Designation: D 1578 – 93

Standard Test Method for Breaking Strength of Yarn in Skein Form[1]

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1. Scope

1.1 This test method covers the determination of the breaking strength of yarn in skein form. The observed breaking strength is expressed in units of force, and equations are provided to convert breaking strength to skein breaking tenacity and to skein break factor.

NOTE 1—For the determination of the breaking strength and elongation of yarn by the single strand method, refer to Test Method D 2256.

1.2 This test method is applicable to spun yarns, either single or plied, composed of any fiber or blend of fibers, but is not suitable for yarns which stretch more than 5 % when the tension is increased from 2.5 to 7.5 mN/tex or 0.03 to 0.08 gf/denier.

1.3 This test method provides three options based on the perimeter of the reel, the number of wraps in the skein, and the machine speed or time-to-break.

1.3.1 *Option 1*—Eighty, forty, or twenty turns on a 1.50-m or 1.5-yd reel, broken at 300 mm/min or 12 in./min.

1.3.2 *Option 2*—Fifty turns on a 1.00-m or 1-yd reel, broken at 300 mm/min or 12 in./min.

1.3.3 *Option 3*—Fifty turns on a 1-m reel, broken in 20 s.

NOTE 2—Option 1 is in general use in the United States, Option 2 is used for woolen yarns, and Option 3 has been proposed in the International Standards Organization (ISO) for international use.

NOTE 3—Metric reels are available with 1 and 1.125-m circumferences. Data from the two reels will be about 1 % different (see 5.6). ISO uses a 1-m circumference reel.

1.4 This test method is frequently combined with the determination of linear density carried out on the same skeins. Special precautions for reeling such skeins are noted.

1.5 Where appropriate, this test method states all requirements in SI units. The traditional units are inch-pound and are exact values.

1.6 *This standard does not purport to address all of the safety problems, 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 76 Specification for Tensile Testing Machines for Textiles[2]

D 123 Terminology Relating to Textiles[2]

D 1776 Practice for Conditioning Textiles for Testing[2]

D 1907 Test Method for Yarn Number by the Skein Method[2]

D 2256 Test Method for Tensile Properties of Yarns by the Single-Strand Method[2]

D 2258 Practice for Sampling Yarn for Testing[2]

D 2904 Practice for Interlaboratory Testing of a Textile Test Method that Produces Normally Distributed Data[2]

3. Terminology

3.1 *Definitions:*

3.1.1 *breaking force*, *n*—the maximum force applied to a material in a tensile test carried to rupture.

3.1.1.1 *Discussion*—Force is commonly expressed as millinewtons (mN), newtons (N), grams-force (gf), or pounds-force (lbf).

3.1.2 *force*, *n*—a physical influence exerted by one body on another which produces acceleration of bodies that are free to move and deformation of bodies that are not free to move. (Compare *strength*).

3.1.3 *skein break factor*, *n*—the comparative breaking strength of a skein of yarn adjusted for the linear density of the yarn expressed in an indirect system; the product of the breaking strength of the skein and the yarn number expressed in an indirect system. (*Syn.* count-strength product)

3.1.3.1 *Discussion*—A statement of the break factor of the skein must indicate the number of wraps in the skein if this is not otherwise apparent; without information on the number of wraps, a statement of the break factor is meaningless. Break factor is frequently given other designations such as lea count constant, lea product, and breaking ratio.

3.1.4 *skein*, *n*—a continuous strand of yarn in the form of a flexible coil having a large circumference in proportion to its thickness.

3.1.5 *skein breaking tenacity*, *n*—the skein breaking strength divided by the product of the yarn number in a direct numbering system and the number of strands placed under tension.

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

3.1.5.1 *Discussion*—Observed breaking strength can be converted to breaking tenacity by dividing the breaking strength by the product of the yarn number measured in a direct numbering system and the number of strands placed under tension (twice the number of wraps in the skein (see Eq 7)).

3.1.6 *skein strength, n*—the force required to rupture a skein of yarn, expressed in units of force, as breaking strength.

3.1.7 *strength, n*—the property of a material that resists deformation induced by external forces. (Compare*force*).

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

4. Summary of Test Method

4.1 A skein of yarn, prepared by winding the prescribed number of turns on a reel, is broken on a tensile testing machine.

NOTE 4—If the yarn number is also required for the determination of skein breaking tenacity or break factor, the broken skein may be weighed and the yarn number calculated as directed in Test Method D 1907.

