Designation: D 1422 – 99

Standard Test Method for Twist in Single Spun Yarns by the Untwist-Retwist Method[1]

This standard is issued under the fixed designation D 1422; 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[2] describes the determination of twist in single spun yarns when only an approximation of the true twist is required.

NOTE 1—For a more accurate method see Test Method D 1423.

1.2 This test method is applicable to spun single yarns in continuous lengths, and also to spun yarns raveled from fabrics, provided specimens at least 200 mm (8 in.) long can be obtained.

1.3 The values stated in either inch-pound or SI units are to be regarded separately as standard. Within the text, the SI units are shown in parentheses. The values stated in each system are not exact equivalents; therefore each system shall be used independently of the other. Combining values from the two systems may result in nonconformance within this test method.

1.4 This test method has been found satisfactory for use in determining twist in all single ring spun yarns and 100% cotton open-end yarns. For all open-end spun yarns that are not 100 % cotton this test method has not been found to be satisfactory for determining twist but may be used to measure deviation from an average value.

1.5 This specification shows the values in both inch-pound units and SI units. The "inch-pound" units is the technically correct name for the customary units used in the United States. The "SI" units is the technically corrected name for the system of metric units known as the International System of Units. The values stated in either acceptable metric units or in other units shall be regarded separately as standard. The values expressed in each system may not be exact equivalents; therefore, each system must be used independently of the other, without combining in any way.

1.6 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility 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[3]

D 1059 Test Method for Yarn Number Based on Short-Length Specimens[3]

D 1423 Test Method for Twist in Yarns by the Direct-Counting Method[3]

D 2258 Practice for Sampling Yarn for Testing[3]

3. Terminology

3.1 *Definitions:*

3.1.1 *direction of twist*, *n*—the right or left direction of the helix formed in a twisted strand as indicated by superimposition of the capital letter "S" or "Z."

3.1.1.1 *Discussion*—Yarn has **S** twist if, when the yarn is held in a vertical position, the visible spirals or helices around its central axis conform in direction of slope to the central portion of the letter" S," and **Z** twist if the visible spirals or helices conform in direction of slope to the central portion of the letter "Z." When two or more yarns, either single or plied, are twisted together, the letters "S" and "Z" are used in a similar manner to indicate the direction of the last twist inserted.

3.1.2 *single yarn*, *n*—the simplest strand of textile material suitable for operations such as weaving, knitting, etc.

3.1.2.1 *Discussion*—A single yarn may be formed from fibers with more or less twist; from filaments with or without twist; from narrow strips of materials such as paper, cellophane, or metal foil; or from monofilaments. A yarn which is either twistless or can be rendered twistless in a single untwisting operation. When twist is present, it is usually all in the same direction.

3.1.3 *spun yarn*, *n—in a staple system*, a continuous strand of fibers held together by some binding mechanism.

3.1.3.1 *Discussion*—The binding mechanism most commonly used in spun yarns is twist. Other useful mechanisms that are used are chemical additives, wrapping, entanglement, or some combination of these. Test Method D 1422 is applicable only to yarns which have twist.

3.1.4 *twist*, *n—in textile strands*, the helical or spiral configurations induced by turning a strand about its longitudinal axis.

---

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

Current edition approved Nov. 10, 1999. Published January 2000. Originally published as D 1422 – 56 T. Last previous edition D 1422 – 92.

[2] This test method is commonly designated by the less precise term" Untwist-Twist Method."

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

3.1.4.1 *Discussion*—Twist is usually expressed as the number of turns about the axis that are observed in a specified length either metres (tpm) or inches (tpi).

3.1.5 *twist factor,* TF, *n*—the product obtained when the twist expressed in turns per centimetre is multiplied by the square root of the yarn number expressed in tex:

$$\text{Twist factor (TF)} = \text{tpcm} \times \sqrt{T} \quad (1)$$

where:

T = yarn number expressed in tex.

