Designation: D8394 – 21

Standard Test Method for Automated Measurement of Maturity, Fineness, Ribbon Width, and Micronaire of Cotton Fibers[1]

This standard is issued under the fixed designation D8394; 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 linear density (gravimetric fineness hereafter stated as fineness), maturity, micronaire, and ribbon width of cotton fibers from a loose, chemically untreated sample taken before harvest, during ginning, during mill processing or unraveled from raw (undyed) yarn or fabric.

1.2 This test method requires the use of an integrated instrument, for example, the Cottonscope (see Fig. 1), that measures the maturity, fineness, ribbon width, and micronaire of cotton fiber.[2]

NOTE 1—For another test method to determine the maturity of cotton fibers, refer to Test Method D1442.

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

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, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.5 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standards:*[3]

D123 Terminology Relating to Textiles

D1441 Practice for Sampling Cotton Fibers for Testing

D1442 Test Method for Maturity of Cotton Fibers (Sodium Hydroxide Swelling and Polarized Light Procedures)

D1776 Practice for Conditioning and Testing Textiles

D7139 Terminology for Cotton Fibers

E691 Practice for Conducting an Interlaboratory Study to Determine the Precision of a Test Method

E177 Practice for Use of the Terms Precision and Bias in ASTM Test Methods

3. Terminology

3.1 *Definitions:*

3.1.1 For all terminology relating to D13.11, Cotton Fibers, refer to Terminology D7139. The following terms are relevant to this standard; fineness, maturity, micronaire, ribbon width, and snippet.

3.1.2 *fineness, gravimetric, n*—the linear mass density of fiber measured in millitex (mtex). Synonymous with linear density (ASTM's definition for linear density – mass per unit length).

3.1.3 *ribbon width, n*—the distance measured in microns (μm) across an individual cotton fiber width in longitudinal section viewed under a polarized light microscope.

3.1.4 *snippet, n*—fibers cut into very short lengths of less than 1 mm.

3.1.5 For all other terminology related to textiles, refer to Terminology D123.

4. Summary of Test Method

4.1 Cotton fibers are cut into snippets no greater than 1 mm using scissors, a guillotine or mechanical corer. The snippets are weighed, dropped into a water filled bowl and dispersed by a magnetic stirrer so that they spread randomly across the instrument's digital camera viewing port. Two to three droplets of a non-foaming surfactant can be used to aide dispersion of the snippets in the water bath. The individualized and dispersed fibers are then photographed under polarized light and the data collected by the instrument's software, which analyzes the color images to determine fineness, maturity, micronaire and ribbon width.

[1] This test method is under the jurisdiction of ASTM Committee D13 on Textiles and is the direct responsibility of Subcommittee D13.11 on Cotton Fibers.

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[2] The sole source of supply of the apparatus known to the committee at this time is Cottonscope Pty. Ltd., 13 Willcock Street, Ardross 6153, Western Australia. If you are aware of alternative suppliers, please provide this information to ASTM International Headquarters. Your comments will receive careful consideration at a meeting of the responsible technical committee,[1] which you may attend.

[3] 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.

FIG. 1 Cottonscope Instrument

5. Significance and Use

5.1 Cotton fiber that is on average finer and more mature is more desirable than coarse or immature fiber, although distinction between these qualities cannot be made quickly and accurately using current test methods. Immature fibers break more easily during processing and have a tendency to form into neps (small entanglements) during processing in the spinning mill. These consequences adversely affect yarn and fabric quality and appearance. Yarn and fabric produced from immature fiber is typically also less lustrous and does not take up dye consistently so yarn and fabric appearance may be different after dyeing.

5.2 Maturity has a high positive correlation with fiber length and strength but genetic differences and differences in fiber wall thickness caused by plant diseases, soil, and water conditions during the growing season interfere with this relationship.

5.2.1 Fine fibers are required for fine count yarn manufacture and fiber fineness affects yarn count, evenness and strength. Both fineness and ribbon width are strong genetic traits evident between species and affected by growing conditions within species.

5.2.2 Micronaire has traditionally been used as a measure of fiber fineness although the value actually measures fiber specific surface area or surface area per unit weight. As a result, micronaire varies concomitantly with both maturity and fineness (see Fig. 2). Maturity and fineness are related to mi-

