



# Standard Test Method for Stretch Properties of Knitted Fabrics Having Low Power<sup>1</sup>

This standard is issued under the fixed designation D 2594; 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 fabric stretch and fabric growth of knitted fabrics intended for applications requiring low-power stretch properties.

1.2 This test method includes procedures for fabric growth and stretch and can be used individually when required by individual specifications.

1.3 This test method is not applicable to fabrics intended for support or other applications requiring high-power stretch properties.

NOTE 1—For information on testing high-power and woven stretch fabrics, refer to Test Methods [D 3107](#) and [D 6614](#).

1.4 The values stated in either SI or inch-pound units are to be regarded separately as the standard. Within the text, the inch-pound units are shown in parentheses. The values stated in each system are not exact equivalents; therefore, each system shall be used independently of the other. Combining values from the two systems may result in nonconformance with the specification.

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:*<sup>2</sup>

[D 123](#) Terminology Relating to Textiles

[D 1776](#) Practice for Conditioning and Testing Textiles

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

[D 2906](#) Practice for Statements on Precision and Bias for Textiles

[D 3107](#) Test Methods for Stretch Properties of Fabrics Woven from Stretch Yarns

[D 4849](#) Terminology Relating to Yarns and Fibers

[D 4850](#) Terminology Relating to Fabric

[D 6614](#) Test Method for Stretch Properties of Textile Fabrics-CRE Method

## 3. Terminology

3.1 *Definitions:*

3.1.1 For definition of textile terms used in this test method: bench marks, refer to Terminology [D 4849](#).

3.1.2 For definitions of textile terms used in this test method: fabric growth; fabric stretch; low-power stretch and tension, refer to Terminology [D 4850](#).

3.1.3 For definitions of other textile terms used in this test method, refer to Terminology [D 123](#).

## 4. Summary of Test Method

4.1 *Fabric Growth*—Bench marks of a known distance are made on a fabric specimen. A specified tension is applied to a fabric specimen by a prescribed cycling technique. The tension is removed and after several specific recovery times under zero tension, the distance between the bench marks is remeasured after each time interval. The fabric growth is calculated from the length difference between the bench marks prior to application of the tension and after each respective recovery time interval.

4.2 *Fabric Stretch*—Bench marks of a known distance are made on a fabric specimen. A specified tension is applied to a fabric specimen by a prescribed cycling technique and the resulting distance between the bench marks measured. The fabric stretch is calculated from the length difference between the bench marks prior to application of the tension and under while under the tension.

## 5. Significance and Use

5.1 This test method specifies test conditions for measuring the fabric growth and fabric stretch of knitted fabrics intended for use in swimwear, anchored slacks, and other form-fitting apparel (also commonly known as semi-support apparel) applications, as well as test conditions for measuring the fabric growth of knitted fabrics intended for use in sportswear and other loose-fitting apparel (also commonly known as comfort stretch apparel) applications. The applicability of this test

<sup>1</sup> This test method is under the jurisdiction of ASTM Committee D13 on Textiles and is the direct responsibility of Subcommittee D13.59 on Fabric Test Methods, General.

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<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.

method to the measurement of fabric growth and fabric stretch of knitted fabrics intended for use in slacks, sport coats, and suits has not been determined.

5.2 This test method is not recommended for acceptance testing of commercial shipment because the between-laboratory precision is known to be poor.

5.2.1 If there are differences of practical significance between reported test results for two laboratories (or more), comparative tests should be performed to determine if there is a statistical bias between them, using competent statistical assistance. As a minimum, ensure the test samples to be used are as homogeneous as possible, are drawn from the material from which the disparate test results are obtained, and are assigned randomly in equal numbers to each laboratory for testing. The test results from the two laboratories should be compared using a statistical test for unpaired data, at a probability level chosen prior to the testing series. If a 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.

**6. Apparatus**

6.1 *Frame*<sup>3</sup>, suitable for supporting the hanger assembly illustrated in Fig. 1 and tension forces applied during testing.

6.2 *Hanger Assembly*<sup>3</sup>, consisting of hangers, hanger rods, and chain.

