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Designation: D 3107 – 03

An American National Standard

Standard Test Methods for Stretch Properties of Fabrics Woven from Stretch Yarns[1]

This standard is issued under the fixed designation D 3107; 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 determination of the amount of fabric stretch, fabric growth, and fabric ~~g~~ recovery of fabrics woven in whole or in part from stretch yarns after a specified tension and extension.

1.2 This test method is intended for use with woven fabrics exhibiting high stretch (greater than 12 percent) and good recovery properties from low tension (up to 360 g/cm or 2 lb/in. of fabric width). When agreed upon, this test method can be used for fabrics woven in whole or in part from non-stretch yarns that exhibit limits within the stretch ~~yarns.~~

[1] This test is under the jurisdiction of ASTM Committee D13 on Textiles, and is the direct responsibility of Subcommittee D13.59 on Fabric Test Methods, General. Current edition approved Feb. 10, 2003.Published April 2003. Originally approved in 1975 as D 3107–75. Discontinued September 1999 and reinstated as D 3107–03. Last previous edition approved in 1980 as D 3107–75–(1980)

~~Formerly under~~ characteristics shown above.

1.3 This test method allows the ~~jurisdiction~~ use of ~~ASTM Committee D-13 Textiles, this~~ two tension options commonly used in the textile industry; 1.35 kg (3 lb.) and 1.8 kg (4 lb). Several calculations are included for fabric stretch, fabric growth and fabric recovery, and can be used individually when required by individual specifications.

1.4 This test method ~~was discontinued~~ should not be used to measure breaking elongation of woven fabrics which is covered in Test Method D 5035.

1.5 The values stated in either SI units 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.

1.6 *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.*

2. Referenced Documents

2.1 *ASTM Standards:*

D 123 Terminology Relating to Textiles[2]
D 1776 Practice for Conditioning and Testing Textiles[2]
D 2904 Practice for Interlaboratory testing of a Textile Test Method that Produces Normally Distributed Data[2]
D 2906 Practice for Statements on Precision and Bias for Textiles[2]
D 4848 Terminology for Force, Deformation and Related Properties of Textiles[3]
D 4849 Terminology for Fibers and Yarns[3]
D 4850 Terminology Relating to Fabric[3]
D 5035 Test Method for Breaking Force and Elongation of Textile Fabrics (Strip Method)

3. Terminology

3.1 *Definitions*:

3.1.1 For definitions of textile terms used in this method, refer to D 4850 for: bench marks, fabric stretch, and fabric growth; for definition of the textile term: tension, refer to Terminology D 4848; for definition of the textile term: stretch yarn, refer to Terminology D 4849.

3.1.2 For definitions of other textile terms, refer to Terminology D 123.

4. Summary of Test Method

4.1 *Fabric Stretch under a Specified Tension*—Bench marks of a known distance are made on a fabric specimen. A specified tension is applied to a fabric specimen by a prescribed technique and the resulting distance between bench marks while the

specimen is under the tension is measured. The fabric stretch is calculated from the length difference between bench marks prior to application of the tension and while under the tension.

4.2 *Fabric Growth after a Specified Tension*—Bench marks of a known distance are made on a fabric specimen. A specified tension is applied to a fabric specimen by a prescribed technique. The tension is removed and after various time intervals, the relaxed distance between the bench marks is remeasured. The fabric growth is calculated from the length difference between the bench marks prior to application of the tension and after relaxation.

4.3 *Fabric Growth after Stretching to a Specified Extension*—Bench marks of a known distance are made on a fabric specimen. A specimen, paired to one used in the fabric stretch test, is held at a specified extension for a prescribed period of time. The tension is then removed from the specimen and the distance between the bench marks is measured after the specimen has been allowed to relax for various time intervals. The fabric growth at each time interval is calculated from the distance between the bench marks of the specimen prior to stretching and the length after each relaxation period at zero tension.

4.4 *Fabric Recovery*—fabric recovery is calculated as the percentage of the fabric growth recovered with respect to the fabric growth determined after tension and/or after a specified extension obtained at the various relaxation intervals.