5. Significance and Use

5.1 Test Method D 1578 for testing any spun yarn for breaking strength is considered satisfactory for acceptance testing of commercial shipments since the method has been used extensively in the trade.

5.1.1 In case of a dispute arising from differences in reported test results when using Test Method D 1578 for acceptance testing of commercial shipments, the purchaser and the 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 which are as homogeneous as possible and which 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 results from the two laboratories should be compared using Student's *t*-test for unpaired data and an acceptable probability level chosen by the two parties before 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 in the light of the known bias.

5.2 This test method is not suitable for yarns that stretch more than 5 % when the force is increased from 2.5 to 7.5 mN/tex or 0.03 to 0.08 gf/denier, because (*a*) they require special precautions as to tension in reeling, and (*b*) users of such yarns are more interested in their elastic behavior at low forces than in their ultimate breaking strength.

5.3 For Option 1, it is advisable to use a tensile testing machine of the proper capacity to break skeins with 80 turns. If it is necessary to break skeins having only 40 or 20 turns, convert the observed results to an 80-turn basis by multiplying by factors of 2 or 4, respectively. (The available literature does not show that any significant error is introduced by the use of these factors.)

5.4 The circumference of the skeins used to determine the breaking load is not critical, and as a consequence, close control of the tension at which the skeins are wound is not necessary. If, however, the same skeins are to be used to determine yarn number for any purpose, the skeins must be reeled under controlled tension on a reel meeting the requirements given in Test Method D 1907.

5.5 For some purposes it may be advisable to convert the skein breaking strength observed for yarn of one number to the estimated skein breaking strength of a different yarn number. Factors for making such a conversion for cotton yarns are given in 11.2. No corresponding factors have been developed for yarns spun from other fibers.

5.6 The results obtained from different options are not fully comparable because the breaking force per wrap increases slightly as the perimeter of the skein is reduced. The skein breaking tenacity observed for 1-m skeins may be as much as 4 % higher, and from 1-yd skeins 5 % higher, than that observed for 1.5-yd skeins. These relationships may vary with the type of yarn or with yarn unevenness and should not be used as conversion factors. With a reasonable number of specimens, this method provides a useful index that combines the effects of unevenness and single strand strength.

5.7 This method is rarely, if ever, used for filament yarns because their uniformity makes it possible to obtain reliable results economically by the single-strand method.

6. Apparatus

6.1 *Reel*—A hand or motor-driven reel having a perimeter of 1.50 m or 1.5 yd for Option 1, 1.0 m or 1 yd for Option 2 (see Note 3), or 1 m for Option 3. The reel shall be fitted with a traversing mechanism that will minimize bunching the yarn on the reel and with an indicator of the length wound. A warning bell or an automatic cutoff that will operate at a specified number of turns is advisable. It is also recommended that the reel have a collapsible arm for relaxing the tension on the skeins to facilitate their removal from the reel. If yarn number is to be determined from the same skeins, refer to Test Method D 1907 for additional reel specifications.

6.2 *Package Holders*—Vertical spindles for bobbins or cones if not provided as an integral part of the reel, shafts on which tubes or flanged spools can turn freely.

6.3 *Tensile Testing Machine*—A constant-rate-of-traverse (CRT type) or constant-rate-of-extension (CRE type) tensile testing machine of suitable capacity as prescribed in Specification D 76, capable of operating the moving clamp (spool) at a uniform speed of 300 ± 10 mm/min or 12 ± 0.5 in./min (for Options 1 and 2) or capable of operating at a rate that will break the skein broken in an average time of 20 ± 3 s from the start of application of tension to the skein (for Option 3). The machine shall be equipped with spools not less than 25 mm or 1 in. nor more than 30 mm or 1.25 in. in both diameter and length, and supported with at least one spool free to turn on its axis. The distance between the spools shall be sufficient to permit placing the skeins on the spools in a wide, flat band.

6.4 *Skein Holder or Rack*, having parallel pegs or bars placed a sufficient distance apart to hold the skeins extended to nearly their full length without either stretching, kinking, or entangling the yarn.

7. Sampling

7.1 *Lot Sample*—Take a lot sample as directed in an

applicable specification, or as agreed upon between the purchaser and the supplier. In the absence of an applicable specification or agreement, take a lot sample as directed in Practice D 2258.

NOTE 5—An adequate specification or other agreement between the purchaser and the supplier requires taking into account variability between shipping units, between packages or ends within a shipping unit, and between specimens from a single package so as to provide a sampling plan with a meaningful producer's risk, consumer's risk, acceptable quality level, and limited quality level.