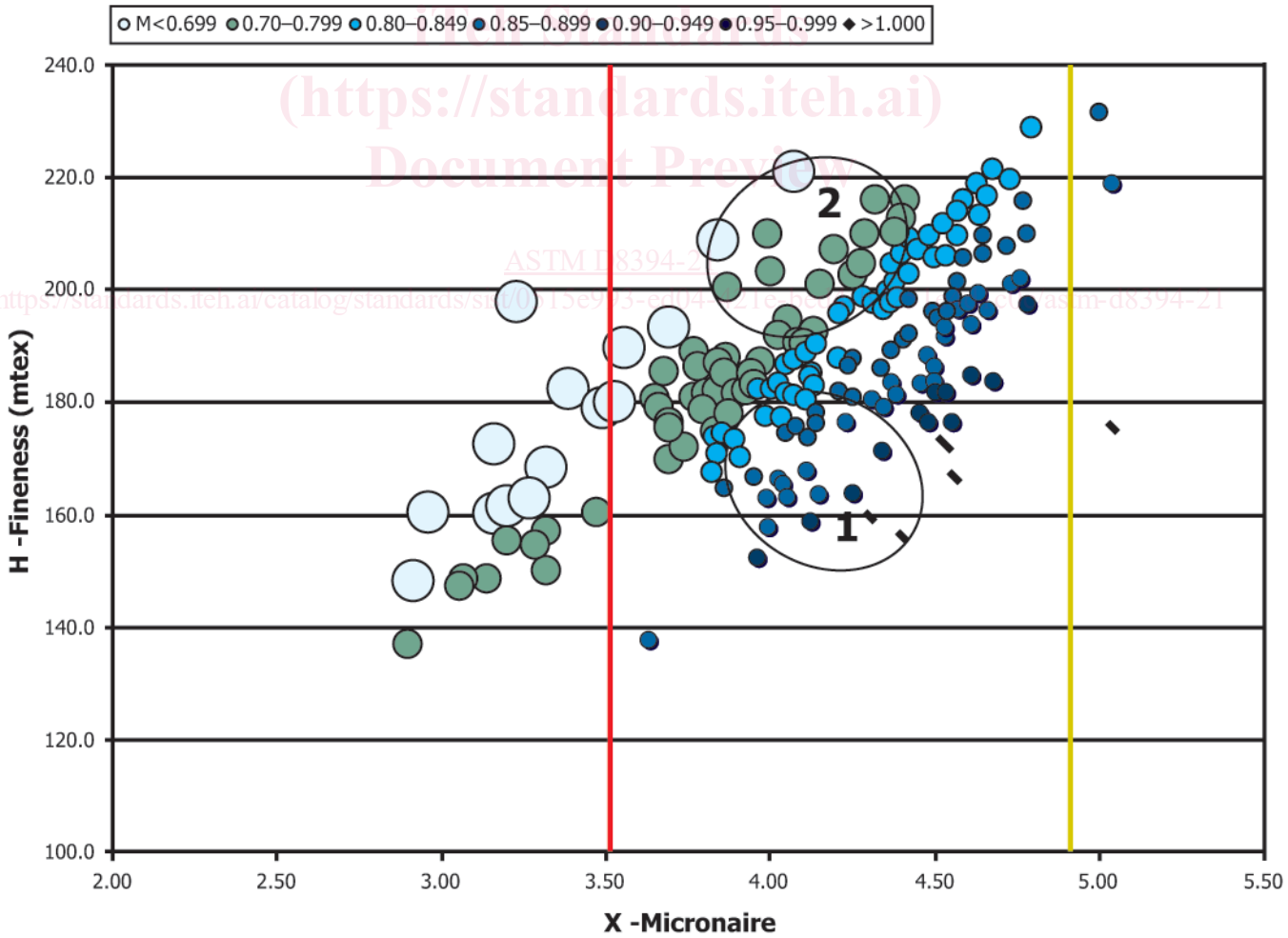

FIG. 2 Relationship Between Micronaire (X), Fineness (H), and Maturity (M)

cronaire via Lord's equation.[4]

5.3 Cottonscope values have been judged against fineness, maturity and ribbon width values produced by examination of thousands of individual, magnified fiber cross-sections. Relationships with equivalent values by these and other older test methods are highly significant[5,6] particularly if the number of cross-sections analyzed is high (>3000) and the cross-sections are carefully prepared and measured. Cottonscope measures approximately 20,000 fiber (snippets) per measurement and is a quick test in comparison to previous methods, for example, directly measuring cross-sections. The good relationship observed between ribbon width and the perimeter of fiber cross-sections makes ribbon width of interest to plant breeders and scientists observing fiber perimeter responses to plant and crop treatments.

5.4 The precision of Cottonscope has been measured. Measurement of consistent quality, machine picked cotton using a test regime of one in three bales (with two specimens tested per bale sample), provides a precision of between 6.8 and 7.5 % for fineness, between 1.2 and 1.5 % for maturity, between 4 and 5 % for micronaire and less than 1 % for ribbon width. These values incorporate sample and instrument variance but not inter-laboratory variance. Precision is improved by increasing the number of sub-samples measured per bale. The values for maturity and micronaire are similar to reported high volume instrument values.

