Designation: D 1423 – 9902

Standard Test Method for Twist in Yarns by Direct-Counting[1]

This standard is issued under the fixed designation D 1423; 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.

This standard has been approved for use by agencies of the Department of Defense.

[1] This test method is under the jurisdiction of ASTM Committee D-13 on Textiles, and is the direct responsibility of Subcommittee D13.58 on Yarn Test Methods, General.
Current edition approved ~~Nov.~~ Sept. 10, ~~1999.~~ 2002. Published ~~January 2000.~~ November 2002. Originally published as D 1423 – 56 T. Last previous edition D 1423 – ~~98.~~ 99.

1. Scope

1.1 This test method covers the determination of the amount and direction of twist at the completion of any stage of twisting in single (spun or filament), plied, cabled, or novelty (exclusive of long-term repeat patterns) yarns. The procedures are designed primarily for yarns in packages, but, with special precautions, they are applicable to yarns taken from fabrics. The procedure for spun yarn in 9.2 is also applicable to rovings.

1.2 For plied yarns, this test method covers the determination of the twist of the plied yarns and the twist of the single yarn before plying. For cabled yarns, the test method covers the determination of the cable or hawser twist; the twist of the plied yarn after plying, but prior to the last twisting operation; and the twist of the single yarn before plying. Procedures are also included for the determination of the twists of the single and plied yarn components as they lie in the final structure. Also, directions are included for the determination of twist in plied yarn made with direct cabling technology.

1.3 This test method is not intended for 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). Following the procedures of this test method for such yarns would be independent of the bias and precision determined for this test method. The report from such testing should include the tension used for this testing.

1.4 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.

NOTE 1—For a more rapid but less accurate method of determining twist in single spun yarns, refer to Test Method D 1422.
NOTE 2—This test method has been evaluated for use in determining twist in open end yarns and is not recommended.

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 1059 Test Method for Yarn Number Based on Short-Length Specimens[2]
D 1422 Test Method for Twist in Single Spun Yarns by the Untwist-Retwist Method[2]
D 1425 Test Method for Unevenness of Textile Strands Using Capacitance Testing Equipment[2]
D 1776 Practice for Conditioning and Testing Textiles for ~~Testing~~ [2]
D 1907 Test Method for Yarn Number by the Skein Method[2]
D 2258 Practice for Sampling Yarn for Testing[2]
D 3888 Terminology Relating to Open-End Spinning[3]
D 4849 Terminology Relating to Fibers and Yarns[3]

[2] *Annual Book of ASTM Standards*, Vol 07.01.
[3] ~~Woods, H. J., "The Kinematics~~
[3] *Annual Book of ~~Twist, I, The Definition of Twist," Journal of Textile Science~~ ASTM Standards, Vol ~~4, 1931, pp 33–36.~~ 07.02.*

3. Terminology

3.1 *Definitions:*

3.1.1 *cable twist, n*—the construction of cabled yarn, cord, or rope in which each successive twist is in the opposite direction 3.1 Refer to the preceding twist, an S/Z/S or Z/S/Z construction.

3.1.2 *direction Terminology D 4849 for definitions 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."

3.1.2.1 *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 following terms used in a similar manner to indicate the this standard: direction of the last twist inserted.

3.1.3 *final twist, n*—the number of turns per unit length in a twist, single yarn component of a plied yarn or the plied yarn component of a cabled yarn as the component lies in the more complex structure. (*Syn.* "as-is" twist)

3.1.4 *hawser twist, n*—the construction of cabled yarn, cord, or rope in which the single and first-ply twist are in the same direction and the second-ply twist is in the opposite direction, an S/S/Z or Z/Z/S construction.

3.1.5 *original twist, n*—the twist in a single or plied yarn component of a plied or cabled yarn as the component was before incorporation into the more complex structure.

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

3.1.6.1 *Discussion*—A single yarn may be formed from fibers with more or less twist; from filaments with or without twist; from narrow strips of material 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.

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

3.1.7.1 *Discussion*—The binding mechanism most commonly used in spun yarns is twist. Other mechanisms used are chemical additives, wrapping, entanglement, or some combination of these.

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

3.1.8.1 *Discussion*—Twist is usually expressed as the number of turns about the axis that are observed in a specified length, either turns per metre (tpm) or turns per inch (tpi).

3.1.9 *twist yarn, twist, 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.

3.1.9.1 *Discussion*—Twist multiplier 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 yarn.