6.3 *Lightweight Rule*<sup>3</sup>, fitted with a pin hook at the zero point of the scale for attachment to the specimen, graduated either in units of percent of original gage length of 125 mm (5 in.) or in units of 1 mm (1/16 in.).

6.4 *Tensiometer or Weights*<sup>3</sup>, that can be attached to the bottom hanger of the hanger assembly, capable of providing total tensions of 2.27 kgf (5 lbf) and 4.54 kgf (10 lbf) to the specimen, ± 1 %.

6.5 *Turnbuckle*<sup>3</sup>, or equivalent, having a length of 25 to 75 mm (1 to 3 in.).

6.6 *Sanforized Marker*, to establish bench marks on the specimen.

6.7 *Timer*, with increments of at least 1 min.

**7. Sampling and Test Specs**

7.1 *Primary Sampling Unit*—Consider rolls of fabric or fabric components of fabricated systems to be the primary sampling unit, as applicable.

7.2 *Laboratory Sampling Unit*—As a laboratory sampling unit take from rolls at least one full-width piece of fabric that is 2 m (2 yd) in length along the selvage (machine direction), after removing a first 1 mm (1 yd) length. For fabric components of fabricated systems use the entire system.

7.3 *Test Specimens*—From each laboratory sampling unit, cut 5 wale-wise (lengthwise) and 5 course-wise (widthwise) test specimens 125 ± 3 mm (5 ± 0.1 in.) by 500 ± 10 mm (15.5 ± 0.3 in.). Cut the long dimension of the wale-wise specimens parallel to the wale direction and the course-wise specimens parallel to the course direction. Take specimens representing a broad distribution from different positions diagonally across the width of the laboratory sampling unit. Consider the long direction as the direction of test. Label to maintain specimen identity.

7.3.1 For fabric widths 125 mm (5 in.) or more, take no specimen closer than 25 mm (1 in.) from the edges of the laboratory sampling unit.

7.3.2 For fabric widths less than 125 mm (5 in.), use the entire width of the laboratory sampling unit for specimens.

7.3.3 Ensure specimens are free of folds, creases, or wrinkles. Avoid getting oil, water, grease, etc., on the specimens when handling.

7.3.4 If the fabric has a pattern, ensure that the specimens are a representative sampling of the pattern.

7.3.5 After cutting, fold each specimen in half lengthwise forming a loop and sew the edges opposite the fold together 6 to 13 mm (0.25 to 0.50 in.) from the cut edges and parallel to the short direction of the specimen.

7.3.6 Lay the specimen on a flat surface and place bench marks 125 ± 3 mm (5 ± 0.01 in.) apart on the central section of one face of the looped specimen establishing a gage length along the length of the specimen. Record as measurement (A).

**8. Conditioning**

8.1 Bring the test specimens to moisture equilibrium for testing in the standard atmosphere for testing textiles as

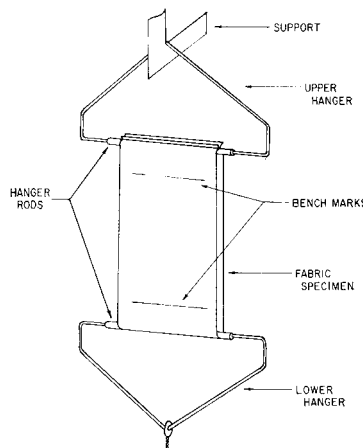


FIG. 1 Hanger Assembly

<sup>3</sup> This equipment is available commercially.

directed in Practice **D 1776**, or if applicable, in the specified atmosphere in which the testing is to be performed.

## 9. Preparation of Test Apparatus and Calibration

9.1 Verify measuring scales and tension weights are within calibration.

## 10. Procedure

10.1 Test the test specimens in the standard atmosphere for testing textiles, as described in Practice **D 1776**.

10.2 Handle the test specimens carefully to avoid altering the natural state of the material.

### 10.3 Fabric Growth:

10.3.1 Slide the specimen loop over the upper hanger rod and secure the rod in the hanger such that the seam of the loop lies along the rod.

