



Designation: D 1445 – 95

An American National Standard

Standard Test Method for Breaking Strength and Elongation of Cotton Fibers (Flat Bundle Method)¹

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INTRODUCTION

The flat bundle test for cotton fiber strength gained immediate acceptance after its introduction in 1953. The first successful instrument was an inclined plane device with the beam calibrated in pounds. The specimen was clamped with no space between the jaws and was called zero-gage strength. Results were expressed in Pressley Index (P.I.) calculated as the force-to-break in pounds divided by the bundle weight in mg. Obviously, P.I. is not a standard engineering unit.

Before the introduction of the flat bundle test, cotton fiber strength had been measured by the Chandler round bundle test (see former Method D 414) and the results expressed in pounds per square inch (psi). The U.S. Department of Agriculture obtained results from both instruments on specimens from the same samples of a large number of cottons. From this study, an empirical equation to express flat bundle test results in psi was

$$\text{Breaking strength, 1000 psi} = (10.81106 \times \text{P.I.}) - 0.12$$

When it was shown that a finite gauge length test was more highly correlated with yarn strength than tests made at zero gage length, the clamp design was modified to accommodate a 1/8 inch (3.2 mm) spacer. Selection of an engineering unit for reporting of results from 1/8 inch (3.2 mm) gauge tests presented a problem. However, the use of the tex for linear density and the introduction of a pendulum type instrument calibrated in kilograms led to the expression of results in grams-force per tex (gf/tex). The clamp width without spacer is 11.81 mm and with spacer is 15.00 mm. The bundle of fibers is mounted across the clamp width and trimmed to the width. The bundle mass is mg/11.81 mm or mg/15.00 mm.

The use of the flat bundle test in domestic and international commerce has had a long and successful history. Correcting this error in the empirical relationship would have serious adverse affects in the textile industry. Therefore, the empirical relationship is retained to calculate zero gage cotton fiber tensile strength designated as the Pressley strength in Eq 3 and 4 of D 1445.

1. Scope

1.1 This test method covers the determination of (1) the tensile strength or breaking tenacity of cotton fibers as a flat bundle using a nominal zero gage length, or (2) the tensile strength or breaking tenacity and the elongation at the breaking load of cotton fibers as a flat bundle with 1/8-in. (3.2-mm) clamp spacing. This test method is applicable to loose fibers of untreated cottons whether taken before processing or obtained from a textile product.

1.2 This test method is designed primarily for use with special fiber bundle clamps and special strength testing instruments but may be used with other tensile strength and elongation testing machines when equipped with appropriate adapters to accommodate the fiber clamps.

NOTE 1—Other methods for measuring the breaking tenacity of fiber bundles include Test Method D 1294, Test for Breaking Strength of Wool Fiber Bundles—1 in gage Length;² Test Methods D 4604, Measurement of Cotton Fibers by High Volume Instruments (HVI) (Motion Control Fiber Information System); Test Methods D 4605, Measurement of Cotton Fibers by High Volume Instruments (HVI) (Spinlab System of Zellweger Uster, Inc.).

¹ This method is under the jurisdiction of ASTM Committee D13 on Textiles, and is the direct responsibility of Subcommittee D13.11 on Cotton Fibers.

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² Annual Book of ASTM Standards, Vol 07.01.



1.3 The values stated in either acceptable metric units or in other units shall be regarded separately as standard. The values expressed in each system may not be exact equivalents; therefore, each system must be used independently of each other, without combining values in any way.

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 and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 ASTM Standards:

- D 123 Terminology Relating to Textiles²
- D 1294 Test Method for Tensile Strength and Breaking Tenacity of Wool Fiber Bundles 1-in. (25.4-mm) Gage Length²
- D 1441 Practice for Sampling Cotton Fibers for Testing²
- D 1447 Test Method for Length and Length Uniformity of Cotton Fibers by Fibrograph Measurement²
- D 1776 Practice for Conditioning Textiles for Testing²
- D 3025 Practice for Standardizing Cotton Fiber Test Results by Use of Calibration Cotton Standards²
- D 4604 Test Methods for Measurement of Cotton Fibers by High Volume Instruments (HVI) (Motion Control Fiber Information System)³
- D 4605 Test Methods for Measurement of Cotton Fibers by High Volume Instruments (HVI) (Spinlab System of Zellweger Uster, Inc.)³

3. Terminology

3.1 Definitions:

3.1.1 *breaking load, n*—the maximum force applied to a specimen in a tensile test carried to rupture.

