Designation: D 5103 – 01

Standard Test Method for Length and Length Distribution of Manufactured Staple Fibers (Single-Fiber Test)[1]

This standard is issued under the fixed designation D 5103; 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 average staple length and staple length distribution of both manufactured and natural fibers by manually measuring single fiber lengths. This test method is also used to measure the length of fibers removed from a staple yarn, but such a measurement may not represent the fiber's staple length, as manufactured.

1.2 Because this test method requires measuring the length of only 50 fibers, it is not suitable for use in determining the number of long fibers that occur infrequently in a sample.

NOTE 1—For determination for overlength fibers, refer to Test Method D 3513.

NOTE 2—For methods covering the determination of the average length and length distribution of natural fibers, refer to the following methods: for cotton, Test Method D 1440, and Test Method D 1447, for wool, Test Method D 519, Test Method D 1234, and Test Method D 1575.

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 519 Test Method for Length of Fiber in Wool Top[2]

D 1234 Test Method for Sampling and Testing Staple Length of Grease Wool[2]

D 1440 Test Method for Length and Length Distribution of Cotton Fibers (Array Method)[2]

D 1447 Test Method for Length and Length Uniformity of Cotton Fibers by Fibrograph Measurement[2]

D 1575 Test Method for Fiber Length of Wool in Scoured Wool and in Card Sliver[2]

D 1577 Test Methods for Linear Density of Textile Fibers[2]

D 1776 Practice for Conditioning and Testing Textiles[2]

D 2258 Practice for Sampling Yarn for Testing[2]

D 3333 Practice for Sampling Manufactured Staple Fibers, Sliver, or Tow for Testing[3]

D 3513 Test Method for Overlength Fiber Content of Man-Made Staple Fiber[3]

3. Terminology

3.1 *Definitions:*

3.1.1 *length distribution, n—of staple fibers*, a graphic or tabular presentation of the proportion or percentage (by number or by mass) of fibers having different lengths.

3.1.2 *velveteen, n*—a woven fabric in twill or plain weave made with a short closely packed filling pile in imitation of velvet.

3.1.3 For definitions of other textile terms used in this test method, see Terminology D 123.

4. Summary of Test Method

4.1 Each fiber to be tested is gripped at the tips with forceps, fully extended without stretching, and measured. The average fiber length of the measured fibers is calculated and the length distribution curve is plotted.

5. Significance and Use

5.1 This test method is used for research, development, quality control, product specifications, and may be used for acceptance testing of commercial shipments of textile fibers. However, caution is advised since information on between-laboratory precision is lacking. Comparative tests as directed in 5.1.1 may be advisable.

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, test samples that are as homogenous as possible, drawn from the material from which the disparate test results were obtained, and randomly assigned in equal numbers to each laboratory for testing. The test results from the two laboratories should be compared using a statistical test for upaired 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

[1] This test method is under the jurisdiction of ASTM Committee D 13 on Textiles and is the direct responsibility of Subcommittee D13.58 on Yarn and Fiber Test Methods.

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

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

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adjusted in consideration of the known bias.

5.2 This test method provides objective measurements for determining the average fiber length and length distribution in a sample of fiber.

5.3 The staple length diagram of a fiber sample can be used to determine the relative number of fibers above and below a specified length. If a fiber is too long, it will not process well in spinning, and if there is a preponderance of short fibers, the yarn might have lower than normal breaking strength.

6. Apparatus

6.1 *Test Board*, covered with suitable material, for example, velveteen, of contrasting color to that of the fiber and at least 10 mm (½in.) longer than the longest fiber to be measured.

6.2 *Precision Scale*, graduated with 1.0-mm (0.02-in.) divisions.

6.3 *Illuminated Magnifier*,[4] with a 3×–10× lens equipped with illumination, optional (see 9.7).

6.4 *Forceps*,[5] two pairs, fine-pointed forceps, curved or straight tips.

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. 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 units within a shipping unit if applicable, and within specimens from single package, end or other laboratory sampling units 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 the purchaser and supplier such as an agreement to use Practice D 3333 or Practice D 2258. 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.

7.2.1 *For Staple Fiber*—Take 50-g samples from laboratory units.

7.2.2 *For Sliver (or Top) or Tow*—Take 1 m from the leading end which has a clean, uniform appearance.

7.2.3 *For Yarns*—Prepare at least a 50-m skein from each package.

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

7.3.1 Carefully remove twist before taking specimens from yarn. Using tweezers and grasping the specimens at the ends, gently remove the required number of specimens from the laboratory sampling units for testing. In some cases, if specimens are not to be tested immediately, place them on an identified short-pile of plush surface for storage until ready to test.

8. Conditioning

8.1 Conditioning is not necessary unless the material is received in an unusual state, for example, water soaked. If a sample is received in an unusual state, precondition and condition as directed in Practice D 1776.

9. Procedure

9.1 Test the specimens in the standard atmosphere for testing textiles, which is 70 ± 2°F (21 ± 1°C) and 65 ± 2 % relative humidity.

9.2 Clean the test board by using the sticky side of pressure-sensitive cellophane tape, vacuuming, or other suitable method to remove debris.

9.3 Switch on the illuminated magnifier.

9.4 Place the measuring scale on the test board.

9.5 Pull an individual fiber gently from the laboratory sample.

9.6 Grip both ends of the fiber with forceps perpendicular to the axis of the fiber. The ends of the fiber should be in line with the tips of the forceps.

