Designation: D7879 – 13

Standard Test Method for Determining Flax Fiber Widths Using Image Analysis[1]

This standard is issued under the fixed designation D7879; 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 involves the measurement and analysis of two-dimensional projections of flax fibers using image analysis software in the longitudinal plane to determine the average and distribution of fiber widths.

1.2 The values stated in SI units are to be regarded as standard. No other units of measurement are included in this standard.

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:*[2]

D123 Terminology Relating to Textiles
D1776 Practice for Conditioning and Testing Textiles
D6798 Terminology Relating to Flax and Linen

3. Terminology

3.1 *Definitions:*

3.1.1 For all terminology related to Flax and Linen see Terminology D123.

3.1.1.1 The following terms are relevant to this standard: average fiber width (μm).

3.1.1.2 For definitions of all other textile terms see Terminology D6798.

4. Summary of Test Method

4.1 This test method involves the preparation of flax fibers for digital capture, the scanning of the fibers for analysis, and the calibration and standardization of the image processing. From the image analysis, the arithmetic mean and its standard deviation, median, and numerical distribution of the fiber widths are calculated.

5. Significance and Use

5.1 Longitudinal preparation is much quicker and less damaging than cross-sectional analysis and allows the fibers to be evaluated in their natural state.

5.2 This test method provides measurement of a flax fiber specimen that uses less specimen preparation, produces consistent results, and minimal specimen modification. It has been shown that the median values of width correlate very well with the Optical Fiber Diameter Analyzer (OFDA), an apparatus developed for measuring the value and distribution of wool fiber diameters.

6. Interferences

6.1 Out of focus objects.

6.2 Real resolution of image capturing device impacts measurements.

6.3 Fingerprints, cracks, scratches, tape, dust and other impurities (non-fibrous objects) on the glass slides can bias measurement results.

6.4 Results will be incorrect or misleading if the operator of the software has not properly set up the image capture parameters.

6.5 Image processing techniques employed to complete missing or incompletely developed fiber boundaries must be used with caution as false boundaries may be created.

6.6 Vibrations or movement of the sample during image capture can blur the image and must be minimized or eliminated when using automatic image analysis.

6.7 Non-uniform illumination can influence feature detection and threshold using automatic image analyzers.

6.8 Operation of the equipment in a non-environmentally controlled room may result in fiber shape deviations after initial fiber conditioning has occurred.

7. Apparatus

7.1 *Fiber Preparation Apparatus:*

[1] This test method is under the jurisdiction of ASTM Committee D13 on Textiles and is the direct responsibility of Subcommittee D13.17 on Flax and Linen.

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[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

7.1.1 A coarse comb or other device used to distribute fibers to create a single focal plane and better enable fiber edge detection.

NOTE 1—Excessive overlap of fibers reduces the possibility of observing all of the fibers in a single focal plane.

7.1.2 Two flat surfaces capable of compressing the sample where at least one surface is optically transparent.

NOTE 2—The purpose of the flat and compressive surfaces is to create a uniform focal plane to capture a majority of fibers in one focal plane.

7.2 *Image Capture Hardware:*

7.2.1 The hardware device must capture an image with a real optical resolution of at least 4000 dpi (1 dot = 6.35 μm). The hardware device must be able to provide a digital image in a RAW format for storage and analysis.

NOTE 3—Stated resolution does not necessarily correspond to the real optical resolution.

7.2.2 The apparatus must be able to create a sharp image by automatic or manual focusing.

7.3 *Image Analysis Software:*

7.3.1 Software must be capable of importing a digital image (including RAW formatted images), performing feature extraction, and calculating fiber widths for further analysis and electronic data export.

7.3.2 Software must be capable of manual or automatic adjustments so that it measures the specimen of interest (for example, flax fiber and fiber bundles 8-100 μm).

7.3.3 Software must be capable of displaying the original image with an overlay of the feature extraction image to adjust the threshold for proper edge detection.

8. Reagents and Materials

8.1 Materials may include National Institute of Standards and Technology (NIST) traceable calibration images, synthetic fibers of known diameter, and components of the apparatus. No reagents are used.

9. Hazards

9.1 There are no known hazards.

10. Sampling, Test Specimens, and Test Units

10.1 This test method describes the measurement of the sample of interest taken from the lot and is not necessarily an accurate representation of the lot's distribution. No less than three test specimens must be taken; additional specimens will be dependent on the accuracy required by the end user and the natural variation of the fibers. Due to this variation, it is suggested that at least 100 fibers be analyzed from each specimen.