3.2 Refer to each other Terminology D 123 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 Terminology D 3888 for cotton system,

k = 9.567 and Eq 2 becomes Eq 4:

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

3.1.10 *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.

3.1.11 *twist take-up, n*—the change in length of a yarn or other textile strand caused by twisting, expressed as a percent of the original untwisted length.

3.1.12 *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 terms used in this test method, refer to Terminology D 123. standard.

4. Summary of Test Method

4.1 A specified length of specimen is mounted in a twist device. One end is rotated until all the elements are free of twist. The number of turns is counted and the turns per unit length are calculated.

4.2 The amount of twist in the component elements of a plied or cabled yarn is determined by either of two options.

4.2.1 In the procedure for determining original twist, one end of the yarn is fixed while the other end is rotated until the structural components are parallel. Any one or all of these components may then be used as test specimens.

4.2.2 In the procedure for determining final twist in components, both ends of one component of the yarn are held fixed while all the other components are removed and discarded. The twist is then determined in the remaining component.

5. Significance and Use

5.1 Test Method D 1423 for testing for twist in yarns by the direct-counting method is considered satisfactory for acceptance testing of commercial shipments because current estimates of between-laboratory precision are acceptable and the method has been used extensively in the trade for acceptance testing.

5.1.1 If there are differences or of practical significance between reported test results for two laboratories (or more), comparative tests should be performed to determine if there is a statistical bias between them, using competent statistical assistance. As a minimum, use the test samples should be used that are for such comparative tests as homogeneous as possible, that are drawn from the same lot of material from which that resulted in 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. laboratory. The test results from the two laboratories involved 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 for that material must be adjusted in consideration of the known bias.

5.2 The determination of twist in a straight section of a yarn is not the simple straightforward operation it appears to be, for the test results may be greatly influenced by variations in test procedures and techniques. In all manipulations, extreme care is necessary to prevent specimen rotation altering the twist level before testing begins.

5.3 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 wrap on the package.

5.4 When a yarn is incorporated into or removed from a more complex structure, alterations may occur as a result of the plying, untwisting, or raveling operation. For example, when determining the twist in plied yarn by the procedure for determining original twist, as the plied yarn is untwisted, a comparable amount of twist is reinserted in, or removed from, the single-yarn components. As a consequence, the single yarns have approximately the original twist prior to the plying operation but not the twist they have when they are functioning as components of the plied yarn. The latter or final twist may be estimated by adding the ply twist to (or subtracting it from) the single-yarn twist depending on the directions of the ply and singles twist. For a more precise determination, the test procedure must be modified. There are thus two different procedures for preparing specimens of the component elements of a plied or cabled yarn for twist determination. The procedure for the original twist measures the twist in a component of a complex strand after the components have been untwisted. The procedure for final twist measures the twist in a component as it lies in the complex strand. Although the original twist procedure is most often used, selection of a particular procedure will depend on the type of information needed.

NOTE 3—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 ⅓ tpi.

5.5 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.

5.6 The optimum amount of twist depends upon the use for which the yarn is intended. The amount of twist affects both the strength and elongation properties of the yarn with increased twist being associated with increased elongation. The relationship between twist and strength is more complex.

5.6.1 In filament yarns, some twist up to 280 tpm (7 tpi) or a suitable sizing is required to facilitate textile operations. A small increase in twist results in a slight increase in strength, but a further increase results in a loss in strength. However, higher twist in such yarns may be used to subdue luster or increase elongation, or to secure other special effects, as in crepe fabrics.

5.6.2 In conventional ring spun yarns a certain minimum amount of twist is necessary to bind or hold the individual fibers together to produce a useful yarn. A limited increase in twist will result in an increase in strength until the critical twist level for

[4] Data from the interlaboratory test for single spun yarns are on file in ASTM Research Report No. D-13-1002. Data for single filament, plied, and cabled yarns are filed in RR No. D-13-1005. A copy

[4] Woods, H. J., "The Kinematics of each report is available on loan from ASTM Headquarters, 100 Barr Harbor Drive, West Conshohocken, PA 19428. Twist, I, The Definition of Twist," *Journal of Textile Science*, Vol 4, 1931, pp 33–36.

the particular yarn involved has been reached, but further increase in twist results in a loss in strength.

