five specimens have been tested for each principal direction from each laboratory sampling unit.

### 11. Calculation

11.1 *Tearing Force, Individual Specimens*—Calculate the trapezoid tearing force for individual specimens to the nearest 0.1 mN (0.1 lbf) using readings directly from the data collection system or autographic recorder using Option 1 or 2 as indicated by the initial peak of the tearing action of the material (this is the point at which tearing commences), unless otherwise agreed upon between the purchaser and the supplier.

11.1.1 *Option 1, Average of Five Highest Peaks:*

11.1.1.1 For fabrics exhibiting five peaks or more, after the initial peak determine the five highest peak forces to the nearest 0.1 mN (0.1 lbf).

11.1.1.2 High peaks that are the result of yarn distortion from the clamps and bunching up in the breaking field shall be included in the determination of the five highest peak forces.

11.1.1.3 Calculate the average of these five highest peak forces.

11.1.2 *Option 2, Single-Peak Force*—For fabrics exhibiting less than five peaks, record the highest peak force as the single-peak force to the nearest 0.1 mN (0.1 lbf).

11.2 *Tearing Strength*—Calculate the trapezoid tearing strength as the average tearing force for each testing direction and condition for each laboratory sampling unit and for the lot for each principal direction.

11.3 *Standard Deviation, Coefficient of Variation*—Calculate when requested.

TABLE 2 Trapezoid Tear Strength, lb, Critical Differences for the Conditions Noted<sup>A</sup>

| Materials | Number of Observations in Each Average | Single-Operator Precision | Within-Laboratory Precision | Between-Laboratory Precision |
|-----------|--|---------------------------|-----------------------------|------------------------------|
| S/1008H   | 1                                      | 7.27                      | 7.27                        | 7.27                         |
|           | 2                                      | 5.14                      | 5.14                        | 5.14                         |
|           | 5                                      | 3.25                      | 3.25                        | 3.25                         |
|           | 10                                     | 2.30                      | 2.30                        | 2.30                         |
| S/28305   | 1                                      | 27.5                      | 27.5                        | 43.9                         |
|           | 2                                      | 19.5                      | 19.5                        | 39.3                         |
|           | 5                                      | 12.3                      | 12.3                        | 35.2                         |
|           | 10                                     | 8.7                       | 8.7                         | 34.9                         |
| S/9408R   | 1                                      | 7.9                       | 7.9                         | 12.2                         |
|           | 2                                      | 5.6                       | 5.6                         | 10.9                         |
|           | 5                                      | 3.5                       | 3.5                         | 10.0                         |
|           | 10                                     | 2.5                       | 2.5                         | 9.7                          |

<sup>A</sup> The critical differences were calculated using  $t = 1.960$ , which is based on infinite degrees of freedom.

11.4 *Computer-Processed Data*—When data are automatically computer-processed, calculations are generally contained in the associated software. Record values as read from the direct-reading scale to the nearest 0.1 mN (0.1 lbf). In any event, it is recommended that computer-processed data be verified against known property values and its software described in the report.

NOTE 5—A peak suitable for calculation is characterized by a 10 % minimum raising or falling of force.

### 12. Report

12.1 Report that the trapezoid tearing strength was determined in accordance with Test Method D5587. Describe the fabric or product sampled and the method of sampling used.

12.2 Report the following information for each laboratory sampling unit and for the lot as applicable to a material specification or contract order:

12.2.1 Trapezoid tearing strength for each testing direction and condition.

12.2.2 Tear distance as described in 10.4.

12.2.3 Calculation option used, either single-peak force or average of the five highest peak forces, and whether any yarn distortion occurred in the specimens during the test.