10.3.2 Slide the folded end of the loop over the lower hanger rod and secure the rod to the hanger.

10.3.3 Place the upper hanger in the slot in the top bar of the supporting frame.

10.3.4 Attach the rule to the specimen loop by inserting the rule pin hook through the face of the fabric in the center of the upper bench mark.

10.3.5 Attach the chain by means of the turnbuckle to the lower hanger and extend the specimen loop to the amount specified in **Table 1**, that is, such that the lower bench marks line up with the specified percentage stretch point on the scale.

NOTE 2—If the scale is in units of measurement, it is helpful to calculate the corresponding percentage.

10.3.6 Lock the chain in the corresponding notch in the lower crossmember of the frame. Adjust the turnbuckle to make minor adjustments of the position of the lower bench mark.

10.3.7 Allow the loop to remain in the extended position for  $2\text{ h} \pm 5\text{ min}$ .

10.3.8 After  $2\text{ h} \pm 5\text{ min}$ , unlock and release the chain and remove the lower hanger from the specimen loop.

10.3.9 Measure the position of the lower bench mark relative to the scale on the rule to the nearest 1 % of original gage length or 1 mm ( $1/16\text{ in.}$ ) after recovery under no tension as follows:

10.3.9.1 After  $60 \pm 5\text{ s}$  and record as measurement (B), and

10.3.9.2 After  $1\text{ h} \pm 5\text{ min}$  record as measurement (C).

10.3.10 Remove the tested specimens, in turn, and continue as directed in **10.3** until three specimens for each the wale and course directions have been tested for each laboratory sampling unit.

### 10.4 Fabric Stretch:

10.4.1 Place a new specimen in the stretch testing equipment as directed in **10.3.1-10.3.4**.

10.4.2 Attach the tensiometer to the lower hanger, grasp and manually exercise the specimen loop by cycling four times

between 0 to 2.27 kgf (0 to 5 lbf) for loose-fitting (comfort stretch) apparel fabrics, or between 0 and 4.54 kgf (0 and 10 lbf) for form-fitting (semi-support) apparel fabrics allowing 4 to 6 s to complete each cycle.

10.4.2.1 Weights that provide the same tension can be used in place of the tensiometer.

NOTE 3—The choice of the cycling force should be based on the intended end use of the fabric being tested. If the intended end use is not known, the fabric growth and fabric stretch may be determined using both the loose-fitting and the form-fitting apparel test conditions.

10.4.3 Continue and begin a fifth cycle holding the tensiometer at the specified tension force for 5 to 10 s, then measure the position of the lower bench mark relative to the scale on the rule to the nearest 1 % of original gage length or 1 mm ( $1/16\text{ in.}$ ) while under tension. Record as measurement (D).

10.4.4 Remove the tested specimens, in turn, and continue as directed in **10.4** until two specimens for each the wale and course directions have been tested for each laboratory sampling unit.

## 11. Calculation

11.1 If the scale is graduated in percent of original gage length, read the percent fabric growth and fabric stretch directly from the scale to the nearest 1 %, otherwise, use the calculations in **11.1.1**.

11.1.1 Calculate the fabric growth and fabric stretch properties of individual specimens to the nearest 1 % using Eq **1-3**, as applicable.

$$\text{Fabric Growth}_{60\text{s}}, \% = 100 \times (B-A)/A \quad (1)$$

$$\text{Fabric Growth}_{1\text{h}}, \% = 100 \times (C-A)/A \quad (2)$$

$$\text{Fabric Stretch}, \% = 100 \times (D-A)/A \quad (3)$$

where:

A = original distance between bench marks prior to tension force, mm (in.) (from **7.3.6**),

B = distance between bench marks, mm (in.) measured after release of the tension, force following 60 s recovery, (from **10.3.9.1**),

C = distance between bench marks, mm (in.) measured after release of the tension, force following 1 h recovery, (from **10.3.9.2**), and

D = distance between bench marks, mm (in.) measured while specimen is under tension force (from **10.4.3**).