5.4.1 The method has not yet been widely controlled for acceptance testing. Inter-laboratory trials have shown agreement and precision can be good if instrument calibrations and test procedures are properly coincided. Calibration material should be conditioned before testing as directed in Practice D1776.

5.4.2 Cottonscope algorithms are calibrated using known cotton and fiber standards, for example, USDA AMS prepared calibration cottons, measured on a manufacturer's standard instrument with values and the calibration material passed to the next instrument. It is advised if there are differences of practical significance between reported test values for two or more laboratories, comparative tests should be performed to determine any statistical bias between them, using competent statistical analysis. Ideally, these tests are performed using the same homogenous material.

6. Apparatus and Reagents

6.1 *Cottonscope Instrument* (Fig. 1) is a known instrument with these capacities.[2]

6.2 *Guillotine*[2]or *Pneumatic Corer*[7] for cutting snippets from samples of loose cotton fiber to a length less than 1 mm.

6.3 *Tweezers, Weighing Pans, Cleaning Brush.*

6.4 *Balance,* with a capacity of at least 100 mg and a sensitivity of 0.1 mg.

6.5 *Surfactant,* clear, low-foaming liquid surfactant, for example, Teric169, to aid the dispersion of snippets in the water bath.

7. Hazards

7.1 Care should be applied when cutting fiber specimens using the guillotine or corer.

8. Sampling and Preparation of Test Specimens

8.1 Test specimens should be taken from sub-samples or samples in accordance with a competent statistical analysis. Practice D1441 may be used. Measurements of maturity and ribbon width do not require samples to be pre-conditioned before measurement.

8.1.1 For unprocessed (raw) cotton from the gin or cotton bale that has not been blended, at least five sub-samples from different areas of the sample are required. Regimes for sampling fiber from cotton fruit on single plants or multiple plants in rows need to be determined using competent statistical analyses.

8.1.2 For intermediate or semi-processed mill products such as card or draw frame sliver, three sub-samples from different areas of the sample are required.

8.1.3 Fibers can be unraveled or unpicked from yarn or fabric for testing. Sampling fiber from yarn or fabric should be determined using competent statistical analyses.

8.2 If standard conditions are not used, average fineness values will be affected. Application of relative humidity values 15 to 25% above or below standard relative humidity affects average fineness values by up to 3 %.

8.3 Fibers are guillotined or cored to produce snippets for testing. The test specimen will be comprised of these snippets and shall weigh 50.0 ± 0.5 mg. Use a brush to thoroughly clean the preparation area, weighing tray, and cutting device or guillotine of snippets before preparing the next sample.

8.4 Weighed snippets (test specimen) are tipped into the instrument's water bowl and allowed to submerge and then disperse. Once the snippets are dispersed, start the test.

9. Preparation of Cottonscope

9.1 The Cottonscope instrument should be located on a vibration-free table or bench top in a dry, low draft location away from direct sunlight. The operating temperature should be between 5 and 50 °C. Otherwise, operate under conditions as directed in Practice D1776.

[4] Lord, E., "Air Through Plugs of Textile Fibres, Part II. The Micronaire Test for Cotton," *J. Textile Inst*., 47, T17-T47, 1956.

[5] Rodgers J, Delhom C, Fortier C, et al., "Rapid measurement of cotton fiber maturity and fineness by image analysis microscopy using the Cottonscope," *Text. Res. Journal*, 2012; 82, pp. 259-271.

[6] Paudel D, Hequet E, Abidi N., "Evaluation of cotton fiber maturity measurements," *Industrial Crops and Products*, 45, 2012, pp. 435-441.

[7] The sole source of supply of the apparatus known to the committee at this time is SIRO Agriculture and Food, 75 Pigdons Road, Waurn Ponds 3216, Victoria, Australia. If you are aware of alternative suppliers, please provide this information to ASTM International Headquarters. Your comments will receive careful consideration at a meeting of the responsible technical committee,[1] which you may attend.

9.2 Follow the manufacturer's instructions for turning on the instrument, for the addition of water and for the cleaning of the water tank and filter assembly. Before adding water, add 10 mL of a low-foaming surfactant to 1.5 L of distilled water at room temperature and mix for at least 10 s. Fig. 3 shows the instrument's water tank and filter assembly.

9.3 Initiate the instrument's software. Activate the water bowl fill and repeat until the water flows evenly into the bowl without generating bubbles. If small bubbles persist in forming as observed on the camera screen, remove them using a small, soft bristled cleaning brush.

9.3.1 The water in the bath should be changed weekly or more frequently if clarity of the camera image becomes contaminated with trash or dust from fiber specimens or with the growth of bacterial or fungal colonies.