12.2.4 Note any modifications made to the clamps per 10.4.1 (if necessary).

12.2.5 Condition of the specimens (without wetting or wet).

12.2.6 When calculated, the standard deviation or the coefficient of variation.

12.2.7 For computer-processed data, identify the program (software) used.

12.2.8 Make, model, and capacity of testing machine.

12.2.9 Type of clamps used and any modifications.

12.2.10 Any modification of this test method.

### 13. Precision and Bias<sup>5</sup>

13.1 *Summary*—In comparing two averages, the differences should not exceed the single-operator precision values shown in Table 2 for the respective number of tests and for materials

<sup>5</sup> Supporting data have been filed at ASTM International Headquarters and may be obtained by requesting Research Report RR:D13-1119.

**TABLE 3 Trapezoid Tear Strength, lb**

| Materials     | Grand Average | Components of Variance Expressed as Standard Deviations <sup>A</sup> |                             |                              |
|---------------|---------------|--|-----------------------------|------------------------------|
|               |               | Single-Operator Component  | Within-Laboratory Component | Between-Laboratory Component |
| Woven Fabrics |               |  |                             |                              |
| S/1008H       | 14.3          | 2.6  | 0.0                         | 0.0                          |
| S/28305       | 101.9         | 9.9  | 0.0                         | 12.3                         |
| S/9408R       | 34.4          | 2.8  | 0.0                         | 3.4                          |

<sup>A</sup> The square roots of the components of variance are being reported to express the variability in the appropriate units of measure rather than as the squares of those units of measure.

having averages similar to those shown in **Table 3** in 95 out of 100 cases when all the observations are taken by the same well-trained operator using the same piece of equipment and specimens randomly drawn from the sample of fabric. Larger differences are likely to occur under all other circumstances. A precision and bias has not been performed on fabrics that typically contain yarn distortion.

**13.2 Interlaboratory Test Data**—An interlaboratory test was run in 1994 through 1995 in which randomly drawn samples of three fabrics were tested in each of five laboratories. Two operators in each laboratory each tested eight specimens of each fabric using this test method. Four of the eight specimens were tested on one day and four specimens were tested on a second day. Analysis of the data was conducted using Practices **D2904** and **D2906**. The components of variance for trapezoid

tear strength expressed as standard deviations were calculated to be the values listed in **Table 3**. The three woven fabric types were:

Material 3—S/1008H, Plain Weave Sheeting, With Spun Yarns  
 Material 7—S/28305, Plain Weave, Continuous Filament Yarns  
 Material 13—S/9408R, Twill Weave

**13.3 Precision**—For the components of variance reported in **Table 3**, two averages of observed values should be considered significantly different at the 95 % probability level if the difference equals or exceeds the critical differences listed in **Table 2**. There were sufficient differences related to the fabric type and structure to warrant listing the components of variance and the critical differences separately. Consequently, no multi-fabric comparisons were made.

**NOTE 6**—The tabulated values of the critical differences should be considered to be a general statement, particularly with respect to between-laboratory precision. Before a meaningful statement can be made about two specific laboratories, the amount of statistical bias, if any, between them must be established with each comparison being based on recent data obtained on specimens taken from a lot of fabric to the type being evaluated, so as to be as nearly homogeneous as possible, and then randomly assigned in equal numbers to each of the laboratories.

**13.4 Bias**—The value of trapezoid tear strength can only be defined in terms of a test method. Within this limitation, this test method has no known bias.

## 14. Keywords

14.1 fabric; tearing strength; trapezoid

## APPENDIX

### (Nonmandatory Information)

#### X1. CONDITIONS WHEN USING CRT-TYPE TENSILE TESTERS

##### X1.1 General

**X1.1.1** The following information is provided for determining trapezoid tearing strength using the CRT-type tensile tester with this test method. See **1.1.1**.

**X1.1.2 Tensile Testing Machine**, of the constant-rate-of-traverse (CRT) pendulum type conforming to the requirements of Specification **D76** with autographic recorder or automatic microprocessor data gathering systems.

**X1.1.3** Set the testing speed to  $300 \pm 10$  mm/min ( $12 \pm 0.5$  in./min). Disengage the pawls from the ratchet to render them inoperative.

**X1.1.4** Report that the trapezoid tearing test was determined using a CRT-type tensile tester.

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