5. Significance and Use

5.1 This test method is used to determine the stretch, growth and recovery properties that garments made with the fabric tested may be expected to exhibit during use.

5.2 This test method is not recommended for acceptance testing of commercial shipments 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 or more laboratories, comparative tests should be performed by those laboratories to determine if there is a statistical bias between them, using competent statistical assistance. As a minimum, use test samples that are as homogeneous as possible, are drawn from the material from which the disparate test results were obtained, and are randomly assigned in ~~September 1999~~ 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 ~~accordance~~ consideration of the known bias.

5.3 Some stretch fabrics are constructed with ~~Section 10.5.3.1~~ stretch yarns in only the filling direction. Consequently, for those fabrics, only the filling direction needs to be tested.

6. Apparatus

6.1 *Stretch Testing Instrument*[4] consisting of the following:

6.1.1 *Frame or Board* with a fixed clamp at the top.

6.1.2 *Separate Clamp*, or other means of attaching a weight with a known mass to the bottom of the test specimen.

6.1.3 *Dowel Pin*, or equivalent, approximately 6 mm (¼ in.) diameter

6.1.4 *Scale*, to measure the span of bench marks on the specimen graduated either in units of percent of original gage length or 1 mm (0.5 in) ± 0.1 %.

6.1.5 *Locking Mechanism*, for the bottom clamp to maintain specimen extension.

6.2 *Tensioning Weights*, for each position, with an attached hook, when combined with the clamp described in 6.1.2 and the dowel pin described in 6.1.3 provides a total mass of 1.8 kg (4 lb) for option 1 or 1.35 kg (3 lb) for option 2, each having tolerances of (± 1 %).

6.3 Sanforized Marker or equivalent, to measure the distance between bench marks.

6.4 Timer, with increments of at least 10 s.

7. Sampling and Test Specimens

7.1 *Lot Sample*—as a lot sample for acceptance testing, take a random number of shipping units directed in a applicable material specification or other agreement between the purchaser and the supplier. Consider rolls of fabric or fabric components of fabricated systems to be the primary sampling unit, as applicable.

NOTE 1—An adequate specification or other agreement between the purchaser and the supplier requires taking into account the variability between shipping units, between packages within a shipping unit, and between specimens from a single package to provide a sampling with a meaningful producer's risk, consumer's risk, acceptable quality level and limiting quality level.

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

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

[3] *Annual Book of ASTM Standards*, Vol 7.02.

[4] Apparatus is commercially available

7.3 *Test Specimens and Preparation*— From each laboratory sampling unit, take three pairs of test specimens 65 by 560 mm (2.5 by 22 in.) with the long direction parallel to the test direction. Take specimens representing a broad distribution from different positions diagonally across the width of the laboratory sampling unit. Label to maintain specimen identity.

7.3.1 When an end -use product or garment is provided, take specimens from different areas. That is, if the product is a garment worn on the upper body, if possible, take specimens from the shoulder, shirt tail, shirt back and front, and sleeve. In some cases, the size of the specimen panels may not always allow taking 560 mm (22 in.) long specimens in the test direction.

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

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

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

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

7.3.6 Ravel the specimens to a width of 50 ± 1 mm (2.00 ± 0.05 in.) taking approximately the same number of yarns from each side of the specimen.

7.3.7 Fold one end of the specimen 32 mm (1.25 in.) and stitch a seam approximately 25 mm (1 in.) from the fold.

7.3.8 Cut a slit approximately 10 mm (⅜ in.) long in the center of the strip on the fold.

7.3.9 Lay the specimen on a smooth flat surface and allow to relax for 30 minutes.

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

10.2 Place bench marks at least 250 ± 1 mm (10 ± 0.05 in.) apart in the center of the specimen.

10.3 *Fabric Stretch after applying a Specified Tension*:

10.3.1 Select the tension option (1) 1.8 kg (4.0 lb) or (2) 1.35 kg (3 lb) as directed in a material specification or contract order. In the absence of a material specification or contract order use option 1.

10.3.2 Clamp the end of one specimen in the top clamp of the stretch tester such that the folded and sewn loop end hangs freely.

