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Standard Test Method for Evenness of Textile Strands Using Capacitance Testing Equipment[1]

This standard is issued under the fixed designation D1425/D1425M; 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 indirect measurement of evenness (mass variation) of non-conductive textile strands, including top, comber lap, sliver, roving, and yarn produced from staple fibers and continuous filament yarns, by means of capacitance testing equipment.

1.2 Strands made from fiber blends can be tested using this test method only if the different fibers are uniformly distributed throughout the strand.

1.3 The test method provides numeric values for the measurement and evaluation of short-, mid-, and long-term mass variations of the tested strand in terms of frequently occurring faults classified as thin places, thick places, and neps and graphical representations of evenness values in the form of diagram charts, spectrograms, length variation curves, and histograms.

1.4 The values stated in either SI units or inch-pound units are to be regarded separately as standard. The values stated in each system may not be exact equivalents; therefore, each system shall be used independently of the other. Combining values from the two systems may result in non-conformance with the standard.

1.5 *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
D2258 Practice for Sampling Yarn for Testing
D4849 Terminology Related to Yarns and Fibers
E177 Practice for Use of the Terms Precision and Bias in ASTM Test Methods
E691 Practice for Conducting an Interlaboratory Study to Determine the Precision of a Test Method

3. Terminology

3.1 *Definitions:*

3.1.1 The following terms are relevant to this standard: electric constant; evenness; imperfections; length between, L_b; length capacitance zone, L_c; mass variation; mean deviation of evenness, U%; sample length L_s; strand; strand irregularity; and total imperfections.

3.1.2 For definitions of other textile terms used in this test method, refer to Terminology D123 and Terminology D4849.

4. Basic Principles of Test Method

4.1 Properties of strand irregularity measured along its length are measured in terms of mass variation.

4.2 The direct method of evenness testing utilizes the technique of cutting and weighing strand segments of length L_b and is the reference method of determining evenness (mass variation). Utilization of the capacitance measurement technique is an indirect testing method. The accuracy of an indirect method of testing can be judged by a comparison of evenness values between it and the direct method (cutting and weighing).

4.3 In capacitance testing, a high frequency electric field is generated in the space between a pair of capacitor plates (measuring slots). If the mass of a strand moving between the plates changes, the electrical field between the plates changes accordingly, and results in electrical signal output variation proportional to the mass variation of the strand.

4.4 Evenness is always expressed as variation between successive lengths L and over a total length Ls. When the L_c evenness is measured, it corresponds to the length capacitance zone width, i.e., 8 mm [0.3 in.] for yarns, 12 mm [0.5 in.] for rovings and fine slivers, and 20 mm [0.8 in.] for slivers that are referred to as short-term evenness. Longer-term evenness may also be evaluated by electronically increasing the L_c.

[1] This test method is under the jurisdiction of ASTM Committee D13 on Textiles and is the direct responsibility of Subcommittee D13.58 on Yarns and Fibers.

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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.

5. Summary of Test Method

5.1 A textile strand is passed through a length capacitance zone of an evenness tester at a constant speed. The mass variation of successive L_c interval lengths is measured and from which other values of evenness are derived: coefficient of variation, short-, mid- and long-term variations, and imperfections.

6. Significance and Use

6.1 This test method for the determination of evenness of textile strands is used extensively for acceptance testing of commercial shipments of filament or spun staple yarn, comber laps, roving, sliver, or tops.

6.2 Values of strand evenness are also used in quality control, process optimization, and together with yarn strength measurements, as the first appraisal of a strand's quality. A low evenness value is, in general, preferred. Higher evenness values generally indicate poor yarn manufacturing practices, lower yarn strength, and poorer fabric appearance. Experience has shown that the relationship of evenness to the prediction of yarn performance and to fabric appearance is not a simple one. An evenness value must, therefore, be used cautiously and be supplemented by additional evenness information, such as mid-term and long-term mass variations, thin, thick, and nep imperfection counts, diagram chart spectrogram chart, length variation curve, and histogram analyses.