10. Calibration and Standardization

10.1 Calibration uses cotton and polyester fiber reference samples that cover the entire range of measurements for maturity (M), fineness (H), and ribbon width (D). A minimum of five reference or calibration samples is preferred for each variable. Examples of current calibration reference values are shown in Table 1.

10.2 Follow software prompts to initiate, store, and select calibrations.

TABLE 1 Example of Calibration Fiber Reference Numbers

Cottonscope Reference Results				
Sample ID	H (mtex)	M	D (um)	X
31105	268.4	0.890	16.52	5.48
gm-39	136.1	0.598	16.27	1.92
5740	160.7	0.785	15.42	3.36
5741	193.8	0.888	15.35	4.45
5742	248.5	0.895	15.96	5.06
PL7[A]	–	–	27.54	–
PL12[A]	–	–	17.99	–
PL14[A]	–	–	13.05	–

[A] Polyester staple fiber. Other listed fiber is cotton.

11. Conditioning

11.1 Condition samples to be measured in the standard atmosphere for testing textiles as directed in Practice D1776 before preparing and weighing test specimens.

12. Procedure

12.1 The daily measurement of a control cotton fiber is recommended to ensure instrument stability is checked routinely.

12.2 Weigh 50.0 ± 0.5 mg of snippets from the required sample. Enter the specimen's identity and exact weight of the specimen in the instrument's software and then transfer the

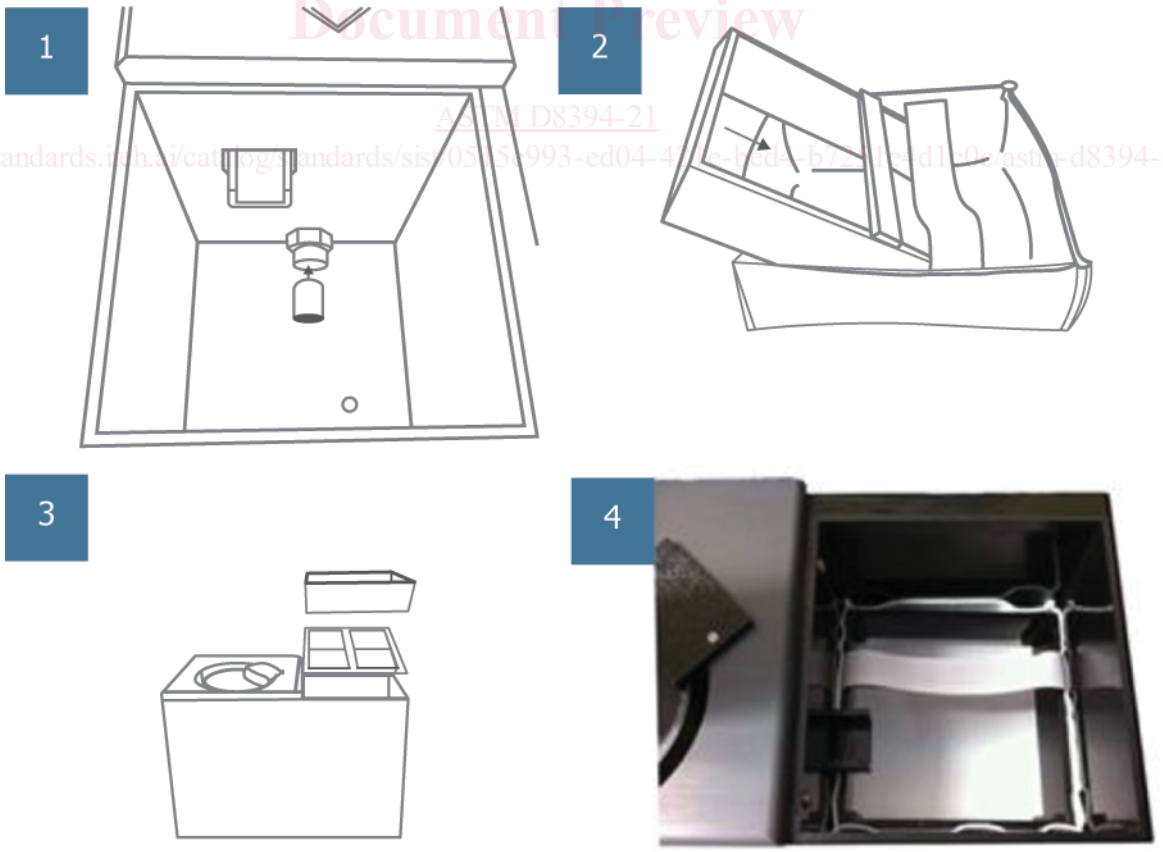

FIG. 3 Cottonscope Filter Assembly