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

This standard is issued under the fixed designation D 1425/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

1.1This test method covers the indirect measuring of unevenness of textile strands from tow, top, sliver, roving, and yarn produced from staple fibers and filament yarns by means of continuous runs using capacitance testing equipment.

1.2The test method provides a value of "short-term unevenness," a single value expressing the complicated strand property that is unevenness.

1.3The test method is applicable to all yarns, rovings, slivers, and tops, except as indicated below.

1.3.1Low twist filament yarns should be tested only if additional twist is inserted during testing.

NOTE1—In many cases, low twist yarns tend to flatten to a ribbon while passing through the condenser of the instrument, and the recorded value of unevenness is increased above the true value.

1.3.2Strands made from fiber blends should be tested only if blending is uniform along the strand.

NOTE2—Nonuniform blending may cause a higher reading of unevenness than the true value if the component fibers differ in dielectric constant. The magnitude of the increase of unevenness readings due to nonuniform blending cannot be stated in general terms.

1.4The values stated in either acceptable metric units or in other units shall be regarded separately as standard. The values stated in each system may not be exact equivalents; therefore, each system must be used independently of the other, without combining values in any way.

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]

D 123 Terminology Relating to Textiles

D 1776 Practice for Conditioning and Testing Textiles

D 2258 Practice for Sampling Yarn for Testing[2] Practice for Sampling Yarn for Testing

D 4849 Terminology Related to Yarns and Fibers

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

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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* , Vol 07.01. volume information, refer to the standard's Document Summary page on the ASTM website.

3. Terminology

3.1 *Definitions:*

3.1.1 *coefficient of variation unevenness, CV%*electric constant, *n—in textiles*, the standard deviation of the linear densities over which unevenness is measured expressed as a percentage of the average linear density for the total length within which unevenness is measured. (See also *unevenness, mean deviation unevenness* .) —*in textile capacitance testing*, the change in the electrical field as measured by the sensors (capacitors) of an evenness instrument when a non-conductive textile strand travels between capacitor plates.

3.1.1.1 *Discussion*—The dielectric change is measured as the ratio of the amount of stored energy between the capacitors without a strand and during the movement of a strand through the sensor zone and is in direct proportion to the mass variation that is output to a diagram chart.

3.1.2 *integrator*evenness, CV% (or U%), *n— in textile unevenness testing*, a device that calculates the coefficient of variation unevenness or the mean deviation unevenness. in textiles, the coefficient of mass variation derived from the standard deviation of the mass variation of a specified strand length (L_s) over the mass variation (formerly known as unevenness).

3.1.2.1 *Discussion*—The terms "integrator" and "integration" as applied to textile unevenness testing do not imply integration in the strict mathematical sense. The type integrator, linear or quadratic, must be carefully selected depending upon a known irregularity of the material; that is, purely random or purely periodic.

3.1.3*length between, L_b*—For strands with normal mass variation distribution, the relationship between CV% and U% is U% is multiplied by 1.25. Although both CV% and U% are used as values of evenness, CV% is considered more accurate CV% is gradually replacing U% as the only calculated measurement of evenness.

3.1.3 *imperfections*, *n—in textile unevenness testing*, the length between which unevenness is measured; the equivalent of the length of strand segments weighed in a direct method of measuring unevenness.

3.1.4*length within, L_w*, *in textile evenness testing*, the individual number of thick places, thin places, and neps of a sample strand length measured by a capacitive evenness tester at selected sensitivity settings.

3.1.4 *length between, L_b*, , *n—in textile unevenness testing*, the length over which unevenness is measured.

3.1.4.1*Discussion*—The total length of the strand from which the segments weighed were sampled in a direct method of measuring unevenness. For indirect methods, the maximum value of length within is the tested length from the specific package.

3.1.5*linear integrator*in textile evenness testing, the length of strand segments weighed to determine evenness for the direct method (cut & weigh) of measuring evenness.

3.1.5 *length capacitance zone, L_c*, *n— in textile unevenness testing*, an integrator that operates continuously and reports unevenness for a certain, and unchanging, time past. —, the width of the measurement field of the capacitive sensor.

3.1.5.1 *Discussion*—The input to the integrator immediately preceding the moment of taking a reading receives greater "weight" than the prior input, and this "weighting" gradually decreases with the lapse of time. (*Syn.* fading memory integrator)

3.1.6*mean deviation unevenness, U%*—The capacitive sensor measurement field determines the length between the indirect method of evenness testing. The Lc is the length of strand being measured between the sensing elements at any moment. L_c is analogous to L_b of the direct method.

