Designation: D 6774 – 02

Standard Test Method for Crimp and Shrinkage Properties for Textured Yarns Using a Dynamic Textured Yarn Tester[1]

This standard is issued under the fixed designation D 6774; 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 crimp contraction, residual fiber shrinkage and their variability of all types of filament yarns (partially oriented yarn (POY), fully oriented yarn (FOY), flat yarns, textured and bulked continuous filament (BCF) carpet yarns) using an automated tester.

NOTE 1—For another method of testing crimp in textured yarns, refer to Test Method D 4031.

1.1.1 This method may also be used for non-textured yarns.

1.2 This test method is limited to crimped, multi-filament yarns ranging from 22.0 to 890 dtex (15 to 800 denier) and for BCF yarns from 890 to 4200 dtex (800 to 3800 denier).

1.3 The values stated in either SI or US customary units are to be regarded separately as standard. Within the text, the U.S. customary units are 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 method.

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 Textiles[2]

D 2258 Practice for Sampling Yarn for Testing[3]

D 4031 Test Method for Bulk Properties of Textured Yarns[2]

D 4849 Terminology Relating to Fibers and Yarns

3. Terminology

3.1 For definitions of textile terms in this test method, refer to Terminology D 4949. For other textile terms used in this test method, refer to Terminology D 123.

4. Summary of Test Method

4.1 The specimen passes through a pretension device to remove crimp. The specimen then passes, at a constant speed, around an input roller, to a calibrated sensor which maintains a specific tension.

4.1.1 Subsequently, the specimen passes through a heating element, at a low tension, where the specimen shrinks and again is crimped.

4.1.2 The crimped specimen then goes to an intermediate roll, at a low tension.

4.1.3 The specimen then travels to a second sensor, which maintains a tension equal to the pretension applied, to remove developed crimp.

4.2 Residual fiber shrinkage, crimp developed, and maximum total contraction are calculated by the computer software using speeds of the input, intermediate and output rolls.

5. Significance and Use

5.1 Test Method D 6774, for determining maximum total contraction, crimp, and residual fiber shrinkage in textured filament yarns is suitable for acceptance testing of commercial shipments.

5.1.1 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, use the samples for such a comparative tests that are as homogeneous as possible, drawn from the same lot of material as the samples that resulted in disparate results during initial testing and randomly assigned in equal numbers to each laboratory. The test results from the laboratories involved should be compared using a statistical test for unpaired data, 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.

5.2 The properties and their variability as measured by this method relate to bulk appearance, stretch and recovery of fabrics and dyeability of yarns.

5.3 For some yarns, elapsed time between processing and testing has a marked effect on the results, of this test, especially during the first 72 h. The effect is caused by stress decay which

[1] This test method is under the jurisdiction of ASTM Committee D13 on Textiles and is the direct responsibility of Subcommittee D13.58 on Yarn Test Methods, General.

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[2] *Annual Book of ASTM Standards*, Vol 07.02.

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

is known to be minimal beyond the seventh day and after which time the yarn remains relatively stable. Therefore, specimens should only be compared if tested after the same elapsed time. Samples can be tested at-line, thus having little to no elapsed time between processing and testing.

6. Apparatus

6.1 *Textured Yarn Tester*[4], equipped with the following:

6.1.1 *Non-contact Heater Tube*, with a temperature range from 100 to 205°C (with an accuracy of ± 1°C), for filament yarns 22.0 to 890 dtex (15 to 800 denier): or

6.1.1.1 *Non-contact Heater Tube*, with a temperature range from 185 to 250°C (with an accuracy of ± 1°C), for textile and BCF yarns 890 to 4200 dtex (800 to 3800 denier).

6.1.2 *Pretension Device*

6.1.2.1 For filament yarns 22.0 to 890 dtex (15 to 800 denier), to control the tension within a range of 5 to 25 g, with an accuracy of ±3 %: or

6.1.2.2 For textile and BCF yarns 890 to 4200 dtex (800 to 3800 denier), to controls the tension within a range of 10 to 250 g, with an accuracy of ± 3 %.