10.3.3 Measure and record the distance between the bench marks to the nearest 1 % or 1 mm (0.05 in.) and record as Distance O1 (original before tension is applied).

10.3.4 Insert a dowel pin, or equivalent, through the loop and place the tension weight hook through the slit in the fold and over the dowel pin, thereby providing the specified tension to the specimen.

10.3.5 Pre-stress the specimen slowly by cycling 3 times between 0 and the total tension specified. A complete cycle should take approximately 5 s of which the specimen is under the specified tension for approximately 3 s.

10.3.5.1 Following the third cycle, apply the specified tension for a fourth time and measure the fabric stretch as directed in 10.3.6.

10.3.6 Determine fabric stretch after specified tension as applicable to a material specification or contract order as directed in 10.3.6.1 through 10.3.6.2. Measure the distance (fabric stretch) between the bench marks to the nearest 1 % of original gage length while the fabric is under the specified tension as follows. In the absence of a material specification or contract order, use 10.3.6.2.

10.3.6.1 Immediately (within 10 s). Record as distance A.

10.3.6.2 After 30 ± 1 min Record as distance B.

10.4 *Fabric Growth after applying a Specified Tension*:

10.4.1 After following the directions in 10.3, remove the tension weight and allow to recover without tension. Determine fabric growth after specified tension as applicable to a material specification or contact order as directed in 10.4.1.1-10.4.1.5. Measure the distance between bench marks to the nearest 1 % of original gage length after the tension is removed as follows. In the absence of a material specification or contract order, use 10.4.1.2.

10.4.1.1 Immediate (within 10 s) Record as distance C.

10.4.1.2 after 30 ± 1 s Record as distance D.

10.4.1.3 after 30 ± 1 min. Record as distance E.

10.4.1.4 after 1 h ± 1 min. Record as distance F.

10.4.1.5 after 2 h ± 1 min. Record as distance G.

10.4.2 Remove the tested specimens, in turn, and continue as directed in section 10.3 and 10.4 until 3 specimens have been tested for each laboratory sampling unit.

10.5 *Fabric Growth after Stretching to a Specified Extension*:

10.5.1 Place the second specimen of the pair in the stretch testing equipment as directed in 10.3.1, then measure and record the distance between the bench marks to the nearest 1 % of original gage and record as Distance O2 (original before stretch).

10.5.2 Extend the specimen 85 % of the average fabric stretch calculated in 11.1.1, Eq 2 and hold for a period of 30 ± 1 min. Record as distance H.

10.5.3 After 30 ± 1 min, release the specimen from the bottom clamp and allow it to hang freely.

10.5.4 Determine fabric growth after extension as applicable to a material specification or contract order as directed in 10.5.4.1-10.5.4.4. Measure the distance between bench marks to the nearest 1 % of original gage length after the tension is removed as follows. In the absence of a material specification or contract order, use 10.5.4.2.

10.5.4.1 After 30 ± 1 s. Record as distance I.

10.5.4.2 After 30 ± 1 min. Record as distance J.

10.5.4.3 After 1 h ± 1 min. Record as distance K.

10.5.4.4 After 2 h ± 1 min. Record as distance L.

10.5.5 Remove the tested specimens, in turn, and continue as directed in 10.5 until 3 specimens have been tested for each laboratory sampling unit.

11. Calculation

11.1 If using a scale graduated in percent of original gage length, read the percent fabric stretch, fabric growth, and fabric recovery directly from the scale to the nearest 1 %, otherwise, use the calculations in 11.1.1 and 11.1.4, as applicable.