3.1.2 *breaking tenacity, n*—the maximum resistance per unit size of material to deformation in a tensile test carried to rupture; that is, the breaking load, or force, per unit linear density of the unstrained specimen. (See also breaking strength.)

3.1.3 *cotton, n*—a vegetable seed fiber consisting of unicellular hairs attached to the seed of several species of the genus *Gossypium* of the family Malvaceae. (Also see Table 4 in Annex 2 of D 123.)

3.1.4 *elongation at breaking load, n*—in fiber strength testing of cotton, the elongation corresponding to the maximum load, and expressed as a percentage of the $\frac{1}{8}$ " (3.2-mm) gage length.

3.1.5 *tenacity, n*—in a tensile test, the force exerted on the specimen based on the linear density of the unstrained material.

3.1.5.1 *Discussion*—In textiles, tenacity is considered a property of fibers and yarns, and tensile strain is the complementary property of fabrics. In direct yarn numbering systems,

tenacity is force divided by linear density. In indirect yarn numbering systems, tenacity is force times the reciprocal linear density.

3.1.6 *tensile strength, n*—the maximum resistance of material to deformation in a tensile test carried to rupture; that is, the breaking load, or force per unit cross-sectional area of the unstrained specimen.

3.2 For definitions of other textile terms used in this test method, refer to Terminology D 123.

4. Summary of Test Method

4.1 A bundle of fibers is combed parallel, secured in clamps, cut to a known length, broken in the tensile testing machine, and weighed. Tensile strength or breaking tenacity is calculated from the ratio of breaking load to bundle mass (weight).

4.2 Elongation at the breaking load may be determined on the specimens tested for breaking strength with $\frac{1}{4}$ -in. (3.2-mm) clamp spacing. The elongation is normally calculated as a percentage of the nominal gage length.

5. Significance and Use

5.1 When the level of results in the laboratory the purchaser and the supplier are both controlled by use of calibration cottons, Test Method D 1445 for the determination of the tensile strength and elongation is considered satisfactory for acceptance testing of commercial shipments of cotton and has been used extensively in trade for acceptance testing.

5.1.1 *Discussion*—Tenacity is commonly expressed as millinewtons per tex (mN/tex), grams-force per denier (gf/den) or pounds-force per denier (lbf/den). Tenacity in millinewtons/tex is numerically equal to tenacity in grams-force/tex times 9.81.

5.1.2 In case of a dispute arising from differences in reported test results when using Test Method D 1445 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. The 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 Student's *t*-test for unpaired data and an acceptable probability level chosen by the two parties before the 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 the light of the known bias.

5.2 This test method is useful in research studies to determine the influence of variety, environment, and processing on fiber strength and elongation; and in studies of the relationships between these fiber properties, processing performance, and quality of end-product.

³ Annual Book of ASTM Standards, Vol 07.02.



5.3 Values obtained for flat bundle tenacity and elongation show a high correlation with values measured on single fibers and require much less time and skill.

5.4 Studies have shown that strength measurements obtained with different types of instruments are highly correlated, but the results are on different levels.⁴

5.5 By use of correction factors calculated from tests made on standard calibration samples of known or established test values, the results obtained with different types of instruments at a specified gage length can be adjusted to comparable levels. Due to differences in cottons, strength test results for one gage length cannot be reliably estimated from tests made at a different gage length.

6. Apparatus and Materials

6.1 *Tensile Testing Machine*—Either of two commercially available fiber bundle tensile testing machines, one of the pendulum and one of the inclined-plane type, described in Appendix X1, or other machine from which comparable results can be obtained.

6.2 Laboratory Balance:

6.2.1 *Balance*, having a capacity of 3 or 5 mg and a sensitivity of ± 0.01 mg for the zero gage length test.

6.2.2 *Balance*, having a capacity of 5 or 10 mg and a sensitivity of 0.01 mg for $\frac{1}{8}$ -in. (3.2-mm) gage length test.

6.3 Ancillary equipment from the instrument manufacturers.

6.3.1 *Clamp Vise* (Pressley type or Stelometer type), with a device to indicate approximately 8 lbf·in. (9 kgf·cm) torque.