6.1.3 *Sensor Assemblies*, for Zones 1 and 2 (see Fig. 1).

6.1.3.1 *Fine Yarn Sensors*, 22.0 to 890 dtex (15 to 800 denier).

6.1.3.2 *Heavy Yarn Sensors*, 890 to 4200 dtex (800 to 3800 denier).

6.1.4 *Computer, Software and Printer*.

6.2 *Static Eliminator*, optional if necessary.

NOTE 2—A static eliminator is used when the static level in the yarn is great enough to cause the filaments to flare out and cause snagging of the filaments on components of the tester.

6.3 *Automatic Package Changer*, for high volume production testing, optional.

6.4 *Tensiometer*.

7. Sampling

7.1 *Lot Sample*—For acceptance testing, take a lot sample of shipping containers as directed in an applicable specification, or as agreed upon between the purchaser and supplier. In the absence of an applicable specification or agreement, take a lot sample as directed in Practice D 2258.

NOTE 3—An adequate specification or other agreement between the purchaser and the supplier requires taking into account the variability between shipping units, between packages or ends within a shipping unit, and between specimens from a single package 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 at random from each shipping container in the lot sample the number of laboratory sampling units as directed in an applicable material specification or other agreement between purchaser and supplier such as an agreement to use Practice D 2258. Preferably, take the same number of laboratory units from each shipping container in the lot sample.

7.3 *Number of Specimens*—Test ten, 2-m length, specimens

[4] The sole source of supply of the Textured Yarn Apparatus known to the committee is Lawson-Hemphill Sales, Inc., PO Drawer 6388, Spartanburg, South Carolina 29304, or (International Sales) Lawson-Hemphill Inc., 96 Hadwin Street, Central Falls, Rhode Island 02863. If you are aware of alternative suppliers, please provide information to ASTM headquarters. Your comments will receive careful consideration at a meeting of the responsible technical committee, which you may attend.

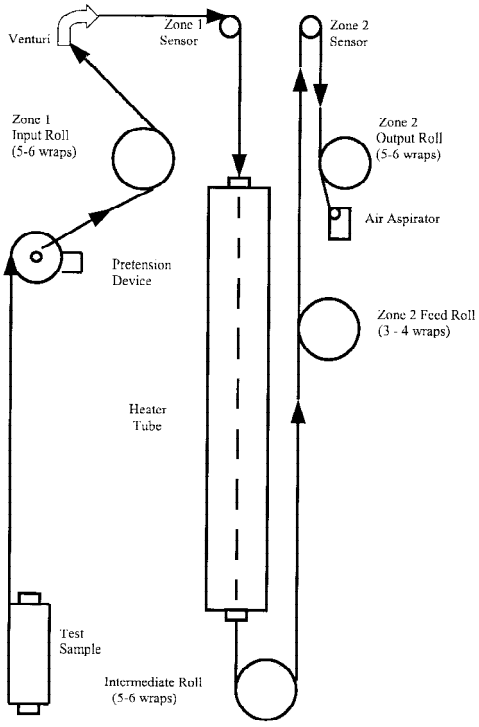

FIG. 1 Diagram of the Yarn Thread Path through the Textured Yarn Tester

from each package in the laboratory sample.

NOTE 4—Current software for the test apparatus is designed to measure only in meters. When available, tests can be run in 2 yd increments.

8. Conditioning

8.1 Conditioning and preconditioning are not required. Testing may be performed in the production area (at-line).

9. Preparation and Calibration of Apparatus

9.1 For yarn types and deniers not previously tested, and for which initial set-up conditions have not been established, follow the directions in Annex A1 before proceeding to 9.2.

9.2 For previously tested yarn types and deniers for which set-up procedures have been established, prepare and calibrate the tester using the established set-up procedure for that yarn, manufacturer's manual, A1.1-A1.10 and the following information.