10.1.1 Gently loosen flax fibers such that individual fibers can be accessed and extracted to produce a laboratory sample.

NOTE 4—The specimen should be handled gently to reduce fiber width reduction due to fiber separation during fiber extraction. Unattached shive, trash, and other impurities should be removed by gentle shaking.

10.1.2 Take the test specimen fibers by random sampling from the laboratory sample.

10.1.3 Use a coarse comb or other device to distribute test specimen fibers on a flat surface thus creating a single focal plane and enabling better fiber edge detection.

NOTE 5—Fine combs, multiple combings, or rigorous combing, or combination thereof, can reduce fiber width measurements.

10.1.4 Use two flat surfaces capable of compressing and securing the fiber specimen where at least one surface is optically transparent to create a uniform focal plane.

11. Preparation of Apparatus

11.1 Follow manufacturer's guidelines.

12. Calibration and Standardization

12.1 The system must be calibrated for accurate fiber width measurement.

12.1.1 The scanner and software must be periodically calibrated according to manufacturer's recommendations using images of known dimensions (for example, NIST traceable images).

12.1.2 Users are required to evaluate fiber generated images for uniform edge detection and optimize the software parameters for optimal image overlay. The software must be calibrated to visually depict the fiber's edge (generated fiber images should overlay original images with proper edge detection).

NOTE 6—Edge detection may be dependent upon light source decay.

13. Conditioning

13.1 Bring the laboratory flax fiber sample from the prevailing atmosphere to moisture equilibrium for testing which is 21 ± 1ºC (70 ± 2ºF) and 65 ± 2 % relative humidity and check the equilibrium as directed in Practice D1776. No preconditioning is required.

14. Procedure

14.1 Prepare fiber test specimen for image capture.

14.2 Follow manufacturer's guidelines to acquire image of fiber test specimen.

14.3 Import the digital image, perform feature extraction, and determine fiber widths using the image analysis software.

14.4 Repeat 14.1 – 14.3 for remaining fiber test specimens.

15. Calculation or Interpretation of Results

15.1 Calculate fiber width statistics (for example, arithmetic mean fiber width, sample standard deviation, and median).

NOTE 7—Image analysis software may automatically generate these statistics.

15.2 Additional reporting will be defined by agreement between supplier and user of the data.

16. Report

16.1 Report the following information:

16.1.1 Identity of the laboratory sample.

16.1.2 Material type.

16.1.3 One typical image.

16.1.4 Name of testing laboratory.

16.1.5 Type and length of preconditioning used.

16.1.6 Temperature and relative humidity conditions during testing.

16.1.7 Image capture hardware used.

16.1.8 Optical resolution used.

16.1.9 Type of image analysis software used, software parameters, and version.

16.1.10 Name of operator.

16.1.11 Date of the test.

16.1.12 Number of specimens tested.

16.1.13 Number of fibers examined.

16.1.14 Arithmetic mean fiber width.

16.1.15 Sample standard deviation.

16.1.16 Median.

16.1.17 Fiber width distribution curve (for test specimens and laboratory samples).

16.1.18 Minimum and maximum width used during image analysis to isolate the objects of interest.

17. Precision and Bias

17.1 *Precision*—The mean, standard deviation, and 95 % repeatability limit (2.8 × sample standard deviation) of within-laboratory samples tested with the same method, equipment, laboratory, and operator for various sample of flax fiber are shown in Table 1.

17.2 *Bias*—With the limitation imposed by within-laboratory evaluation, this test method has no known bias.

TABLE 1 Mean, Standard Deviation, and Within-laboratory Repeatability Limit

Sample Type[A]	Statistic	Thickness (μm)
1	Mean	28.59
	Standard deviation	2.65
	Repeatability Limit	7.41
2	Mean	56.40
	Standard deviation	2.88
	Repeatability Limit	8.07
3	Mean	58.63
	Standard deviation	6.63
	Repeatability Limit	18.55
4	Mean	27.19
	Standard deviation	1.65
	Repeatability Limit	4.63
5	Mean	24.61
	Standard deviation	0.23
	Repeatability Limit	0.64
6	Mean	32.36
	Standard deviation	6.83
	Repeatability Limit	19.13

[A]The average and standard deviation are from three samples. The repeatability limit is derived by multiplying 2.8 by the sample standard deviation in accordance with Form and Style of ASTM Standards, Section A21.2.5.

18. Keywords

18.1 fiber diameter distribution; fiber width measurement; flax fiber; image analysis; slide scanner