5.7 The same amount of twist in yarns of different sizes (diameter) will produce yarns with different degrees of compactness, twist character, and twist angles. The twist multiplier or twist factor is approximately proportional to the tangent of the angle that the surface fibers make with the axis of the yarn. Therefore, the greater the angle, the greater the twist multiplier. A constant twist multiplier indicates comparable compactness and degree of liveliness in yarns of different sizes and conversely a difference in twist multiplier indicates a difference in compactness in yarns of the same size. Yarns intended for different uses are frequently made with different twist multipliers, for example, warp yarns and filling yarns.

5.8 Different cabling processes will influence the calculation of twist from single component twist measurement. The length of cabled yarn before untwisting is used for the calculation of twist for single components using direct cabling technology. In case of 2 or more step twist technology the length of the cabled yarn after untwisting is used for calculation of the twist level in the single yarn components.

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 of the lengths specified in 9.2 and 9.3 and to permit measuring the change in length during untwisting. Means shall be provided for applying the specified tensions to the specimen and for determining the specimen length with an accuracy of ±0.5 mm (0.02 in.). The movable but nonrotatable clamp shall be capable of being traversed with substantially no friction to permit determining the untwisted length of the specimen under the specified tension. The counting device shall be resettable to zero count and shall indicate the total number of turns to the nearest 0.1 turn.

6.2 *Dissecting Needle or Stylus*.

6.3 *Gage or Calipers*.

6.4 *Magnifying Glass with Stand*.

6.5 *Equipment for Reeling Laboratory Sample Skeins,* optional.

7. Sampling and Test Specimens

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 Sampling Unit*—From each primary sampling unit, take a laboratory sample as specified in 7.2.1 and 7.2.2

7.2.1 For packaged yarns, take a minimum of five packages.

7.2.2 For rolls, take a full width of sufficient length that will provide the 25 yarn specimens described in 7.3 and 7.4.

7.3 *Test Specimens*:

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

7.3.2 *Filament Yarn Singles*—Take eight specimens from each laboratory sampling unit of filament yarn singles containing 100 tpm or 2.5 tpi or less, and five specimens per laboratory sampling unit of filament yarn singles containing more than 100 tpm or 2.5 tpi.

7.3.3 *Plied and Cabled Yarns*——Take five specimens per laboratory sampling unit of plied and cabled yarns for each component to be tested.

7.4 *Selection of Specimens*:

7.4.1 Take an approximate 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 the manufacturing processes. When preparing specimens, conditioning them or inserting them in the tester, take care to avoid any change in twist.

7.4.2 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 3). 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.

7.4.3 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. A strip about 2 m (2 yd) long is recommended as a source for filling yarn specimens.

7.4.4 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 method of feed is not known take specimens at random from the whole laboratory sample.

7.4.5 For warp-knit fabric, prepare specimens as directed in Test Method D 1059. Cut strips from which the test specimens can be raveled for testing as needed (Note 4). Cut these strips so as 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 4—To minimize changes in twist, specimens should not be unraveled from the strips until they are to be placed in the twist tester.

8. Conditioning

8.1 Bring the sample to moisture equilibrium for testing in the standard atmosphere for testing textiles as directed in Practice D 1776, except that preconditioning is not necessary.

9. Procedure

9.1 *General Directions*:

9.1.1 Test all specimens in the standard atmosphere for testing textiles which is a temperature of 21 ± 1°C (70 ± 2°F) and a relative humidity of 65 ± 2 %.

9.1.2 Check the twist tester to ensure that the longitudinal play and radial play of the clamp assemblies are small enough to ensure the required precision.

9.1.3 Determine the twist with the precision stated in Table 1.

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.

PROCEDURE FOR ORIGINAL TWIST

9.2 *Spun Single Yarns*:

9.2.1 Set the movable clamp to obtain a gage length as long as convenient but somewhat less than the staple length of the fiber used to spin the yarn. For yarns spun on the cotton spinning system use a gage length of 15, 20, or 25 mm ~~or 0.5,~~ (0.5, 0.75, or 1.0 in). For yarns spun on the worsted spinning system and the woolen spinning system use a gage length of 25 or 50 mm (1.0 or 2.0 in.). Set the counter at zero. Mount the specimen in the clamps under a tension of 0.25 ± 0.05 cN/tex (0.25 ± 0.05 gf/tex). Avoid any change in the twist while handling the yarn. Cut the specimen free from the package and from the yarn to be discarded, leaving less than 25 mm (1 in.) of the specimen protruding from each clamp.