6.3 Continuous filament yarns should be tested for mass variation on evenness testers that are specifically designed to test this yarn type; failure to do so will result in inaccurate test results. Further, low-twist, continuous filament yarns tend to flatten to a ribbon configuration while passing through the sensor of a capacitance instrument. This flattening effect will cause false mass variation measurements by the capacitive sensor (commonly referred to as shape effect). Evenness testers that are specifically designed to test continuous filament yarns insert a false twist to the yarn strand during testing to overcome the flattening effect and thus ensure accurate mass variation measurements.

6.4 Strands made from fiber blends should be tested only if the different fibers are uniformly distributed throughout the strand. Non-uniform blending may cause a higher reading of mass variation than the true value if the component fibers differ in dielectric constant.

6.5 Evenness values obtained on different instruments will be comparable for strands from the same sample provided the following parameters are the same in all cases: (1) the measure of evenness used (CV% or U%); (2) the capacitive length zone L_c; (3) the sample length, *Ls*; (4) instrument test speed, (5) laboratory temperature and humidity conditions (see 10.1); and (6) test specimen preparation, and (7) test specimen variation. When different models of an instrument are used, and one or more of the seven parameters are not identical, test results may differ.

6.6 If there are any differences of practical significance between reported test results for two (or more) laboratories, comparative tests should be performed using an agreed upon number of samples that are homogeneous and randomly assigned. Competent statistical assistance should be used to determine if there is a statistically significant difference between the laboratories. If a bias is found, either its cause must be found and corrected, or future testing for that material must be adjusted in consideration of the statistically significant differences found.

7. Apparatus

7.1 *Capacitance-Type Evenness Testing Instruments*—A textile strand evenness tester that utilizes the electronic capacitance measuring principle.

7.1.1 Differences between older and newer capacitance testers for calibration, recording devices, test settings, and data output can be found in the manufacturer's instruction manual for specific models.

7.2 *Package holders, guides, tension devices, unwinding, and take-up mechanisms*——Devices and attachments to evenness testing instruments that aid in the uniform delivery of the strand at specified speed, without undue acceleration or deceleration, at a reasonably constant tension. These devices are especially critical for loose textile strands such as sliver, roving, and comber laps

7.3 *Recording device*—Printer or computer-generated files from which numeric and graphic test data can be produced.

7.4 *Twist insertion device*—A mechanism that inserts false twist into continuous filament yarns. This mechanism is used only on evenness testers that are designed to test continuous filament yarns.

8. Sampling

8.1 Unless otherwise agreed upon, as when specified in an applicable material specification, take a lot sample and laboratory sample as directed in Practice D2258.

8.2 Typical spun yarn sample lots are ten or twenty packages, unless otherwise agreed upon.

9. Number of Specimens

9.1 Conduct a test on each yarn package or bobbin in the sample lot. Refer to 11.1, Table 1 for the recommended test length. If required, multiple tests on successive test lengths can be performed on each package or bobbin.

9.2 Conduct a test on each sample of sliver, roving, comber lap, top or the number of test recommended by the equipment manufacturer. Refer to 11.1, Table 1 for the recommended test length. If required, multiple tests on successive test lengths can be performed on each sample.

10. Conditioning

10.1 Condition strands according to Practice D1776. Preconditioning is not required unless in the case of dispute.

10.2 For yarn, the time required for conditioning depends on the fiber, the size of the package and the compactness of the yarn wound on the package. Further, a shorter conditioning time may be sufficient if only the outside layer of a yarn package is to be tested than if the whole package is to be tested.

TABLE 1 Recommended Strand Speeds and Evaluating Times

Material	Strand Speed	Evaluating Time
Top or sliver	4 m/min [4 yd/min]	5 or 10 min
Sliver or roving	8 m/min [8 yd/min]	5 or 10 min
Sliver or roving	25 m/min [25 yd/min]	5 or 10 min
Sliver	50, 100 m/min [50, 100yd/min][A]	1 or 2.5 min
Roving	50, 100, 200 m/min [50, 100, 200yd/min]	2.5 or 5 min
Yarn	400, 800[B] m/min [400, 800 yd/min]	0.5 ,1.0, 1.25 or 2.5 min
Filament Yarns	100, 200, 400 or 800 m/min [100, 200, 400 or 800 yd/min]	2.5 min

[A]This speed may be used if the sliver specimen is not stretched or if a powered unwinding apparatus is used.
[B]The 800 m/min or yd/min testing speed is not available on all instruments.

