Designation: D 1425 – 96

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

This standard is issued under the fixed designation D 1425; 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 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.

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

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

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

NOTE 1—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.

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

NOTE 2—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.

1.4 The 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.

1.5 *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:*

D 123 Terminology Relating to Textiles[2]

D 2258 Practice for Sampling Yarn for Testing[2]

3. Terminology

3.1 *Definitions:*

3.1.1 *coefficient of variation unevenness, CV%, 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*.)

3.1.2 *integrator, n—in textile unevenness testing*, a device that calculates the coefficient of variation unevenness or the mean deviation 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, 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, 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, n—in textile unevenness testing*, an integrator that operates continuously and reports unevenness for a certain, and unchanging, time past.

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%, 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*.)

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

3.1.7 *quadratic integrator, 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)

3.1.8 *strand, 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.

3.1.9 *strand irregularity, n—in textiles*, variation in a property along a strand.

3.1.10 *unevenness, 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*.)

3.1.11 *unit length of instrument, L_c, n—in textile unevenness testing*, the length of strand being measured between the sensing elements at any moment.

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

4. Basic Principles of Test Method

4.1 Properties 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.

4.2 Unevenness 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.

4.3 Unevenness 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 D 1425, 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.

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

4.5 A 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.

4.6 If 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.

5. Summary of Test Method

5.1 A 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.

6. Significance and Use

6.1 Test Method D 1425 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.

6.1.1 In case of a dispute arising from differences in reported test results when using Test Method D 1425 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.

6.2 The interpretation of results of unevenness tests is a complex matter and a detailed discussion is outside the scope of Method D 1425. 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.

6.3 A 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.

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.

NOTE 3—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.

7.2 System for imparting false twist into low-twist filament yarn while it passes between the sensing elements and provides a constant tension on the yarn.

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 D 2258.

9. Number of Specimens

9.1 Test one specimen from each package. The recommended evaluating test times and strand speeds are listed in Table 1.

10. Conditioning

10.1 The strand to be tested must have a uniform moisture content along its length. Atmospheric conditions must therefore be stable and the strand must be in equilibrium with the prevailing atmosphere. To satisfy this condition, testing should be carried out after thorough conditioning in the standard atmosphere for testing textiles. Preconditioning is generally not advisable as it prolongs the time required for conditioning.

10.2 The time required for conditioning depends on the fiber and on the size and compactness of the package. Also, a shorter conditioning time is sufficient if only the outside layer of a package is to be tested for unevenness than if the whole package is to be used for testing. As a general guide, condition tightly wound packages for 48 h and strands in loose form for 24 h.

11. Selection of Testing Parameters

11.1 *Measure of Unevenness*—A choice between CV% and U% is possible only when the chart is used for the evaluation of unevenness. When unevenness is evaluated automatically, then the selection of CV% or U% depends on the type of integrator that is available with the unevenness testing instrument.

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, roving, or yarn	25 m/min (25 yd/min)	5 or 10 min
Roving or yarn	50 m/min (50 yd/min)	5 min
Yarn	100 m/min (100 yd/min)	2.5 or 5 min
Yarn	200 m/min (200 yd/min)	1, 2.5, or 5 min
Yarn	400 m/min (400 yd/min)	2.5 min

NOTE 4—Unevenness values are not comparable unless the same expression for unevenness is used. Conversion factors between CV% and U% have been proposed, but they are approximations only and their use is not recommended.

11.2 *Length Between and Length Within*—The possibilities of selecting L_b and L_w are limited by the design of the unevenness testing instrument. The unevenness value obtained from testing depends on both L_b and L_w; unevenness decreases rapidly when L_b increases and increases slowly when L_w increases. Therefore, if unevenness values are to be comparable, L_b and L_w must be the same for all the tests to be compared.

11.2.1 *Length Between*—L_b is usually equal to L_c (unit length of the instrument) and is determined by the instrument used. In all evenness testing instruments, the circuit allows L_b to be increased above L_c. The use of a longer L_b frequently assists visual inspection of an autographic unevenness chart by the suppression of short-term peaks, since the longer term periodicities can be observed more readily. Such an increased setting of L_b is referred to as a dampened or inert setting.

NOTE 5—When unevenness is determined by cutting and weighing, then L_b can be selected at will. As an example, in the determination of the linear density of sliver, L_b is frequently 1 m or 1 yd, while in the determination of the linear density of yarn, it is frequently 100 m or 120 yd.

11.2.2 *Length Within*—More freedom of choice is available in the selection of L_w than in the selection of L_b. In the determination of CV% or U%, the longer L_w is, the longer short term unevenness is included in the unevenness value obtained. The minimum length that should be tested is 40 m or 50 yd.

11.2.2.1 When determining unevenness from the chart, L_w can be selected at will. It is equal to the strand-to-chart speed ratio multiplied by the evaluated chart length if either CV% or U% is being determined.

11.3 *Strand Speed*—The choices of speeds of travel of the strand are 4, 8, 25, 50, 100, 200, and 400 m/min or 4, 8, 25, 50, 100, 200, and 400 yd/min.

11.3.1 The speed of travel must not be excessive for the type of strand under test. Stretching of the strand must be held to a minimum. Yarns can normally be tested at higher speeds than yarn intermediates such as slivers or rovings. Normally, slivers and tops are tested at 25 m/min or 25 yd/min, rovings at 50 m/min or 50 yd/min, and yarns at either 100, 200, or 400 m/min, or 100, 200, or 400 yd/min.