11.2 Calculate the average of three specimens to the nearest 1 % for the fabric growth calculated in **11.1** for the laboratory sampling unit and for the lot, as applicable.

11.3 Calculate the average of two specimens to the nearest 1 % for the fabric stretch calculated in **11.1** for the laboratory sampling unit and for the lot, as applicable.

## 12. Report

12.1 Report that the fabric growth and fabric stretch were determined as directed in Test Method **D 2594**. Describe the material or product sampled and the method of sampling used.

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

**TABLE 1 Specimen Stretch Percentage Points**

Apparel Type	Wale Direction	Course Direction
Loose-fitting (comfort stretch)	15	30
Form-fitting (semi-support)	35	60

12.2.1 Individual and average fabric growth after 60 s recovery.

12.2.2 Individual and average fabric growth after 2 h recovery.

12.2.3 Individual and average fabric stretch.

12.2.4 Original distance between bench marks.

12.2.5 Percent extension used for fabric growth.

12.2.6 Tension used for fabric stretch.

**13. Precision and Bias**

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 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 material. Larger differences likely are to occur under all other circumstances.

13.2 *Interlaboratory Test Data*<sup>4</sup>—An interlaboratory test was run in 1966–1967, in which randomly-drawn samples of six materials were tested in each of six laboratories. Each laboratory tested three specimens for fabric growth and two specimens for fabric stretch on each material in both the wale and course direction using Test Method D 2594. The precision statement is based upon a testing plan described in Practices **D 2904** and **D 2906**. The components of variance expressed as coefficients of variation were calculated to be the values listed in **Table 2**.

<sup>4</sup> Data from the interlaboratory test can be inspected at the Textile Research Laboratory, E. I. Dupont de Nemours and Co. Inc., Chestnut Run, Wilmington, DE 19880.

**TABLE 2 Components of Variance as Standard Deviations, Percentage Points<sup>A</sup>**

Properties	Components of Variance as Standard Deviations, Percentage Points		
	Repeatability		Reproducibility Between Laboratory Component
	Single- Operator Component	Within- Laboratory Component	
Fabric growth at both 60 s and 1 h			
Wale	—	1	2
Course	—	1	3
Fabric stretch			
Wale	—	3	4
Course	—	4	7

<sup>A</sup>Conditions of single-operator precision.

13.3 *Precision*—For the components of variance reported in **Table 2**, 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 3**.

NOTE 4—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 material 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 procedure of this test method produces a test value that can be defined only in terms of a test method. There is no independent, referee method by which bias may be determined. This test method has no known bias.

**14. Keywords**

14.1 elastomeric; fabric growth; fabric stretch; knitted fabric; low-power stretch

**TABLE 3 Critical Differences, Percentage Points for the Conditions Noted**

Properties	Number of Observations in Each Average	Critical Differences, Percentage Points for the Conditions Noted <sup>A,B</sup>		
		Repeatability		Reproducibility Between- Laboratory Precision
		Single- Operator Precision	Within- Laboratory Precision <sup>B</sup>	
Fabric growth at both 60 s and 1 h				
Wale	1	—	2.8	7.8
	5	—	1.3	7.4
	10	—	0.9	7.3
Course	1	—	2.8	11.3
	5	—	1.3	11.0
	10	—	0.9	10.9
Fabric stretch				
Wale	1	—	8.6	16.9
	5	—	3.9	15.0
	10	—	2.7	14.8
Course	1	—	11.5	27.9
	5	—	5.1	26.0
	10	—	3.6	25.7

<sup>A</sup>The critical differences for **Table 3** were calculated using  $t = 2.00$ , for the within-laboratory component for fabric growth, a value of  $t = 2.03$  for the within-laboratory component for fabric stretch, and value of  $t = 2.57$  for the between laboratory components. These values of  $t$  are based on the actual df (72, 36, and 5 respectively) observed in the development of the components of variance, in place of the value  $t = 1.960$  associated with infinite df.

<sup>B</sup>Conditions of single-operator precision.

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