As a general guide, condition bobbins for 24 h and yarn packages for 48 h. Other strands such as sliver, roving, and laps do not require conditioning and can be tested as soon as they are brought into the laboratory.

10.3 If the standard atmosphere described in Practice D1776 is not available, condition the strand in a stable atmosphere in which the test is to be performed until it has reached equilibrium. Record the conditions under which the test was performed.

10.4 Test results may not be comparable if conditioned and tested in different atmospheres.

11. Selection of Testing Parameters

11.1 *Measure of Evenness*—Recommended evaluation test times and strand speeds are listed in Table 1.

11.1.1 The selection of test speeds is important to avoid stretching strands during the test length and is specific to the type of strand and the model of capacitance tester used. Yarns can normally be tested at higher speeds than yarn intermediates such as sliver or roving. In general, the testing speed setting for sliver and tops is 25 m/min [25 yd/min]. Higher rates can be used if the test instrument is equipped with a powered unwinding device or if the material does not exhibit any additional mass variation caused by stretching at the selected speed. The testing speed rate setting for roving is 50 m/min [50 yd/min]; higher roving test speeds may be used if a powered unwinding device is used. Test speeds for yarns can be either 100, 200, 400, or 800 m/min [100, 200, 400, or 800 yd/min] depending upon the capability of the evenness tester and the characteristics of the yarn.

11.1.2 Imperfection evaluations are conducted on staple yarns only. The range of possible measurements for counting imperfections is shown in Table 2. Select a measurement setting for each imperfection category; it is possible to select more than one setting for each imperfection category on some evenness testers. Different yarn spinning systems will influence which settings to select. See Table 3.

11.2 Check the manufacturer's instructions for other selections such as chart speeds if not using a newer tester.

12. Procedure

12.1 Check the manufacturer's instructions for calibration procedures if not automatically performed by the model used.

12.2 Mount conditioned bobbins or package(s) on a suitable holder or creel truck as described by the instrument manufacturer. Follow the manufacturer's instructions for threading yarn to the evenness tester.

12.2.1 When testing yarn from packages in a sample, the yarn should be pulled from the packages in the same direction (clockwise or counterclockwise). Filament yarns will require specific threading instructions from the manufacturer.

12.2.2 The threading-up procedures for sliver, roving, comber laps, and tops are extremely critical. Threading-up instructions from the manufacturer should be carefully followed.

12.3 Each strand from a bobbin or package should be tested in one uninterrupted run.

13. Calculation

13.1 For older capacitance testers, the final CV% or U% is read from the recording device.

13.1.1 If more than one value of CV% or U% is obtained per individual package, then calculate the average value of evenness for each package.

TABLE 2 Range of Imperfection Settings

Imperfection Category (i.e. frequently occurring faults)	Description of Variation (from Mean Yarn Mass)
Thin Places	-30 to -60 % decrease
Thick Places	+35 to +100 % increase
Neps	<4 mm long, +140 to +400 % increase with respect to a reference length of 1 mm

TABLE 3 Standard Imperfection Settings for Ring, Rotor Spun, and Air Jet Spun Yarns

Spinning System Type	Thick Place Sensitivity Setting	Thin Place Sensitivity Setting	Nep Sensitivity Setting
Ring, Compact, and Air Jet Spinning	+50 %	-50 %	+200 %
Rotor Spinning	+50 %	-50 %	+280 %

13.1.2 Calculate the average of CV% or U% for all packages.

13.1.3 If requested, calculate the coefficient of variation or the standard deviation (or both) of the CV% or U% values obtained for each package to determine between package variation.

13.2 For newer evenness testers, all calculations and reports are automatically produced.

14. Report

14.1 State the test was performed according to ASTM D1425.

14.2 Test instrument's make, model, year, and type of integrator, if used.

14.3 Lot, sample and product identification.

14.4 Number of specimens tested/sample.

14.5 Atmospheric conditions used; if not standard.

14.6 See 13.2

14.7 For older models,

14.7.1 Strand travel speed.

14.7.2 Length of specimen tested.

14.7.3 Chart speed or strand-to-chart speed ratio and method of chart calculation.

14.7.4 Sample length, *Ls*. Newer testers automatically report all of the above information except year of instrument manufacture

