# 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 stretch fabrics, refer to Test Method D 1775.

- 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:
- D 123 Terminology Relating to Textiles<sup>2</sup>
- D 1775 Test Method for Tension and Elongation of Wide Elastic Fabrics<sup>2</sup>
- D 1776 Practice for Conditioning and Testing Textiles<sup>2</sup>
- D 2904 Practice for Interlaboratory Testing of a Textile Test Method That Produces Normally Distributed Data<sup>2</sup>
- D 2906 Practice for Statements on Precision and Bias for Textiles<sup>2</sup>
- D 4848 Terminology of Force, Deformation, and Related Properties of Textiles<sup>3</sup>
- <sup>1</sup> This test method is under the jurisdiction of ASTM Committee D-13 on Textiles and is the direct responsibility of Subcommittee D13.59 on Fabric Test Methods, General.
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  - <sup>2</sup> Annual Book of ASTM Standards, Vol 07.01.
  - <sup>3</sup> Annual Book of ASTM Standards, Vol 07.02.

## 3. Terminology

- 3.1 Definitions:
- 3.1.1 *bench marks*, *n*—marks placed on a specimen to define gage length, that is, the portion of the specimen that will be evaluated in a specific test.
- 3.1.2 *fabric stretch*, *n*—the increase in length of a specimen of fabric resulting from a tension force applied under specified conditions.
- 3.1.2.1 *Discussion*—The difference usually is expressed as a percentage of the initial length of the fabric specimen. Fabric stretch differs from fabric elongation in that the latter (up to the point of rupture) reflects the instantaneously existing amount of stretch under a constantly increasing tension force.
- 3.1.3 fabric growth, n—the difference between the original length of a specimen and its length after the application of a specified tension for a prescribed time and the subsequent removal of the tension.
- 3.1.3.1 *Discussion*—Fabric growth usually is expressed as a percentage of the length of the specimen prior to application of the tension (see also *permanent deformation*).
- 3.1.4 *low-power stretch*, *n*—that property of a fabric whereby it exhibits high fabric stretch and good recovery from low tension.
- $3.1.5 \ tension$ , n—a uniaxial force tending to cause the extension of a body or the balancing force within that body resisting the extension
- 3.1.6 For definitions of other textile terms used in this test method, refer to Terminologies D 123 and D 4848.

#### 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 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 or practical significance between reported test results for two laboratories (or more), comparative tests should be performed to determine if their is a statistical bias between them, using competent statistical assistance. As a minimum, the test samples should be used that are as homogeneous as possible, that are drawn from the material from which the disparate test results are obtained, and that are assigned randomly in equal numbers to each laboratory for testing. Other materials with established test values may be used for this purpose. 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 must be adjusted in consideration of the known bias.

# 6. Apparatus

- 6.1 Frame<sup>4</sup>, suitable for supporting the hanger assembly illustrated in Fig. 1 and tension forces applied during testing.
- 6.2 Hanger Assembly<sup>4</sup>, consisting of hangers, hanger rods, and chain.

- 6.3 Lightweight Rule<sup>4</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 ( $\frac{1}{16}$  in.).
- 6.4 Tensiometer or Weights<sup>4</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,  $\pm$  1 %.
- 6.5 Turnbuckle<sup>4</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  $125 \pm 3$  mm ( $5 \pm 0.1$  in.) by  $500 \pm 10$  mm ( $15.5 \pm 0.3$  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  $125~\mathrm{mm}$  (5 in.) or more, take no specimen closer than  $25~\mathrm{mm}$  (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.

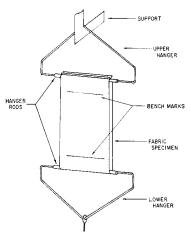


FIG. 1 Hanger Assembly

<sup>&</sup>lt;sup>4</sup> This equipment is available commercially.



- 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  $125 \pm 3$  mm ( $5 \pm 0.01$  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 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 lines 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 h  $\pm$  5 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

**TABLE 1 Specimen Stretch Percentage Points** 

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

- gage length or 1 mm (1/16 in.) after recovery under no tension as follows:
  - 10.3.9.1 After  $60 \pm 5$  s and record as measurement (B), and
- 10.3.9.2 After 1 h  $\pm$  5 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 ( $\frac{1}{16}$ 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.

Fabric Growth<sub>60s</sub>, 
$$\% = 100 \times (B-A)/A$$
 (1)

Fabric Growth<sub>1 h</sub>, 
$$\% = 100 \times (C-A)/A$$
 (2)

Fabric Stretch, 
$$\% = 100 \times (D-A)/A$$
 (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.
- 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>5</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

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

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Properties	Components of Variance as Standard Deviations, Percentage Points					
	Repea	Reproducibility				
	Single-	Within-	Between			
	Operator	Laboratory	Laboratory			
	Component	Component	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>&</sup>lt;sup>A</sup>Conditions of single-operator precision.

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.

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 elastermeric; fabric growth; fabric stretch; knitted fabric; low-power stretch

TABLE 3 Critical Differences, Percentage Points for the Conditions Noted

Conditions Noted						
Properties	Number of Observations	Critical Differences, Percentage Points for the Conditions Noted <sup>A,B</sup>				
	in Each Average	Repeatability		Reproducibility		
	, wordgo	Single- Operator Precision	Within- Laboratory Precision <sup>B</sup>	Between- Laboratory Precision		
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>&</sup>lt;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>&</sup>lt;sup>5</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.

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



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