9.2.2 Remove the twist completely by turning the rotatable clamp until the yarn elements are parallel, as determined by visual examination, or by passing a needle or stylus between the untwisted elements from one clamp to the other.

9.2.3 Note the direction of twist as indicated on the twist tester, or as determined by inspection of the specimen according to the definition given in ~~3.1.2.~~ Terminology D 4849. Record the initial length, the direction of twist, and the number of turns in the specimen with the precision described in ~~9.1.3.~~ Table 1.

9.2.4 Repeat the operation until the required number of specimens has been tested.

9.3 *Filament Single Yarns*:

9.3.1 Set the clamps to secure a ~~nominal~~ gage length of 250 ± 0.5 mm ~~or 10~~ (10 ± 0.02 in.). Set the counter at zero. Mount the specimen in the clamps under a tension of 0.25 ± 0.05 cN/tex (0.25± 0.05 gf/tex) and cut both ends free as directed in 9.2.1. Measure and record the length between clamps to the nearest 0.5 mm (0.02in.) before untwisting (initial length).

9.3.2 Remove the twist completely by turning the rotatable clamp until the yarn elements are parallel as determined by visual examination, or by passing a needle or stylus between the untwisted elements from one clamp to the other. ~~Record the initial length~~ Measure and record the length, direction of twist and the number of turns in the specimen with the precision specified in ~~9.1.3. If requested, measure and record the specimen length after all twist has been removed.~~ Table 1.

9.3.3 Repeat the operation until the required number of specimens has been tested.

9.4 *Plied Yarns and Original Twist in Single-Yarn Components of Plied Yarn*:

9.4.1 Proceed as directed for filament yarns in 9.3 to determine the total number of turns and direction of ply twist in the specimen.

NOTE 5—When the twist in the different component levels is in the same direction there is contraction in specimen length during the untwisting operation. Allowances should be made in the movable clamp position to compensate for the change in length.

9.4.2 Remove the tension and cut away all but one of the strands (Note 6 and Note 7) to obtain an individual end of the single yarn.

NOTE 6—The directions given in 9.4.2 assume that all components of the plied yarn have the same direction and amount of twist. If this is not known, it must be verified. If any difference in kind exists, each component yarn must be tested and reported separately.

NOTE 7—If the single yarns are spun yarns, additional specimens will be required. It is, therefore, recommended to save the cut-away strands without change in twist, as a source of additional specimens.

9.4.3 When the single yarn is a spun yarn remove the strand from the clamps and, being careful not to disturb the twist, proceed

TABLE 1 Required Precision for Given Twist Level

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

as directed in 9.2. When the yarn is a filament yarn, adjust the tension, based on the linear density of the single yarn component, to 0.25 ± 0.05 cN/tex (0.25 ± 0.75 gf/tex). Note the specimen length and proceed as directed in 9.3.2.

9.4.4 Repeat the operations until the required number of specimens has been tested.

9.5 *Cabled Yarns and Original Twist in Single and Plied Yarn Components of Cabled Yarns*:

9.5.1 Proceed as directed for single-filament yarns in 9.3 to determine the total number of turns and direction of hawser or cable twist in the cabled specimen and its length before and after untwisting. (See Note 5.)

9.5.2 Remove the tension and cut away all but one of the plied strands. Adjust the tension to 2.5 ± 0.5 mN/tex (0.25± 0.75 gf/tex) based on the linear density of the individual strand of plied yarn. Note its length and determine the plied yarn twist as directed for filament single yarns in 9.3.2. Record the number of turns and direction of twist in the plied yarn specimen and, if requested, its length after untwisting. (Notes 6 and 7).

9.5.3 Remove the tension and cut away all but one of the strands (Notes 5 and 6) to obtain an individual end of the single yarn. Proceed as directed in 9.4.3.

9.5.4 Repeat the operations until the required number of specimens has been tested.

PROCEDURE FOR FINAL TWIST

9.6 *Final Twist in Complex Yarn Components*:

9.6.1 To determine the twist in a plied yarn as it lies in a cabled yarn or the twist in a single yarn as it lies in a plied yarn, set the movable clamp at a distance greater than that required for testing the component yarn. Mount the specimen in the clamps without tension. Cut all components of the yarn near one clamp except the strand which is to be tested. Without disturbing the twist of the strand to be tested, carefully unwind the other strand or strands. Cut the loose strands near the second clamp and discard them. Proceed as directed in 9.2 or 9.3.