3.1.5.1 *Discussion*—Twist multiplier and twist factor are a measure of the "twist hardness" of yarn because they are approximately proportional to the tangent of the angle between fibers on the outer yarn surface and the axis of the yarn; the larger this angle, the harder the twist. Furthermore, this angle is a function of both the twist content (turns per unit length) and the number of fibers per yarn cross section (yarn number). Hence, twist content alone cannot provide a measure of the twist hardness of a yarn. Twist multiplier and twist factor are proportional to each other and differ only in the units used. The two are related by Eq 2 and Eq 3:

$$TF = k \times TM \quad (2)$$

$$k = 277.29/\sqrt{L} \quad (3)$$

where:

L = length in yards of the hank used to define the indirect yarn number of the type,

N = hanks/lb. In particular for cotton count,

k = 9.567 so that Eq 2 becomes Eq 4:

$$TF = 9.567 \times TM \quad (4)$$

3.1.6 *twist multiplier,* TM, *n*—the quotient of the twist expressed in turns per inch and the square root of the yarn number in an indirect system.

$$\text{Twist multiplier (TM)} = \text{tpi}/\sqrt{N} \quad (5)$$

where:

N = yarn number in an indirect system, the cotton system unless otherwise specified.

3.1.7 *yarn*, *n*—a generic term for a continuous strand of textile fibers, filaments, or material in a form suitable for knitting, weaving, or otherwise intertwining to form a textile fabric.

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

4. Summary of Test Method

4.1 A specimen is untwisted and then retwisted in the opposite direction until it contracts to its original length. It is assumed that the same amount of twist has been inserted as was originally present. Twist, as turns per unit length, is calculated as half the number of turns registered on the counter divided by the specimen length.

5. Significance and Use

5.1 This test method is used for acceptance testing in the trade for economic reasons even though it is less accurate than the direct method, Test Method D 1423.

5.1.1 If there are differences or practical significance between reported test results for two laboratories (or more), comparative tests should be performed to determine if their is a statistical bias between them, using competent statistical assistance. As a minimum, the test samples should be used that are as homogeneous as possible, that are drawn from the material from which the disparate test results are obtained, and that are assigned randomly in equal numbers to each laboratory for testing. Other materials with established test values may be used for this purpose. The test results from the two laboratories should be compared using a statistical test for unpaired data, at a probability level chosen prior to the testing series. If a bias is found, either its cause must be found and corrected, or future test results must be adjusted in consideration of the known bias.

5.2 The "setting" of twist in some fibers causes excessive contraction when the yarn is retwisted in the reverse direction. Therefore, the number of turns required to bring the specimen back to its original length may be less than the number of turns removed in untwisting. This effect may be partially offset by the use of higher pretensioning loads; but this increases the danger of stretching the yarn. Little information is available on the correct tensions to use for yarns made from different fibers or with different amounts of twist.

5.3 In addition to being less tedious, this test method requires fewer specimens than the direct-counting method and the results may be sufficiently accurate for certain purposes. This test method can be useful in those cases where the main objective is to measure variations from an average value. Another possible application is where a large amount of twist testing is required on yarns of similar type and twist. In this case preliminary tests comparing this method and the direct method could be used to determine the correct pretension.

5.4 Twist has important effects on the physical properties of yarn. Low-twist yarn is lofty and is usually preferred for knitting because of its softness, covering power, and warmth. Increasing the amount of twist causes an increase in yarn strength by increasing fiber cohesion, but as the twist angle increases beyond an optimum point, strength decreases due to a loss in effective fiber contribution. Maximum yarn strength is obtained by inserting a medium amount of twist to obtain an optimum balance between these two opposing forces. High twist produces yarns of high density ("hard" or "wiry") and high elongation and may improve the abrasion and impact resistance of fabrics.

5.5 The optimum twist for either manufacturing efficiency or physical properties usually increases as staple length decreases.

5.6 The twist in a yarn before it is packaged may be different from that of the yarn after it has been withdrawn from the package because of changes in tension and the effect of the method of withdrawal. If the yarn is withdrawn over-end, a slight increase or decrease in twist will take place, depending upon the direction of the twist in the yarn, the direction of winding on the package, and the length of the turn (or wrap) on the package.

NOTE 2—The difference in twist between unwinding from the side and over-end is $1/\pi d$, where d is the diameter of the package.[4] Thus, for a 25-mm (1-in.) diameter package, the difference would be about 13 tpm or about one third tpi.