9.2.1 Turn on the motor and check the speed on the computer monitor.

9.2.2 Check that both appropriate sensor assemblies (zone 1 and zone 2) for freedom of movement.

9.2.3 Set the zero adjustment for the sensing arms and calibrate the tester.

9.2.4 Set sensing arm tension and pretension as prescribed in A1.4-A1.6 or refer to manufacturer's operational manual.

9.2.5 Stop the tester motor.

10. Procedure

10.1 Operate the test apparatus as directed in the manufacturer's operating manual.

10.2 When performing routine testing and the parameters have previously been set as directed in Section 9, follow the procedure below.

10.2.1 Thread the yarn in the tester and let the tester run about a minute. Check to ensure that the yarn moves freely through the tester in the center of the heating tube.

10.2.2 Stop the tester.

10.2.3 Set the pretension as required for the yarn under test.

10.2.4 Set the test length to 2 m and the number of tests to ten.

10.2.5 Enter the yarn identification information into the computer and start the test.

10.2.6 When testing multiple packages, with different linear densities, it may be necessary to reset the tensions in the sensing zones and pretension, with the change in linear density.

10.2.7 Remove specimen from the tester when testing is complete.

11. Calculation of Results

11.1 All calculations shown below, including averages, standard deviation and coefficient of variation for the laboratory sampling units and for the lot, are determined using the computer software. Equations used for determining the property values are given in the following sections (see Fig. 2).

11.2 *Total Contraction*—Calculate the total contraction to the nearest 0.1 % using Eq 1.

$$T = 100\,\frac{(R1 - R2)}{R1} \tag{1}$$

where:

T = total contraction, %,
$R1$ = input roller speed, m/min (yd/min), and
$R2$ = intermediate roller speed, m/min (yd/min).

11.3 *Crimp*—Calculate the crimp developed to the nearest 0.1 % using Eq 2.

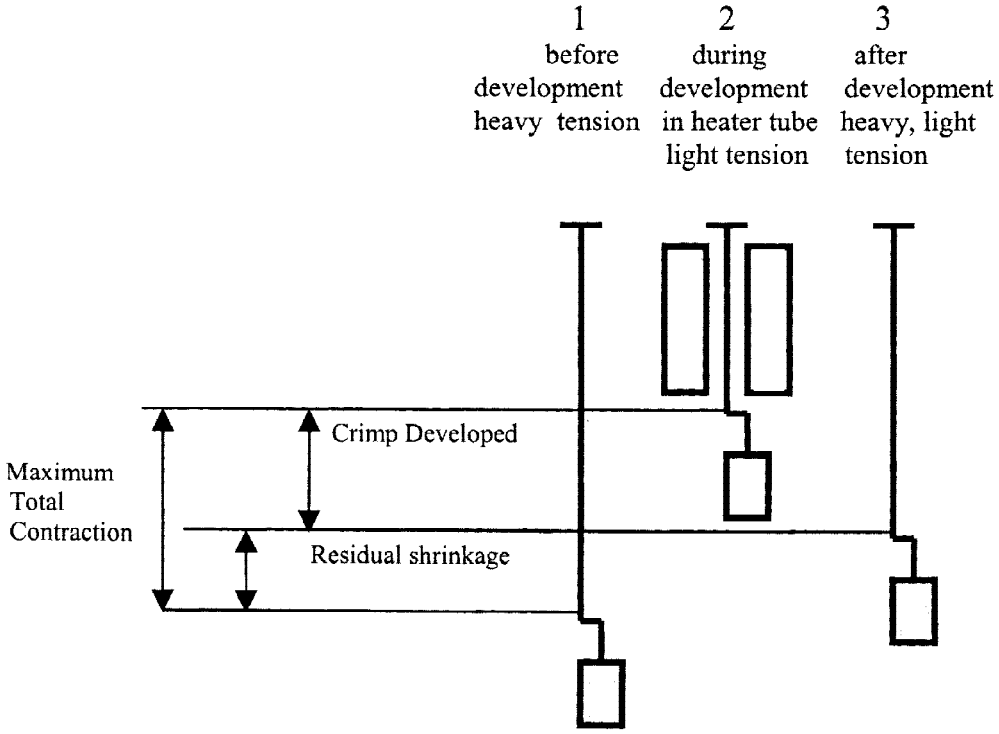

FIG. 2 Diagram Relating the Terminology of Textured Yarn Tester

$$C = 100\,\frac{(R3 - R2)}{R3} \quad (2)$$

where:
C = crimp, %, and
$R3$ = output roller speed, m/min (yd/min).