11.1.1 Calculate the fabric stretch after tension of individual specimens to the nearest 0.1 % using Eq 1 or Eq 2, as applicable to a material specification or contract order.

$$\text{Fabric Stretch 10 s after Tension, \%} = 100 \times (A - O1)/O1 \quad (1)$$

~~R~~

~~etch 30 min after Tension, % = 100 × (B − O1)/O1~~ (2)

$$\text{Fabric Stretch 30 min after Tension, \%} = 100 \times (B - O1)/O1 \quad (2)$$

11.1.2 Calculate the fabric growth after tension of individual specimens to the nearest 0.1 % using Eq 3, as applicable to a material specification or contract order.

$$\text{Fabric Growth after growth by tension} = 100 \times (a - 0_1)/(0_1) \quad (3)$$

Where a = Measurement C, D, E, F, G, as applicable

11.1.3 Calculate the fabric growth after 85 % extension of individual specimens to the nearest 0.1 % using Eq 4, as applicable to a material specification or contract order.

~~Fabric Growth after gASTrowth by Extension = 100 × (b − 0$_2$)/(0$_2$)~~ (4)

$$\text{Fabric Growth after growth by Extension} = 100 \times (b - 0_2)/(0_2) \quad (4)$$

Where b = M~~T~~easurement I, J, K L, as applicable

11.1.4 Calculate the fabric recovery of individual specimens to the nearest 0.1 % using Eq 5 or Eq 6, as appl~~C~~icable.

$$\text{Fabric Growth after growth by tension} = 100 \times (y - c)/(y - O_1) \quad (5)$$

where:

c = Measurement C, D, E, F, G, as applicable,

y = Measurement A or B, as applicable

~~Fabric Recovery aftteesion = 100 × (H − d)/(H − 0$_2$)~~ (6)

$$\text{Fabric Recovery after growth by extension} = 100 \times (H - d)/(H - 0_2) \quad (6)$$

Where d = Measurement I, J, K, L, as applicable

Where:

O1 = original distance between bench marks, mm (in.) prior to tension, (from 10.3.3)

O2 = original distance between bench marks, mm (in.) prior to stretch, (from 10.5.1)

A = distance between bench marks, mm (in.) measured while specimen is under tension 10 s (from 10.3.6.1)

B = distance between bench marks, mm (in.) measured while specimen is under tension 30 min (from 10.3.6.2)

C = distance between bench marks, mm (in.) measured within 10 s after release of the tension. (from 10.4.1.1)

D = distance between bench marks, mm (in.) measured after release of the tension following 30 s relaxation. (from 10.4.1.2)

E = distance between bench marks, mm (in.) measured after release of the tension following 30 min relaxation. (from 10.4.1.3)

F = distance between bench marks, mm (in.) measured after release of the tension following 1 h relaxation. (from 10.4.1.4)

G = distance between bench marks, mm (in.) measured after release of the tension following 2 h relaxation. (from 10.4.1.5)

H = distance between bench marks, mm (in.) measured after 30 minutes at 85 % of average stretch. (from 10.5.2)
I = distance between bench marks, mm (in.) measured after release from tension followed by 30 s relaxation. (from 10.5.4.1)
J = distance between bench marks, mm (in.) measured after release from tension followed by 30 min relaxation. (from 10.5.4.2)
K = distance between bench marks, mm (in.) measured after release from tension followed by 1 h s relaxation. (from 10.5.4.3)
L = distance between bench marks, mm (in.) measured after release from tension followed by 2 h relaxation. (from 10.5.4.4)

11.2 Calculate the average of 3 specimens to the nearest 0.2 % for each fabric stretch, fabric growth, and fabric recovery property calculated in 11.1 for the laboratory sampling unit and for the lot, as applicable.

12. Report

12.1 Report that the fabric stretch, fabric growth, and fabric recovery were determined as directed in Test Method D 3107. 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 stretch after tensioning for 10 s, and 30 min.

12.2.2 individual and average fabric growth after tension, and after relaxation of the test specimen for 10 s (immediate), 30 s, 30 min, 1 h and 2 h.

12.2.3 individual and average fabric growth after stretch, and after relaxation of the test specimen 30 s, 30 min, 1 h and 2 h.

12.2.4 individual and average fabric recovery after applied stretch and/or extension calculated for each time interval required.

12.2.5 original distance between bench marks.

12.2.6 tension used.

12.2.7 percent extension used for fabric growth after extension.

13. Precision and Bias

13.1 *Summary*—In comparing two averages, the differences should not exceed the single-operator precision values shown in Table 1 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 are likely to occur under all other circumstances.