6.3.2 *Fiber Clamps*, having a total thickness of 0.465 ± 0.001 in. (11.81 ± 0.02 mm).

6.3.3 *Spacer*, having a thickness of 0.125 ± 0.001 in. (3.2 ± 0.02 mm).

6.3.4 *Clamp Wrench* or Torque Wrench.

6.3.5 *Coarse Comb*, approximately 8 teeth/in. (3 teeth/cm), or Fibrograph comb.

6.3.6 *Fine Comb*, approximately 52 teeth/in. (20 teeth/cm).

6.3.7 *Black Paper*, to hold bundles.

6.3.8 *Shearing Knife*.

6.3.9 *Tweezers*.

6.3.10 *Standard Calibration Cotton*, having specified fiber strength.⁵

6.3.11 *Fiber Clips or Sample Clips*.

7. Sampling

7.1 Take the lot sample and laboratory sample as directed in Practice D 1441.

8. Preparation, Calibration, and Verification of Apparatus

8.1 *Tensile Testing Instrument*—Before making fiber strength tests, check the instrument and clamp vise for mechanical adjustment as directed for the specific instrument in Appendix X1, or in accordance with the manufacturer's instructions.

8.2 *Laboratory Balance*—Check the zero setting of the laboratory balance and make sure its sensitivity is within the range to be used.

8.3 *Clamp Leathers*—Inspect the leathers in the clamps frequently to ensure that they are in good condition. Keep the inner edges of the leathers trimmed flush with the metal surface and replace the leathers as soon as grooves become evident.

9. Conditioning

9.1 Bring the laboratory sample from the dry side to moisture equilibrium for testing in the standard atmosphere for testing textiles. See Practice D 1776.

NOTE 2—Cotton is normally received in the laboratory in a relatively "dry" condition, making special preconditioning procedures unnecessary. Samples that are obviously damp should be preconditioned before being brought into the laboratory for conditioning.

9.2 Tufts prepared from the laboratory sample must be conditioned as required for the laboratory sample described in 9.1.

10. Preparation of Specimens

10.1 Make the test specimens (flat bundles) from small subsamples (tufts or Fibrograph beards) which have been prepared from the laboratory sample as directed in 10.1.1 or 10.1.2.

10.1.1 Prepare a tuft of fibers either (1) by taking two small pinches at random from the unblended laboratory sample and placing them one on top of the other near their mid-points, or (2) by taking a section from a blended laboratory sample. Hold the tuft between the thumb and forefinger and comb with the coarse comb to remove foreign matter and short fiber. When one end of the tuft has been combed, reverse the tuft and comb the other end, taking care that the middle portion of the tuft is well combed. Approximately 10 strokes are necessary for combing each end of the tuft. Prepare two to six tufts, each weighing 60 to 80 mg, from each sample to be tested. Before testing, condition the tufts as directed in Section 9.

10.1.2 Prepare a Fibrograph beard as directed in Test Method D 1447. Prepare two to six Fibrograph beards for each sample to be tested.

10.2 Test a specimen from each tuft or Fibrograph beard, depending on the precision desired, and if possible, have two technicians participate with each one testing one half the number of specimens.

10.3 Prepare the specimen as directed in either 10.3.1 or 10.3.2.

10.3.1 Grasp the prepared tuft near the midpoint between the center and the end of the tuft, and pull out a portion of the fibers to form a specimen. Hold the specimen firmly by one end and pull the fibers through the fine comb on the vise two or three times to remove loose fibers, neps, and trash. Comb the

⁴ Burley, Jr., S. T., and Carpenter, F. "Evaluation of Results Obtained on Available Types of Fiber Strength Testers Using Various Gauge Spacings and Their Relation to Yarn Strength," AMS-71, U. S. Dept. of Agriculture (Sept. 1955).

⁵ International Calibration Cotton Standards with values for the inclined-plane type testing machine for the zero gage tests and USDA Calibration Cotton Standards with values for both the inclined-plane and pendulum-type testing machines for the zero gage and the $\frac{1}{8}$ -in. (3.2-mm) gage tests are available from the Cotton Division, Agricultural Marketing Service, U.S. Department of Agriculture, 4841 Summer Ave., Memphis, TN 35122.