Designation: D 2102 – 96

Standard Test Method for Shrinkage of Textile Fiber Bundle Test[1]

This standard is issued under the fixed designation D 2102; 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 measurement of the unrestrained shrinkage of a bundle of crimped or uncrimped fibers from exposure to some environment, for instance, boiling water for 15 min.

1.1.1 This test method may be used on fibers from tow and fibers removed from spun or continuous filament yarn.

NOTE 1—For measurement of shrinkage of single fibers, refer to Test Method D 5104.

1.2 The values stated in either inch-pound or SI units are to be regarded separately as the standard. The values stated in each system are not exact equivalents, therefore, each system must be used independently of the other.

1.3 *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 1577 Test Methods for Linear Density of Textile Fibers[2]
D 1776 Practice for Conditioning Textiles for Testing[2]
D 2258 Practice for Sampling Yarn for Testing[2]
D 3333 Practice for Sampling Man-Made Staple Fibers, Sliver, or Tow for Testing[2]
D 5104 Test Method for Shrinkage for Textile Fibers (Single-Fiber Test)[3]

3. Terminology

3.1 *Definitions:*

3.1.1 *shrinkage, n*—a decrease in one or more dimensions of an object or material.

3.1.1.1 *Discussion*—In this method, shrinkage means a decrease in length. The shrinkage is calculated as a percentage of the original specimen length. In some cases, there is an increase in length rather than a decrease. This is referred to as a negative shrinkage or stretch.

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

4. Summary of Test Method

4.1 A uniform bundle of conditioned parallel fibers is lightly loaded between clamps and the nip to nip length measured. Without being removed from the clamps, the bundle specimen is then exposed to the test environment, typically, boiling water for 15 min. After reconditioning, the bundle length is remeasured under the same light loading.

NOTE 2—Due to the very high variability of the shrinkage of individual fibers of high shrinkage types, to obtain a reliable average value would require an excessive number of determinations, each rather tedious. The bundle method does not give the true average value, but rather a weighted value approaching the highest shrinkage fiber in the bundle. Since the weighted value more closely approximates the properties found in a high bulk yarn made from such fibers, the weighted value would seem to be more appropriate.

5. Significance and Use

5.1 Limited accuracy in measuring the change in length produces errors in estimating values for shrinkage below 10 %. However, this test is being used for low level shrinkage fibers because the results give have been found to give an adequate indication of average shrinkage at the lower levels. The test is not adequate for determining variability in average shrinkage at low levels.

5.2 This test method for testing the shrinkage of fibers is not recommended for acceptance testing of commercial shipments of fibers because only a limited amount of data is available. See Section 14.

5.2.1 In case of dispute arising from differences in reported test results when using this test method for acceptance testing of commercial shipments, the purchaser and 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 samples that are as homogeneous as possible and that are from a lot of material of the type in question. These samples should then be randomly assigned in equal numbers to each laboratory for testing. The average results from the two laboratories should be compared using appropriate statistical analysis and an acceptable probability level chosen by the two parties before testing is begun. If a bias is found, either the cause must be found and

[1] This test method is under the jurisdiction of the ASTM Committee D-13 on Textiles and is the direct responsibility of Subcommittee D13.57 on Fiber Test Methods, General.

Current edition approved Nov. 10, 1996. Published December 1996. Originally published as D 2102 – 62 T. Last previous edition D 2102 – 90.

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

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

corrected or the purchaser and supplier must agree to interpret future test results with consideration to the known bias.

5.3 This test method may be used for acceptance testing of commercial shipments of fibers; but caution is advised since information on between laboratory precision is incomplete. Comparative tests as directed in 5.2.1 are advised.

6. Apparatus

6.1 *Jig*,[4] consisting of a frame with fixed upper clamp suitable for holding a small parallel bundle of fibers, a smoothly sliding lower clamp and a means for locking this lower clamp in position, and a suitable scale inscribed on the jig to measure the distance between clamps to the nearest 0.2 mm (0.01 in.).

6.2 *Tape* Adhesive Cellophane or Masking, 25.4 mm optional (1 in.).

7. Sampling

7.1 *Lot sampling*—As a lot sample for acceptance testing, take at random the number of shipping containers directed in the applicable material specification or other agreement between the purchaser and supplier, such as an agreement to use Practice D 3333 or Practice D 2258, as appropriate. Consider shipping containers to be the primary sampling units.

NOTE 3—An adequate specification or other agreement between the purchaser or supplier requires taking into account the variability between shipping units, between packages, ends or other laboratory sampling unit within a shipping unit if applicable, and within specimens from a single package, end or other laboratory sampling unit to provide a sampling plan with a meaningful producer's risk, consumer's risk, acceptable quality level, and limiting quantity level.

7.2 *Laboratory Sample*—As a 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 3333 or Practice D 2258, as appropriate. Preferably, the same number of laboratory sampling units are taken from each shipping container in the lot sample. If differing numbers of laboratory sampling units are to be taken from shipping containers in the lot sample, determine at random which shipping containers are to have each number of laboratory units drawn.

7.3 *Test Specimens*—From each laboratory sampling unit take five specimens at random. If the standard deviation determined for the container from which the laboratory sampling units were taken is more than a value agreed upon between the purchaser and supplier, continue testing in groups of five specimens from the same laboratory sampling units in the container until the standard deviation for all specimens tested for the container is not more than the agreed-to value or, by agreement, stop testing after a specified number.

7.3.1 If testing fibers from yarn, carefully remove twist before taking the specimens.

8. Preparation of Test Specimen

8.1 Prepare test specimen bundles by drawing and lapping fibers to align the fibers in parallel. Be careful not to stretch any of the fibers.