11.4 *Residual Fiber Shrinkage*—Calculate the residual fiber shrinkage to the nearest 0.1 % using Eq 3.

$$S = 100\,\frac{(R1 - R3)}{R1} \quad (3)$$

where:
S = residual fiber shrinkage, %.

12. Report

12.1 State that the specimens were tested as directed in Test Method D 6774. Describe the material or product sampled and the method of sampling used.

12.2 Report the following properties for each specimen and averages for each laboratory sampling unit and lot sample for the following parameters:

12.2.1 Maximum total contraction.

12.2.2 Crimp.

12.2.3 Residual fiber shrinkage.

12.2.4 Standard deviation and coefficient of variation.

12.2.5 Mean values for maximum total contraction and residual fiber shrinkage, and the standard deviation and coefficient of variation for the lot sample.

12.3 Report the following test conditions used for the test:

12.3.1 Test speed used.

12.3.2 Test temperature used.

12.3.3 Specify heater type.

12.3.4 Pretension used.

12.3.5 If static eliminator was used during testing.

12.3.6 Elapsed time.

13. Precision and Bias

13.1 *Precision*—An interlaboratory study was performed to estimate variability of the test method. The study included 12 laboratories. Four operators were used to measure three specimens for five different yarns, which develop crimp in hot wet conditions on two different days. ANOVA was used to determine variance components:

Method repeatability is defined as the "maximum difference" that can "reasonably" be expected between two test results obtained on the same material when the test results are obtained in the same laboratory. Repeatability standard deviation, sr, is taken to be the square root of the "specimen" variance component, and represents within-operator precision.

TABLE 1 Response = Total Contraction (%)

Material	Average	V(Instrument)	V(Operator)	V(Package)	V(Specimen)
75	16.61146	0.03422	0.00000	1.73951	0.02205
150	15.69156	0.01678	0.00000	0.42009	0.03236
165	15.32594	0.11261	0.00000	0.27580	0.02625
190	18.34844	0.35085	0.00000	2.88366	0.07342

TABLE 2 Response = Shrinkage (%)

Material	Average	V(Instrument)	V(Operator)	V(Package)	V(Specimen)
75	3.28594	0.03306	0.00000	0.08752	0.00689
150	1.74146	0.02272	0.00000	0.00268	0.01810
165	4.55219	0.00082	0.00000	0.68329	0.03363
190	2.67563	0.09634	0.00000	0.19280	0.01388

Method reproducibility is defined as the "maximum difference" that can "reasonably" be expected between two test results obtained on the same material when the test results are obtained from different laboratories.[5] s_R, the total standard deviation, is formed by taking the square root of the sum of intra- and inter-laboratory variance components.

TABLE 3 Response = Total Contraction (%)

Material	s_r	Repeatability	s_R	Reproducibility
75	0.14849	0.41160	1.34006	3.71447
150	0.17989	0.49864	0.68501	1.89875
165	0.16203	0.44912	0.64395	1.78493
190	0.27096	0.75108	1.81877	5.04137

TABLE 4 Response = Shrinkage (%)

Material	s_r	Repeatability	s_R	Reproducibility
75	0.08303	0.23016	0.35703	0.98964
150	0.13455	0.37296	0.20857	0.57812
165	0.18338	0.50830	0.84720	2.34831
190	0.11782	0.32658	0.55047	1.52583

13.2 *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 crimp; residual fiber shrinkage; textured yarn; total contraction

[5] John Mandel and Theodore W. Lashof, 1987. The Nature of Repeatability and Reproducibility. Jour. Quality Technology, 19 (1).