9.7 Place the tip of the forceps that is gripping one end of the fiber at a reference point on the measuring scale. An illuminated magnifier may be useful for more precise alignment of the end of the fiber and the references point.

9.8 Without stretching the fiber, extend it to full extension to remove the crimp by moving the forceps gripping the other end of the fiber along the measuring scale. Read the length of the fiber to the nearest 1.0 mm (0.02 in.).

9.9 Repeat operations as directed in 9.5-9.9 to measure the remaining fibers.

10. Calculation

10.1 Tally the fiber measurements and arrange them in descending order as shown in Table 1 or Table 2.

10.2 Calculate the average fiber length for each laboratory sampling unit and for the lot.

10.3 Calculate the cumulative percentage of fibers for each group. Starting with the longest length group, add each number of fibers in the length group to the sum of the fibers in the proceeding length group to obtain the cumulative number of fibers. Convert these cumulative numbers of fibers to percent as shown in column 3 of Table 1 or Table 2.

10.4 Draw a staple length distribution curve by plotting the

[4] A lamp satisfying this requirement is obtainable from Jenson Tools, Inc. Temple, AZ.

[5] A pair of forceps satisfying the requirements is obtainable from Fisher Scientific, 711 Forbes Ave, Pittsburgh, PA 15219.

TABLE 1 Example Tally of Measured Fibers (SI)

Length Group, mm	Number of Fibers	Cumulative Number of Fibers, %
42.0	1	2
41.5	1	4
41.0	1	6
40.5	1	8
40.0	2	12
39.5	1	14
39.0	2	18
38.5	6	30
38.0	12	54
37.5	7	68
37.0	3	74
36.5	2	78
36.0	4	86
35.5	2	90
35.0	1	92
34.5	1	94
34.0	1	96
33.5	1	98
33.0	1	100
Total	50	

TABLE 2 Example Tally of Measured Fibers (Inch-Pound)

Length Group, in.	Number of Fibers	Cumulative Number of Fibers,%
1.66	1	2
1.63	1	4
1.61	1	6
1.59	1	8
1.57	1	10
1.55	1	12
1.53	2	16
1.51	3	22
1.49	5	32
1.47	10	52
1.45	7	66
1.43	4	74
1.41	3	80
1.39	4	88
1.37	3	94
1.35	1	96
1.33	1	98
1.31	1	100
Total	50	

cumulative percent values shown in Table 1 or Table 2 as abscissa against the respective fiber length group as ordinate, as shown in Fig. 1 or Fig. 2.

10.5 Calculate the standard deviation and coefficient of variation.[6]

11. Report

11.1 State that the specimens were tested in accordance with Test Method D 5103. Describe the materials or product sampled and the method of sampling used.

[6] *ASTM Manual on Presentation of Data and Control Chart Analysis, STP 15D,* p. 21.

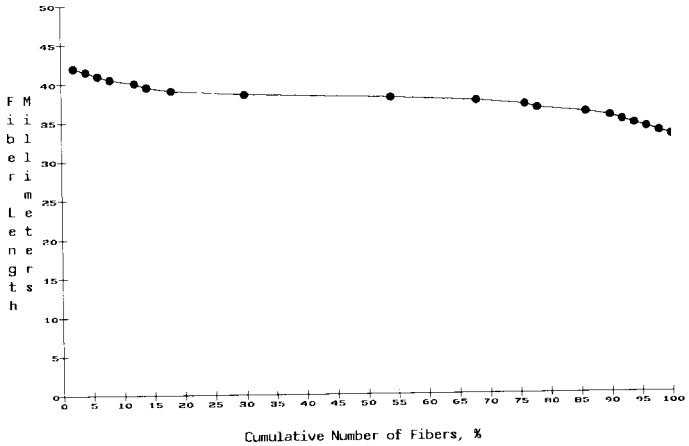

FIG. 1 Example Tally of Measured Fibers, mm

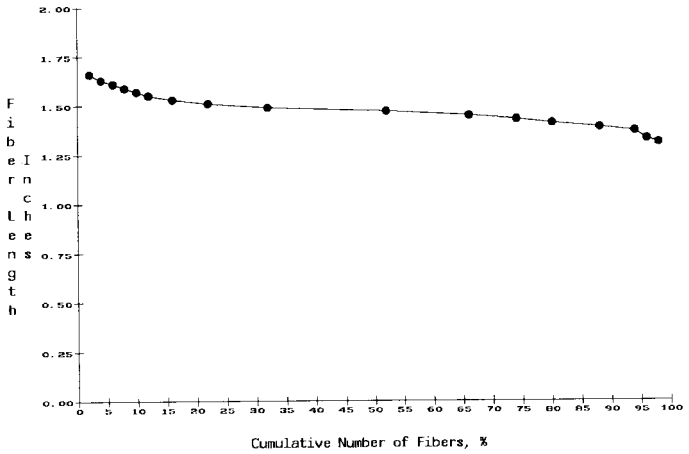

FIG. 2 Example Tally of Measured Fibers, in.

11.2 Report the following information for each specimen:

11.2.1 Tally of measured fibers as shown in Table 1 or Table 2,

11.2.2 Staple length distribution curve of the fibers as illustrated in Fig. 1 or Fig. 2,

11.2.3 Average fiber length for each laboratory sampling unit and for the lot, and

11.2.4 Standard deviation, and coefficient of variation, if requested.

12. Precision and Bias

12.1 *Precision*—The precision of this method is to be established.

12.2 *Bias*—The procedure in this test method has no bias because the value of these properties can be defined only in terms of a test method.

13. Keywords

13.1 length; textile fibers

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