14.7.5 Average value of evenness obtained as CV% or U%.

14.7.6 Coefficient of variation or standard deviation, or both, if calculated.

14.7.7 Individual thin places, thick places and neps/1000m [1000 yd].

14.7.7.1 Total imperfection count per 1000 m (or 1000 yd).

14.7.7.2 Sensitivity setting of each category of imperfection.

14.7.7.3 Imperfection sensitivity setting for short or long staple fiber.

14.8 Type of test (normal, inert, or other).

15. Precision and Bias

15.1 The precision of this test method is based on an inter-laboratory study of D1425, Standard Test Method for Evenness of Textile Strands Using Capacitance Testing Equipment, conducted in 2009. A total of thirteen laboratories participated in the study. The labs reported four replicate test results on five different types of textile yarns – 100 % cotton, ring spun, 100 % cotton, open-end spun; 50/50 poly/cotton, open-end spun; 100 % cellulosic viscose, ring spun; and, 100 % polyester, open-end spun. The results reported in Table 4 and Table 5 represent the average values, computed from four replicate tests. Practice E691 was followed for the design and analysis of the data; the details are given in an ASTM research report.[3]

15.1.1 *Repeatability Limit (r)*—Two test results obtained within one laboratory shall be judged not equivalent if they differ by more than the "*r*" value for that material; "*r*" is the interval representing the critical difference between two test results for the same material, obtained by the same operator using the same equipment on the same day in the same laboratory.

15.1.1.1 Repeatability limits are listed in the research report.[3]

15.1.2 *Reproducibility Limit (R)*—Two test results shall be judged not equivalent if they differ by more than the "*R*" value for that material; "*R*" is the interval representing the critical difference between two test results for the same material, obtained by different operators using different equipment in different laboratories.

15.1.2.1 Reproducibility limits are listed in the research report.[3]

15.1.3 The above terms (repeatability limit and reproducibility limit) are used as specified in Practice E177.

15.1.4 Any judgment in accordance with 15.1.1 and 15.1.2 would have an approximate 95 % probability of being correct.

15.2 *Bias*—At the time of the study, there was no accepted reference material suitable for determining the bias for this test method, therefore no statement on bias is being made.

15.3 The precision statement was determined through statistical examination of 2060 results (at 400 mpm), from thirteen laboratories, and 640 results (at 800 mpm), from four laboratories, on five different materials.

[3] Supporting data have been filed at ASTM International Headquarters and may be obtained by requesting Research Report RR:D13-1138. Contact ASTM Customer Service at service@astm.org.

TABLE 4 CVm – 400 mpm

Material	Average[A]	Repeatability Standard Deviation		Reproducibility Standard Deviation	Repeatability Limit	Reproducibility Limit
	$\bar{x}$	$S\bar{x}$	S_r	S_R	r	R
100 % Cotton Ring CVm	16.54	0.53	0.90	0.94	2.52	2.63
100 % Cotton OE CVm	13.75	0.29	0.38	0.44	1.08	1.23
50/50 Poly/Cottong Blend OE CVm	14.98	0.12	0.24	0.24	0.67	0.68
100 % Cellulose Viscose Ring CVm	12.52	0.31	0.51	0.54	1.44	1.52
100 % Polyester OE CVm	12.25	0.32	0.35	0.44	0.98	1.24

[A] Average of laboratories calculated averages.

TABLE 5 CVm – 800 mpm

Material	Average[A]	Repeatability Standard Deviation		Reproducibility Standard Deviation	Repeatability Limit	Reproducibility Limit
	$\bar{x}$	$S\bar{x}$	S_r	S_R	r	R
100 % Cotton Ring CVm	16.38	0.78	1.54	1.54	4.32	4.32
100 % Cotton OE CVm	13.50	0.00	0.58	0.58	1.62	1.62
50/50 Poly/Cotton Blend OE CVm	15.00	0.00	0.00	0.00	0.00	0.00
100 % Cellulose Viscose Ring CVm	12.75	0.29	0.58	0.58	1.62	1.62
100 % Polyester OE CVm	12.75	0.20	0.61	0.61	1.71	1.71

[A]Average of laboratories calculated averages.

16. Keywords

16.1 strand; textile; evenness; yarn