8.1.1 If fibers are already parallel, as in sliver or tow, split-off bundles of fibers from the side of the material.

8.1.2 Draw and lap the specimen bundles such that the fiber ends at one end of the test specimen bundles are essentially aligned.

8.2 Make up each specimen bundle so that its linear density in tex will result in a loading of 0.9 cN/tex (0.1 gf/d), by the weight of the sliding clamp as obtained in accordance with 9.1.

NOTE 4—*Wraping Bundle Ends*—Cut two short pieces of tape. Carefully wrap the tapes about the end of the specimen bundle. Space the ends to give as long a specimen as practical and compatible with the jig and fiber lengths. Trim the tape ends to fit inside the clamps.

9. Calibration

9.1 Weigh the sliding lower clamp to 0.1 g for determination of specimen bundle size as stated in 8.2. The jig must be partially disassembled to do this.

9.2 Clamp a scale, of approximately 40 mm (1½ in.) in length, in the jaws with exactly 25 mm (1.0 in.) nip to nip. Position the upper clamp to give a reading of 1.00 in. on the inscribed scale.

10. Conditioning

10.1 Precondition and condition the laboratory samples as directed in Practice D 1776.

10.1.1 During preconditioning, spread the samples out to avoid any build up of temperature within the sample that could affect its shrinkage.

11. Procedure

11.1 Make all length measurements on specimens in the standard atmosphere for testing textiles which is 21 ± 1°C (70± 2°F) and 65 ± 2 % relative humidity.

11.2 Place one end of the specimen in one of the fixed clamps at the top of the jig. If used, the tape should be inside the clamp nip. With the specimen in a relaxed state, carefully place the other end in the opposite movable clamp.

11.3 Repeat 11.2 and 11.3 until all specimens are in the jig(s).

11.3.1 If the ends were taped, insert the specimens in the clamps with the tapes inside the clamp and not in the nips.

11.4 Mount the jig vertically and gently release the sliding clamps. The lower clamp and rod (plus a small additional weight, if needed) should now be imposing a loading of 0.9 cN/tex (1.0 gf/den) on the specimen bundle.

11.5 Read the initial gage lengths on the inscribed vernier scales to the nearest 0.2 mm (0.01 in.). Record the length.

11.6 Move the sliding clamps inward. Allow ample slack for shrinkage. Lock the clamps in this retracted position.

11.7 Expose the specimens to the required test environment, typically, boiling water for 15 min.

11.8 Return the specimens to moisture equilibrium with the standard atmosphere for testing and repeat the procedure described in 11.4 and 11.5 to obtain the new lengths.

12. Calculation

12.1 Calculate the percentage shrinkage for each specimen bundle to the nearest 0.1 % using Eq 1:

[4] A jig satisfying these requirements is obtainable from Layman and Russ Machine Co., Inc., P.O. Box 146, Oreland, PA 19075.

$$S = [(B - A)/B] \times 100 \quad (1)$$

where:

S = shrinkage, %,
B = specimen length before treatment, mm (in.), and
A = specimen length after treatment, mm (in.).

12.2 Calculate the average shrinkage for each laboratory sampling unit and for the lot.

12.3 Calculate the standard deviation, coefficient of variation or both for each laboratory sampling unit and for the lot, if requested.

13. Report

13.1 State that the specimens were tested as directed in Test Method D 2102. Describe the material or product sampled, and the method of sampling used.

13.2 Report the following information:

13.2.1 Shrinkage for each laboratory sample unit and for the lot,

13.2.2 Standard deviation, coefficient of variation, or both, if calculated,

13.2.3 Nominal gage length used,

13.2.4 Test conditions (medium, temperature, and time), and

13.2.5 Number of observations.

14. Precision and Bias

14.1 *Summary*—Based on limited information from two laboratories, the single-operator and between-laboratory components of variance shown in Tables 1 and 2 are approximate. In comparing two averages, the differences should not exceed the single-operator precision values shown in Table 2 in 95 out of 100 when all the observations are taken by the same well-trained operator using the same piece of test equipment and specimens randomly drawn from the same sample and tested on the same day. Differences for other laboratories may be larger or smaller. The number of laboratories available to perform the procedure in this test method has diminished over the last few years. If additional laboratories are identified to perform this test, between-laboratory precision will be established.

TABLE 1 Materials and Shrinkage Average and Components of Variance[A]

	Acrylic High-Bulk	Nylon Low Shrinkage
Shrinkage average, %	18.8	3.9
Components of Variance		
Single-operator	1.97	0.245
Between-laboratory	0.886	0

[A] The square roots of the components of variance (standard deviations) are reported to express the variability in shrinkage units of measure rather than the squares of the units of measure.

TABLE 2 Critical Differences[A] in Percent Shrinkage

Material	Number of Observations in Each Average	Single Operator Precision	Between Laboratory Precision
Acrylic	1	5.4	6.0
High-bulk	5	2.4	3.5
	10	1.7	3.0
Nylon	1	0.7	0.7
Low shrinkage	5	0.3	0.3
	10	0.2	0.2

[A] Critical differences were calculated using $Z = 1.96$.

14.2 *Interlaboratory Test Data*—A two-laboratory test was run in 1995 in which samples of two materials were tested. Two operators in each laboratory tested fiber bundle specimens of each material. The components of variance for shrinkage results and the materials are given in Table 1.

14.3 *Critical Differences*—For component 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 in Table 2.

NOTE 5—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 of the type being evaluated to be as nearly homogeneous as possible and then randomly assigned in equal numbers to each of the laboratories.

14.4 *Bias*—The value for shrinkage of textile fibers by the bundle test can only be defined in terms of a test method. Within this limitation, this test method has no known bias.

15. Keywords

15.1 dimensional change; textile fibers