3.1.6 *mass variation*, *n—in textiles*, the average of the absolute values of the deviations of the linear densities of the integrated lengths between which unevenness is measured and expressed as a percentage of the average linear density for the total length within which unevenness is measured. (See also *unevenness, coefficient of variation unevenness*.) in textile evenness testing, the changes of the cross sectional mass along the length of a continuous strand or of a portion of a strand.

3.1.7 *quadratic integrator*mean deviation of evenness U%, *n—in textile unevenness testing*, an integrator that operates continuously and reports unevenness for the time during which it has been active, giving equal weight to all portions of the input. (*Syn.* compensated-memory integrator) in textiles, the average of the absolute values of the deviations of the linear densities of the integrated lengths between which evenness is measured and expressed as a percentage of the average mass variation for the total sample length over which evenness is measured.

3.1.8 *strand*sample length, L_s, *n*—(1) a single fiber, filament, or monofilament, (2) an ordered assemblage of textile fibers having a high ratio of length to diameter and normally used as a unit, including slivers, rovings, single yarns, plied yarns, cords, braids, ropes, etc. —*in textile evenness testing*, the length determined by multiplying the test instrument's speed and the time of the test run.

3.1.8.1 *Discussion*—The total length of the strand from which the segments are weighed determines sample length by the direct method, e.g. the variation in segments weight. For the indirect method for measuring evenness, the sample length L, is the variation of the segment with respect to the average mass.

3.1.9 *strand irregularity*strand, *n— in textiles*, variation in a property along a strand. —(1) monofilament or multifilament yarns; (2) an ordered assemblage of textile fibers having a high ratio of length to diameter and normally used as a unit, including sliver, roving, single yarns, plied yarns, cords, braids, and ropes.

3.1.10 *unevenness*strand irregularity, *n—in textiles*, variation in the linear density of a continuous strand or of a portion of a strand. (See also *coefficient of variation unevenness, mean deviation unevenness*.) , the variation in a property along a strand.

3.1.11 *unit length of instrument, L_c*total imperfections, *n—in textile unevenness testing*, the length of strand being measured between the sensing elements at any moment. in textile evenness testing, an evenness value that is the cumulative number thicks, thins, and neps from a tested strand, strands from a sample, or lot sample.

3.1.12 For definitions of other textile terms used in this test method, refer to Terminology D 123 and Terminology D 4849.

4. Basic Principles of Test Method

4.1Properties of a strand vary along its length and these variations are termed strand irregularity. The variation of one specific property, linear density, is termed unevenness. This method is concerned with measuring the unevenness of a textile strand.

4.2Unevenness is always expressed as between successive lengths and over a total length. When the length between which unevenness is measured (L_b) is very short, 8 mm (0.3 m) for yarn and roving and 12 mm (0.5 m) for slivers, then reference is often made to short-term unevenness.

4.3Unevenness can be measured by direct method or indirect methods. The direct method consists of cutting and weighing strand segments of length L_b and is the reference method of determining unevenness. Unevenness testing instruments, as covered in Method D1425, use the indirect method where unevenness is determined by the measurement of strand properties closely related to and dependent on linear density. The accuracy of the indirect method and of an instrument utilizing it can be judged by a comparison of the value of unevenness it gives with one obtained by the direct method of cutting and weighing.

4.4The unevenness testing instruments measure those properties of the strand which change the capacitance when the strand passes between the plates of a capacitor.

4.5A number of mathematical concepts are used to express the unevenness of a strand. They are all based on the coefficient of variation or its square. There is, therefore, some advantage in using an unevenness testing instrument that gives the coefficient of variation and thereby fits into the general mathematical scheme.

4.6If the method is followed exactly and the testing instrument has been adjusted to eliminate bias in the results, then unevenness values obtained on different instruments will agree for the same strand, or will be comparable for different strands, provided that the following are the same in all cases: (*1*) the measure of unevenness used (see 3.1.5 and 3.1.6); (*2*) the length between, L_b (see 3.1.3); and (*3*) the length within, L_w (see 3.1.4). When different models of instruments are used, then one or more of the three items are often not identical and the test results may differ from instrument to instrument.

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 L_c.