ANNEX

(Mandatory Information)

A1. SET-UP TO ESTABLISH TESTING CONDITIONS FOR THE TEXTURED YARN TESTER

NOTE A1.1—The instructions may vary slightly for the different versions of this instrument. In each case, refer to the manufacturer's operational manual.

A1.1 Set the heater temperature to approximately 100°C and allow ample time for the heater to reach the temperature. This temperature is the starting point for the heat curve.

A1.2 Make a zero calibration using the manufacturer's operation manual.

A1.3 Set the machine speed to 100 m/min. for yarns 22.0 to 890 dtex (15 to 800 denier), or 30 m/min. for textile, and BCF carpet yarns 890 to 4200 dtex (800 to 3800 denier).

A1.4 Set the Pretension to 10 g, or use 100 mg per denier.

A1.5 Set the zone 1 sensing arm. Use the guidelines, Table A1.1, to determine the starting force.

NOTE A1.2—For stretch yarns, it may be necessary to use 4 mg/denier, when testing some high bulk yarns (such as Nylon).

A1.6 To determine the zone 1 weight, use the guidelines in A1.5. Hang the weight on the zone 1 sensor. Adjust the dial until the sensor is level. Make the adjustments in small increments until the sensing arm is balanced.

A1.7 Calibrate the zone 2 sensing arm to a tension of 10 g or 100 mg/denier.

A1.8 String up the tester and start the motor. Make sure the specimen is running through the center of the heater tube.

A1.9 Adjust the aspirator pressure as needed to correct the yarn path using the aspirator pressure gage on the right front of the tester. If the yarn going from the aspirator through the zone 1 is not flowing in a straight line, data will be affected.

A1.10 Set the tension of the yarn between the intermediate feed rolls and the zone 2 feed rolls (see Fig. 1) to approximately 3 g of tension using the tensiometer and turning the zone 2 feeder adjustment.

TABLE A1.1 Tensions for Zones 1 and 2 Sensors

Type Yarn	Tension
Stretch Yarns	0.00204 cN/tex (2 mg/den)
Set Yarns	0.00102 cN/tex (1 mg/den)

A1.10.1 Guidelines for yarns up to 890 dtex (800 denier), use 2 to 5 g between the intermediate feed rolls and the zone 2 feed rolls.

A1.10.2 Guidelines for yarns from 890 dtex (800 denier) and heavier, use 10 to 15 g between the intermediate feed rolls and the zone 2 feed rolls.

A1.11 Obtain a heat curve using the following:

A1.11.1 Set the temperature at 200°C, for yarns up to 890 dtex, or 240°C, for the yarns heavier than 890 dtex.

A1.11.2 In the software, set the tester in the Graph Mode and use the Crimp Out setting, for textile and BCF yarns. For fine denier yarns, use the Graph Mode and the Total contraction setting. Refer to the operation manual for software steps.

A1.11.3 Observe the graph; watch for the crimp output, or total, peak. After the highest reading is observed the curve should level off and begin to drop. Stop the test. The test temperature is the temperature at the center of the level area on the curve. If the curve peaks and starts to drop, then the test temperature is at the peak, of the curve.

NOTE A1.3—The shrinkage line should be linear. If not, it is necessary to increase the zone 2 tension (use the 4 mg/denier) and pretension.

A1.11.4 Set the heater controller to the test temperature, as recorded in A1.11.3, and allow heater ample time to cool down to the set temperature.

A1.11.4.1 If there is no peak in the heat curve, then set the temperature at 190°C and allow the tester to cool to that temperature.

A1.12 Select the Production Mode and start test.

A1.13 Record the following settings for future testing:

A1.13.1 Yarn Identification.
A1.13.2 Test Speed (m/min.).
A1.13.3 Temperature (°C).
A1.13.4 Input or Pretension (g).
A1.13.5 Zone 1 sensing arm tension (mg).
A1.13.6 Tension after the intermediate feed roller (g).
A1.13.7 Zone 2 sensing arm tension (g).