9.6.2 To determine the final twist in single yarn components of cabled yarns or cords, proceed as in 9.6.1, removing first all but one of the plied-yarn components and then all but one of the single-yarn components of the remaining strand of plied yarn. Proceed as directed in 9.2 or 9.3.

10. Calculation

10.1 For each specimen, calculate the amount of twist as turns per metre to the nearest whole number or turns per inch to one decimal, using Eq 6: 1:

$$T = R/L \tag{1}$$

where:
T = twist, tpm (tpi),
R = counter reading, and
L = specimen length, m (in.).

NOTE 8—When

10.1.1 When calculating twist of single yarn or strand components of a cord, use the length of the specimen noted after all but one of the components have been cut from the untwisted cord.

10.2 Calculate

10.1.2 In case of a cord made by direct cabling technology, use the average twist length of all the specimens tested.

10.3 For plied and cabled yarns, calculate cord before untwisting when calculating the amount of twist separately of a single yarn component.

10.2 *twist factor, TF, n*, if requested, for each specimen, calculate the twist factor to nearest one decimpal, using Eq 2:

$$\text{Twist factor } (TF) = \text{tpcm} \times \sqrt{T} \tag{2}$$

where:
tpcm = twist, turns per centimetre,
T = yarn number expressed in tex.

10.2.1 Twist multiplier and twist factor are a measure of the yarn.

10.4 If requested, calculate "twist hardness" of yarn because they are approximately proportional to the coefficient tangent of variation the angle between fibers on the outer yarn surface and the axis of the twist.

10.5 If requested, calculate 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 or and twist factor using are proportional to each other and differ only in the units used. The two are related by Eq 1 or Eq 2 3 and Eq 4:

$$TF = k \times TM \tag{3}$$

$$k = 277.29/\sqrt{L} \tag{4}$$

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 system,
k = 9.567 and Eq 3 becomes Eq 5:

$$TF = 9.567 \times TM \quad (5)$$

10.3 *twist multiplie~~r~~, TM, n,* If requested, calculate the twist multiplier to the nearest one decimal by determining the quotient of the twist expressed in ~~9.1.4.~~

~~10.6 If~~ turns per inch and the square root of the yarn number in an indirect system.

$$\text{Twist multiplier } (TM) = \text{tpi}/\sqrt{N} \quad (6)$$

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

10.4 If requested, calculate the percent take-up ~~by Eq~~ using Eq 7:

$$\text{Twist take-up, \%} = [(U-T)/U] \times 100 \quad (7)$$

where:
U = length of specimen after untwisting, and
T = length of specimen before untwisting.

10.5 Calculate the average twist of all the specimens tested.

10.6 For plied and cabled yarns, calculate the amount of twist separately for each component of the yarn.

10.7 If requested, calculate the coefficient of variation of the twist.

11. Report

11.1 State that the specimens were tested as directed in Test Method D 1423. Describe the material or product sampled and the method of sampling used.

11.2 Report the following information:

11.2.1 Average single, plied, and cabled yarn twist. If final twist of component yarns has been determined, state the fact.

11.2.2 Direction of each twist.

11.2.3 Average twist multiplier or twist factor, if calculated.

11.2.4 Average percent take-up, if calculated.

11.2.5 Coefficient of variation of twist in each yarn, if determined.

11.2.6 Length of the test specimens before and after untwisting.

11.2.7 Tension used, if different from that specified.

11.2.8 Length used in calculation of twist.

12. Precision and Bias

12.1 *Summary*—In comparing two averages, the differences should not exceed the critical differences in 95 cases out of 100 when all the observations are taken by the same well-trained operator using the same piece of equipment and specimens randomly drawn from the same sample of material (see Table 2). The size of the observed differences is likely to be affected by different circumstances. Accuracy is good with no known bias in the test results. Sections 12.2-12.4 explain the basis for this summary and for evaluations made under other conditions.

12.2 *Interlaboratory Test Data:*[5]

12.2.1 *Spun Yarn Singles*—In the first of two tests six laboratories tested the following types of spun yarn singles—polyester-cotton blend, combed cotton, carded cotton, worsted and woolen. These yarns varied in size from 15 to 155 tex and a 25.4-mm

[5] Data from the interlaboratory test for single spun yarns are on file in ASTM Research Report No. D-13-1002. Data for single filament, plied, and cabled yarns are filed in RR No. D-13-1005. A copy of each report is available on loan from ASTM Headquarters, 100 Barr Harbor Drive, West Conshohocken, PA 19428.