13.2 *Interlaboratory Test Data*[5]—An interlaboratory test was run in which randomly-drawn samples of three materials were tested using a tension of 1.8 kg (4.0 lb.) in each of five laboratories. One operator in each laboratory each tested 3 specimens in the filling direction of each material using Test Method D 3107. All 15 specimens for a given material were taken randomly from the same sample. The precision statement is based upon a testing plan described in Practice D 2904 and Practice 2906. The components of variance expressed as coefficients of variation were calculated to be the values listed in Table 1.

13.3 *Precision*—For the components of variance reported in Table 1, 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.

13.4 Also, a single laboratory tested various materials in the filling direction using a 1.35 kg (3 lb) tension. The material style, number of observations, average values and standard deviations are shown in Table 3.

13.5 The components of variance and the critical differences for fabric recovery are expected to be the same as shown for fabric growth because the same measurements are used in their calculations.

NOTE 2—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

[5] ASTM Research Report No. D-13-1028 has been lost and is no longer available from ASTM Headquarters, 100 Bar Harbor Drive, West Conshohocken, PA 19428-2959.

TABLE 1 Components of Variance Expressed as Coefficients of Variation[A]

PROPERTIES	COMPONENTS OF VARIANCE EXPRESSED AS COEFFICIENTS OF VARIATION PERCENT OF AVERAGE		
	REPEATABILITY		REPRODUCIBILITY
	(SINGLE-OPERATOR) COMPONENT	(WITHIN-LABORATORY) COMPONENT	(BETWEEN LABORATORY COMPONENT)
Fabric Stretch	0.3	—	7.2
Fabric Growth	3.1	—	24.6

TABLE 2 Critical Differences, Percent of Grand Average for the Conditions Noted

PROPERTIES, □	NUMBER OF OBSERVATIONS[A] IN EACH AVERAGE	CRITICAL DIFFERENCES, PERCENT OF AVERAGE FOR THE CONDITIONS NOTED[BC]		
		REPEATABILITY□		REPRODUCIBILITY□
		(SINGLE OPERATOR) PRECISION	(WITHIN-LABORATORY) PRECISION	(BETWEEN-LABORATORY) PRECISION
Fabric Stretch	1	0.8	—	20
	2	0.6	—	14
Fabric Growth	1	8.6	—	68
	2	6.1	—	48

[A] Observation refers to a test result comprising of an average of three specimens.
[B] The critical differences for Table 2 were calculated using t = 1.960, which is based on infinite degrees of freedom.
[C] To convert the tabulated values to units of measure, multiply the average of the two specific sets of data being compared by the critical difference expressed as a decimal fraction.

TABLE 3 Average Values and Standard Deviation for Fabrics and Conditions as Noted

Fabric Weave (No. of Tests)	Fiber Content %	Fabric Weight Oz/Sq Yd	Fabric Stretch % Immediate Under 3 lb Tension		Fabric Stretch % After 30 min. Under 3 lb Tension		Fabric Growth % after 1 hr Relaxation No Tension	
			Avg.	Std Dev	Avg.	Std Dev	Avg.	Std Dev
Plain (11)	98Cotton/21Lycla	6.50	12.1	0.294	13.1	0.211	2.74	0.294
Twill (5)	96Cotton/4Spandex	7.00	41.5	2.817	43.1	2.845	8.02	1.000
Sateen (11)	98Cotton/21Lycra	7.50	25.9	0.443	27.3	0.398	5.18	0.275
Twill (22)	98Cotton/2Lycra	8.20	22.0	2.208	23.0	2.051	3.94	0.448
Twill (12)	93Cotton/7Lycra	8.50	22.3	0.428	23.1	0.431	3.76	0.656
Denim (10)	98Cotton/2Lycra	12.0	16.3	3.211	16.9	3.339	3.02	0.720

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. Refer to 5.2.1.

13.6 *Bias*—The procedure of this test method produces a test value that ~~standards shall~~ can be ~~updated~~ 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 fabric stretch; fabric growth; fabric recovery; stretch fabric