11.4 *Chart Speed*—If the chart is used for the evaluation of unevenness, then the ratio of speed of travel of the strand to chart speed shall be small enough to show up the smallest period of fluctuation.

12. Procedure

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

12.1.1 If a standard atmosphere is not available, test in a stable atmosphere after the sample or strand has reached equilibrium.

12.2 Calibrate the unevenness testing instrument as prescribed by the instrument manufacturer (see 7.1).

12.3 Mount the package on a suitable holder. Thread the free end of the strand through the sensing elements of the tester and through the take-up mechanism (see 7.1.1). If a low twist yarn is to be tested, pass it through a device imparting false twist (see 7.2).

NOTE 6—Do not separate the length of strand to be tested from the packages prior to testing.

12.4 Set the take-up mechanism to the speed of travel recommended for the tester unless otherwise agreed upon by purchaser and supplier (see 11.3.1). If a recorder is used, set it to the appropriate speed or to the required strand-to-chart speed ratio (see 11.4).

12.5 Start the take-up mechanism of the tester and recorder, if used. Adjust the controls of the tester to record on the central part of the recorder chart or on the central part of the instrument meter, or both.

12.6 Turn on the integrator. Test the strand (see Table 1) in one uninterrupted run unless otherwise agreed upon by the purchaser and supplier. Record the meter unevenness value.

12.7 Follow the unevenness tester instruction manual for operational procedures not outlined in this test method.

13. Calculation

13.1 The CV% and U% can be estimated from the chart by converting the line of the record into a frequency distribution. U% can also be estimated by the use of a planimeter. Normally, however, CV% or U% will be read from the integrator (see 12.6).

13.2 If more than one value of CV% or U% is obtained for individual packages, then calculate the average of values of unevenness for each package.

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

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

14. Report

14.1 State that the specimens were tested as directed in Test Method D 1425. Describe the material or product sampled and the method of sampling used.

14.2 Report the following information:

14.2.1 Number of specimens tested,

14.2.2 Describe the test apparatus used including the make, model, year, and type of integrator, if used,

14.2.3 Strand travel speed,

14.2.4 Length of specimen tested,

14.2.5 Chart speed or strand-to-chart speed ratio and method of chart calculation, if chart is used,

14.2.6 The values of length between, L_b, and length within, L_w.

NOTE 7—The preferred way of writing the unevenness is to put L_b and L_w values in parentheses (L_b, L_w) after CV% or U%.

Example—CV (8 mm, 100 m) to be read as follows:" coefficient of variation unevenness between 8 mm lengths within 100-m lengths."

14.2.7 Atmospheric conditions used; if not standard,

14.2.8 Average value of unevenness obtained as CV% or U%,

14.2.9 Coefficient of variation or standard deviation, or both, if calculated, and

TABLE 2 Components of Variance as Standard Deviation, cv %[A]

Yarn	Single-Operator Component	Within-Laboratory Component	Between-Laboratory Component
12/1 50/50 polyester/rayon	0.527	0.000	0.635
12/1 100 % polyester	0.694	0.180	0.806
20/1 100 % polyester	1.108	0.000	0.780
37/1 100 % cotton	0.235	0.162	0.520

[A] The square roots of the components of variance are being reported to express the variability in the appropriate unit of measure rather than as the square of that units of measure.

15. Precision and Bias [3]

15.1 *Interlaboratory Test Data*—An interlaboratory test was run in 1987 in which one package each of four yarns was tested in seven laboratories as directed in Practice D 2904. Each of the laboratories used two operators, each of whom tested each yarn on two different days. The samples used in this interlaboratory test were drawn from the same producing positions at the plants where they were spun. The yarns are:

12/1 50/50 polyester/rayon
12/1 100 % polyester
20/1 100 % polyester
37/1 100 % combed cotton

The components of variance expressed as standard deviations are listed in Table 2.

15.2 *Precision*—For the components of variance reported in Table 2, the average of two observed values should be considered significantly different at the 95 % probability level if the difference equals or exceeds the critical differences listed in Table 3.

15.3 *Bias*—The procedure in Test Method D 1425 for measuring the unevenness of textile strands has no bias when values obtained with properly calibrated instruments are checked against values obtained by cutting and weighing successive short segments of a textile strand.

16. Keywords

16.1 strand; textile; unevenness; yarn

[3] A research report is available from ASTM Headquarters. Request RR: D-13-1079.

TABLE 3 Critical Values for the Conditions Noted, 95 % Probability Level

Number of Observations in Each Average	Single-Operator Precision	Within-Laboratory Precision	Between-Laboratory Precision
	12/1 50/50 Polyester/Rayon		
1	1.461	1.461	2.287
2	1.033	1.033	2.041
4	0.730	0.730	1.905
8	0.516	0.516	1.834
16	0.365	0.365	1.797
	12/1 100 % Polyester		
1	1.923	1.987	2.990
2	1.360	1.449	2.662
4	0.962	1.083	2.483
8	0.680	0.843	2.388
16	0.481	0.693	2.339
	20/1 100 % Polyester		
1	3.071	3.071	3.755
2	2.171	2.171	3.064
4	1.535	1.535	2.651
8	1.086	1.086	2.419
16	0.768	0.768	2.294
	37/1 100 % Cotton		
1	0.651	0.791	1.644
2	0.461	0.643	1.578
4	0.326	0.555	1.544
8	0.230	0.505	1.527
16	0.163	0.478	1.518