5.7 When a yarn is taken from a more complex yarn structure or from a fabric, the resultant twist should be considered only an approximation of the original value because of alterations that may have occurred as a result of the effects of unwinding, handling, and mechanical strains met in processing.

6. Apparatus

6.1 *Twist Tester*, consisting of a pair of clamps, one of which is rotatable in either direction and positively connected to a revolution counter. The tester may be hand- or power-driven. The position of one clamp (or both clamps) shall be adjustable to accommodate specimens having the length prescribed in 10.2. The tester shall be provided with a variable tensioning device so constructed that a specific force may be applied to the specimen at the beginning and end of the test and removed completely during the intervening untwisting and twisting operations.

6.2 Dissecting needle or stylus.

6.3 Metal ruler to verify gage length (accurate to 2 mm or 0.1 in.).

7. Sampling

7.1 *Lot Sample*—Select one or more shipping units taken at random to represent an acceptance sampling lot and used as a source of laboratory samples.

7.2 *Laboratory Sample*—For packaged yarns, take a minimum of five packages for the laboratory sample unless otherwise agreed upon between purchaser and seller. For yarns from woven or knitted fabrics, the sample must be large enough to furnish specimens of the length and number specified in 7.3.3.

7.3 *Selection of Specimens*:

7.3.1 As nearly as possible take an equal number of specimens from each package or unit of the laboratory sample. Take the specimens from each package in a random manner to minimize the effect of cyclic variations introduced during manufacturing processes. When preparing specimens, conditioning them, or inserting them in the tester, take care to avoid any change in twist.

7.3.2 For packaged yarns, remove and discard the first 25 m (25 yd) of yarn. Using a minimum of tension, take specimens at random intervals greater than 1 m (1 yd) along the yarn. Withdraw the yarn from the package in the direction of normal use, either from the side or over-end, if known. If the direction is not known, withdraw the yarn from the side (Note 2). When more than five specimens are taken from an individual package, take groups of five or less at intervals of several yards. Do not cut the specimen free from the package or from the yarn to be discarded until after the yarn is secured in the clamps of the twist tester. When possible, take the specimen from near the center of the traverse and not at the traverse reversals.

7.3.3 For woven fabric, take warp specimens from separate ends, since each represents a separate package. Because the fabric may have been woven on any of a variety of looms which are random quilling, sequential quilling or shuttleless, take filling specimens at random through the whole laboratory sample to obtain as representative data as possible. If a strip about 2 m (2 yd) long is used as a source of specimens.

7.3.4 For weft-knit fabric known to be multi-feed, take specimens from successive courses in one portion of laboratory sample. For weft-knit fabric known to be single-feed or for which the type of feed is not known, take specimens at random from the whole sample.

7.3.5 For warp-knit fabrics, cut a walewise strip from which specimens can be raveled for testing as needed (Note 3). Cut strips from which the test specimens can be raveled for testing as needed (Note 4). Cut these strips to provide yarn specimens at least 75 mm (3 in.) longer than the specimen length and to contain more than the required number of specimens for test. If several strips are cut, divide the number of specimens among the strips as nearly equally as possible. Use care to avoid loss of twist prior to testing.

NOTE 3—In order to minimize changes in twist, specimens should not be unraveled from the strips until they are to be placed in the twist tester.

7.4 *Number of Specimens*:

7.4.1 *Spun Yarn Singles*—Take 25 specimens from each laboratory sampling unit of spun yarn singles.

8. Conditioning

8.1 Conditioning is not required for this test method.

9. Procedure

9.1 *To Determine Twist*:

9.1.1 Check the twist tester to be sure that the longitudinal play and radial play of the clamp assemblies are small enough to secure the required precision.

9.1.2 Determine the twist with the precision stated in the following table:

Turns of Twist in Test Specimen (tpm or tpi) × Length (metres or inches)	Precision, in revolutions
5 or less	0.1
Over 5 through 15	0.5
Over 15	1.0

9.1.3 If yarns that extend more than 5.0 % when tension is increased from 2.5 to 7.5 mN/tex (0.25 to 0.75 gf/tex) are to be tested, they must be tensioned by the application of load that produces an extension not greater than 5.0 %. The tension used in these exceptional cases should be agreed upon by all persons interested in the test results.