TABLE 2 Critical Differences at 95 % Confidence Level

Type of Yarn Being Examined	Critical Difference
Spun yarn singles	8.6 % of the grand average[A]
Filament yarn singles:	
Less than 40 tpm or 1.0 tpi	4.0 tpm (0.10 tpi)[B]
40 tpm to 100 tpm (1.0 tpi to 2.5 tpi)	4.8 tpm (0.12 tpi)[B]
More than 100 tpm (2.5 tpi)	6.4 % of the grand average[C] of 5)
Plied yarns and cabled yarns	6.4 % of the grand average[C] of 5)

[A] Averages of 25.
[B] Averages of 8.
[C] Averages of 5.

TABLE 3 Components of Variance as Standard Deviations or as Coefficients of Variation (Units as Indicated)

	Single-Operator Component	Within-Laboratory Component	Between-Laboratory Component
Spun yarn singles	15.45[A]		5.45[A]
Filament yarn singles:			
Less than 40 tpm or 1.0 tpi	0.14[B]		
40 tpm to 100 tpm or 1.0 to 2.5 tpi	0.18[B]		
More than 100 tpm or 2.5 tpi	5.2[A]	0.0[A]	0.9[A]
Plied yarns and cabled yarns	5.2[A]	0.0[A]	0.9[A]

[A] Coefficients of variation as percentages of the average.
[B] Standard deviations expressed in tpi.

(1-in.) nominal gage length was used for all specimens except the woolen spun yarn which was tested using a nominal gage length of 50.8 mm (2 in.). The same yarn packages were circulated to each laboratory in turn where each operator made 25 determinations for each sample. Two laboratories ran duplicate tests using different operators. The components of variance expressed as coefficients of variation are listed in Table 3.

NOTE 98—Because the interlaboratory test was conducted using inch-pound units the critical differences and components of variance are reported in these units. Comparable units in SI units may vary slightly from the mathematical equivalents.

12.2.2 *Filament Yarn Singles (above 100 tpm or 2.5 tpi), Plied, and Cabled Yarns*—A second interlaboratory test was run to determine the twist in filament yarn singles, plied, and cabled yarns using a 254-mm (10-in.) nominal gage length. Five laboratories tested five yarns using the same package in turn. Ten determinations per sample were made by each of the two operators at each laboratory. The samples varied in size from 34 to 308 tex and included rayon, polyester-cotton blend, nylon, and plied cotton yarns. The components of variance expressed as coefficients of variation are listed in Table 3.

12.2.3 *Filament Yarn Singles (100 tpm or 2.5 tpi or less)*—Although no interlaboratory test has been run, the single-operator component of variance has been generally accepted as the values listed in Table 1.

12.3 *Precision*—For the components of variance listed in Table 1, two averages of observed values should be considered significantly different at the 95 % probability level if the difference equals or exceeds the critical differences listed in Table 4.

NOTE ~~10—The~~ 9—The critical differences listed in Table 4 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.

12.4 *Bias*—The procedure described in this test method produces a test value that can be defined only in terms of a test method. There is no independent, referee method by which bias may be determined. This test method has no known bias.

13. Keywords

~~13.1 spun yarn;~~
13.1 twist; twist factor; twist multiplier; twist take-up; yarn

TABLE 4 Critical Differences for the Conditions Noted (Units as Indicated)[A]

	Number of Observations In Each Average	Single-Operator Precision	Within-Laboratory Precision	Between-Laboratory Precision
Spun yarn singles[B]	5	19.2		24.4
	10	13.5		20.3
	25	8.6		17.4
	50	6.1		16.3
Filament yarn singles:				
Less than 40 tpm or 1.0 tpi[C]	1	0.27		
	4	0.14		
	8	0.10		
	16	0.07		
40 tpm to 100 tpm or 1.0 to 2.5 tpi[C]	1	0.35		
	4	0.18		
	8	0.12		
	16	0.09		
More than 100 tpm or 2.5 tpi[C]	3	8.3	8.3	8.7
	5	6.4	6.4	6.9
	10	4.6	4.6	5.2
Plied and cabled yarns[B]	3	8.3	8.3	8.7
	5	6.4	6.4	6.9
	10	4.6	4.6	5.2

[A] The critical differences were calculated using the value t = v 1.960, which is based on infinite degrees of freedom.

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

[C] Critical differences are expressed as tpi. Multiply twist as tpi by 39.4 to obtain tpm.