5. Summary of Test Method

5.1A strand is passed through the sensing device of the evenness tester at constant speed and a momentary value proportional to the linear density of the strand is recorded. The instruments are equipped with an integrator that calculates the unevenness automatically and the value is read while the strand is passing through the instrument after 40 m 50 yd of yarn have been tested.

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 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

6.1Test Method D1425 for the determination of unevenness of textile strands is considered satisfactory for acceptance testing of commercial shipments of filament or spun yarn, roving, sliver, tow, or top since the method has been used extensively in the trade for acceptance testing.

6.1.1In case of a dispute arising from differences in reported test results when using Test Method D1425 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 test specimens that are as homogenous as possible and that are from a lot of material of the type in question. The test specimens should then be randomly assigned in equal numbers to each laboratory for testing. The average result from the two laboratories should be compared using appropriate statistical analysis for unpaired data and an acceptable probability level chosen by the two parties before the testing is begun. If a bias is found, either its cause must be found and corrected or the purchaser and the supplier must agree to interpret future test results with consideration to the known bias.

6.2The interpretation of results of unevenness tests is a complex matter and a detailed discussion is outside the scope of Method D1425. Unevenness is a fundamental feature of yarn construction and influences many properties of the yarn. Unevenness cannot

~~be fully expressed as a single number and various methods exist for a more complete presentation. The value for short-term unevenness determined as directed in this method provides a single number of either CV% or U% which is related to the unevenness of the strand.~~

~~6.3A value of short-term unevenness is useful in quality control, in research, and in a first appraisal of a strand, namely filament or staple yarn, staple roving, sliver, or top, that is an article of commerce. A low unevenness is, in general, preferred. Higher unevenness is generally associated with more difficult processing, lower yarn strength, and poorer fabric appearance. Experience has shown, however, that the relationship of short-term unevenness to performance of the yarn or to fabric appearance is not a simple one. A value of short-term unevenness must, therefore, be used cautiously and should, if possible, be supplemented by additional information on unevenness, such as chart evaluation and spectrogram analysis.~~

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 6.3 6.4 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; (2) the capacitive length zone L (see 3.1.5 and 3.1.5.1); (3) the sample length, Ls (see 3.1.8); (4) instrument test speed, (5) laboratory temperature and humidity conditions (see 12.1 and 12.1.1); and (6) test specimen variation. When different models of an instrument are used, and one or more of the six parameters are not identical, test results may differ.

6.2 Values of strand evenness are also used in quality control, process optimization, and together with yarn strength measurements, is the first appraisal of a strand's quality. A low evenness value is, in general, preferred. Higher evenness values generally indicate difficult spinning, 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 instruments specifically designed to them.; failure to do so will result in inaccurate test results. Further, low-twist, continuous yarns tend to flatten to a ribbon configuration while passing through the condenser of a capacitance instrument. These specific instruments are designed to insert false twist in the condenser during testing to overcome the flattening effect and may result in false variation readings.

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 (see 3.1.1 and 3.1.1.1).

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; (2) the capacitive length zone L (see 3.1.5 and 3.1.5.1); (3) the sample length, Ls (see 3.1.8); (4) instrument test speed, (5) laboratory temperature and humidity conditions (see 12.1 and 12.1.1); and (6) test specimen variation. When different models of an instrument are used, and one or more of the six 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 test should be performed using competent statistical assistance and an agreed upon number of samples that are homogeneous and randomly assigned, should be used to determine if there is a statistically significant difference between them. 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 Unevenness Testing Instruments*~~—All models of unevenness testing instruments use automatic integrators. Certain models of instruments are provided with a standardizing tape for checking the functional operation of the equipment, and certain models of instruments contain a built in electronic checking system.~~

~~NOTE3—The length between, L_b, is usually equal to unit length L_c; however, a damping circuit permits, L_b, to be increased above, L_c.~~

~~7.1.1*Package Holders, Guides, Tension Devices, and Take-Up Mechanism*, which allow for, or assist in, uniform delivery of the strand at the specified speed without undue acceleration or deceleration and at a reasonably constant tension.~~

~~7.1.2*Recorder*, to give a permanent chart record of the test details and to depict the unevenness. It is a means to record all unevenness.~~

~~7.2System for imparting false twist into low-twist filament yarn while it passes between the sensing elements and provides a constant tension on the yarn.~~ —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, 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 in the condenser zone of an evenness testing instrument that inserts false twist into continuous filament yarns