9.1.4 When the nominal yarn number is not known determine the yarn number of the sample as directed in Test Methods D 1059 or D 1907.

9.2 As agreed, or specified, use a gage length of 250 mm (10 in.), or 125 mm (5 in.). Set the clamps of the twist tester at the specified gage length with an accuracy of ±1.0 mm (±0.05 in.).

9.3 Set the counter at zero. Mount the yarn specimen in the twister clamps, adjusting the tensioning device for the selected tension (Note 5) on the specimen as directed in 9.3.1 or 9.3.2.

[4] Woods, H. J., "The Kinematics of Twist, I, The Definition of Twist," *Journal of Textile Science*, JTBIA, Vol 4, 1931, pp. 33–36.

NOTE 4—Selection of the proper tension to use presents difficulties, since the effects of tension vary with different yarns. Trial-and-error methods are suggested for selecting the proper tension to obtain agreement between this method and Test Method D 1423 for any particular yarn. Preliminary tensions in the range from 2.5 to 5.0 mN/tex (0.25 to 0.5 gf/tex) may be tried.

9.3.1 *End-Tensioning Procedure*—Secure one end of the specimen in the nonrotatable clamp and insert the other end of the yarn through the rotatable clamp leaving it open temporarily. Pull the yarn extending through the open clamp until the pointer attached to the nonrotatable clamp has reached the predetermined position for the required tension. Tighten the rotatable clamp securely while the pointer is in this position. Cut off the long end of the yarn, leaving less than 25 mm (1 in.) protruding through the rotatable lamp. Revolve the rotatable clamp in the direction which untwists the specimen, releasing the tension as soon as the specimen starts to elongate. Continue the rotation in the same direction, removing the original twist and imparting twist to the specimen in the direction opposite to the original twist. Reapply the tension when sufficient turns have been reinserted to prevent slippage of the fibers. Continue to reinsert twist until the indicator has returned to its initial position, when the specimen is assumed to have its original length and tension.

9.3.2 *Standard Deflection Procedure*—Position the single end twist attachment and adjust the upper base line before starting. Secure one end of the specimen in the nonrotatable clamp and insert the other end of the yarn through the open rotatable clamp. Apply the selected tension (Note 5) to the approximate midpoint of the specimen. Pull or slacken the yarn extending through the open clamp until the yarn sags a distance of 3 mm (0.125 in.) from the horizontal at the point of application of the load. Tighten the rotatable clamp and remove the applied load from the specimen. Cut off the long end of the yarn, leaving less than 25 mm (1 in.) protruding back of the rotatable clamp. Revolve the rotatable clamp in the direction which untwists the specimen, continuing the rotation in the same direction beyond the zero twist reading. When a sufficient number of turns have been inserted to prevent slippage of the fibers, reapply the tensioning load and continue twisting until the deflection of 3 mm is again observed.

NOTE 5—Approximately twice as much tension must be used with a 125-mm (5-in.) gage length as compared with a 254-mm (10-in.) gage length to obtain the same 3 mm deflection of the point of load on the yarn.

9.4 Record the number of counter turns observed in 9.3.1 or 9.3.2 and the direction of twist, S or Z.

9.5 *Testing Yarn from Fabric*—Remove yarns from fabrics as directed in 9.5.1, 9.5.2, 9.5.3, or 9.5.4 and test for twist as directed in 9.3 and 9.4. Use care to avoid loss of twist prior to testing.

9.5.1 Ravel and discard a few yarns from the laboratory sample until specimens of the required length are obtained. Without loss of twist, ravel about 50 mm (2 in.) of the next yarn and fasten this end in the nonrotatable clamp of the twist tester. Pull the specimen gently out of the fabric sidewise, taking care not to stretch it. Thread the other end through the rotatable clamp and, after adjusting the specimen to the specified length and tension, close the rotatable clamp. Proceed as directed in 9.3.1 or 9.3.2.

9.5.2 In testing filling yarns, test one tenth of the required number of specimens, then cut off and discard one tenth of the length of the strip of fabric and test another tenth of the required number of specimens. Continue in this way until the required number of specimens have been tested. If a strip about 2 m (2 yd) long is used as a source of specimens, this procedure will usually provide specimens from several different bobbins of filling yarn. Since each warp end represents a different package of warp yarn, adjacent warp ends may be tested consecutively without discarding any warp ends between those tested. Keep the fringe clipped to avoid stretching yarns being removed. The smallest sample from which both warp and filling yarns can be tested is a piece approximately 200 mm (8 in.) square. In this case, ravel half of the required number of specimens from each edge of the sample, taking care to identify the warp and filling edges by suitably marking the middle portion of the sample. Proceed as directed in 9.3.1 and 9.3.2.

9.5.3 Cut weft-knit fabric along a course line. Clean the raveling edge to obtain a raveled yarn at least 75 mm (3 in.) longer than the specimen length. Take yarns for testing as specified in 7.3.4.

9.5.4 Ravel sufficient lengths of warp-knit yarns for testing from strips as directed in 7.3.5.

9.6 Determine the amount of twist in specimens taken from knitted fabrics as directed in 9.3.1 and 9.3.2.

10. Calculation and Results

10.1 Calculate the twist as turns per metre to the nearest whole number or turns per inch to one decimal, using Eq 6:

$$T = R/2L \tag{6}$$

where:

T = twist, tpi (tpm),
R = counter reading,
½ = correction for twist-retwist, and
L = specimen length, m (or in.).

10.2 Calculate the average twist for each sample.

10.3 Calculate the standard deviation coefficient of variation, if requested.

11. Report

11.1 State that the specimens were tested as directed in Test Method D 1422. Describe the material or product sampled and the method of sampling used.

11.2 Report the following information:

11.2.1 Average turns per metre or turns per inch.

11.2.2 Standard deviation and coefficient of variation, if calculated,

11.2.3 Direction of twist,

11.2.4 Gage length used, and

11.2.5 Procedure used for tensioning the specimen and the amount of tension or force used.

12. Precision and Bias

12.1 *Interlaboratory Test Data+*—An interlaboratory test was run in which six laboratories each using two operators tested five different types of yarns. Each yarn sample was divided into five packages and circulated to each laboratory in turn. Each operator made three determinations on the same package and accordingly tested a total of 15 specimens for each yarn. The samples included woolen, worsted, carded cotton, combed cotton, and polyester-cotton blend yarns. The yarn sizes varied from 15 to 155 tex and the tensions used by each laboratory were approximately the same. The components of variance expressed as coefficients of variation were calculated to be:

Single-operator component	7.20 % of the average
Within-laboratory component	1.34 % of the average
Between-laboratory component	3.35 % of the average

12.2 *Precision*—For the components of variance reported in 12.1, two averages of observed values should be considered significantly different at the 95 % probability level if they differ by the following critical differences or more:

	Critical Difference, % of the Grand Average, for the Conditions Noted[A,B]	
Number of Observations in Each Average	Single-Operator Precision	Between-Laboratory Precision
1	20.0	22.3
5	8.9	13.4
10	6.3	11.8

[A] The values for the critical differences listed in this table were calculated using $t = 1.960$ which is based on infinite degrees of freedom.

[B] To convert the values of the critical differences to units of measure, multiply the average of the two specific sets of data being compared by the critical differences expressed as a decimal fraction.

NOTE 6—The critical differences listed in the preceding table constitute a general statement, particularly with respect to between-laboratory precision. Before a meaningful statement can be made about two specific laboratories, the amount of statistical bias, if any, between them must be established, with each comparison being based on recent data obtained on randomized specimens from one sample of material to be tested.

12.3 *Bias*—Test results obtained by Test Method D 1422 may differ considerably from those obtained by Test Method D 1423, the referee method.[5,6]

13. Keywords

13.1 spun yarn; twist

[5] Booth, J. E., *Principles of Textile Testing,* Chemical Publishing Co., 1961, pp. 220–227.

[6] Worner, R. K., *Textile Research Journal,* TRJOA, Vol 26, 1956, p. 456.