7.2 *Laboratory Sample*—As a laboratory sample for acceptance testing, take a total of ten packages for yarn spun on the cotton or worsted systems and a total of 20 packages for yarns spun on the woolen system. Select the packages randomly from all the packages in the lot sampling units.

7.3 *Number of Specimens*—Test one skein from each package in the laboratory sample.

8. Conditioning

8.1 *Preconditioning*—Yarns for testing should be wound into skeins for preconditioning and conditioning (see Section 9). Reel one or more extra skeins for use in determining when moisture equilibrium has been reached (see 8.2.1).

8.1.1 Precondition the skeins at a temperature no higher than 50°C or 120°F in an atmosphere having a relative humidity between 5 and 25 %. Skeins will usually reach approximate moisture equilibrium in 4 h especially in moving air. Crowding skeins too close together on the rack, or anything that obstructs the circulation of air, may lengthen the time appreciably.

8.2 *Conditioning*—Condition the skeins in the standard atmosphere for testing textiles, which is 21 ± 1°C or 70 ± 2°F and 65 ± 2% relative humidity, until moisture equilibrium has been reached.

8.2.1 For cotton yarns, a minimum conditioning time of 4 h is specified. Yarns made from other fibers or blends may require other lengths of time. When testing additional samples of the same type of yarn, it may be assumed that moisture equilibrium has been reached after exposure for a time 25 % longer than that found by test to be sufficient.

8.2.1.1 If necessary use the extra skein(s) to determine that moisture equilibrium has been reached when successive weighings at intervals of not less than 15 min do not differ by more than 0.1 %. Do not use the skeins that are to be tested for strength for determining moisture equilibrium.

9. Preparation of Specimens

9.1 *Mounting of Packages*:

9.1.1 For yarns on bobbins, cops, cones, or similar packages, draw the yarn off over the end of the package at a speed between 100 and 300 rpm of the reel.

9.1.2 For yarns on flanged spools or other packages normally unwound from the side, mount the packages to turn freely and draw the yarn from the side of the package at a speed of 20 to 30 rpm of the reel.

9.1.3 When several ends are wound parallel on a single package, draw each end through a separate guide and reel a skein from each end, unwinding from the side of the package.

9.1.4 If the yarn is received in skein form, mount it on an umbrella reel or swift and reel at a speed of 20 to 30 rpm.

9.2 *Reeling*—Draw each end of yarn through a separate guide and attach the yarn to the reel. Turn the reel at a uniform speed and maintain sufficient tension to lay the yarn smoothly on the reel. When the required number of turns have been reeled, tie the ends of the yarn together loosely but securely with a nonslipping knot. For easier separation of skeins on the rack, a loose loop may be made about the skein cross section, and the yarns once again knotted. If skein breaking tenacity or skein break factor is to be calculated, the method of reeling must comply with the additional requirements in Test Method D 1907.

9.2.1 For Option 1, reel 80 turns on a 1.50-m (1.5-yd) reel. If the breaking strength of such a skein is greater than the capacity of the available testing machine, try 40 or 20 turns.

9.2.2 For Option 2, reel 50 turns on a 1-m or a 1-yd reel.

9.2.3 For Option 3, reel 50 turns on a 1-m (1.09–yd) reel. Include extra skeins for adjustment of the tester for time to break.

9.3 *Conditioning*—Transfer the skeins to the rack carefully with as little disturbance of the yarn as possible. Keep the yarns parallel and the skein flat, with no bunching or twisting. Do not stretch or jerk the yarn and do not allow it to kink. If more than one skein is to be stored on each pair of pegs, the skeins may be transferred one at a time to the rack, with rings or washers placed between them for easier separation. Precondition (if not done before reeling) and condition as prescribed in Section 8. Do not remove the skeins from the rack until time of test.

10. Procedure

10.1 Perform all tests in the standard atmosphere for testing textiles, which is 21 ± 1°C or 70 ± 2°F and 65 ± 2 % relative humidity.

10.2 Select the appropriate capacity range of the testing machine as follows:

10.2.1 For Options 1 and 2, a range within which (1) the calibration of the tensile testing machine is accurate within ±1.0 % and (2) the breaking force can be read with a precision of ±2.0 %.

10.2.2 For Option 3, select the capacity and speed of the testing machine to reach the breaking force in an average time of 20 ± 3 s or a testing speed agreed upon by purchaser and supplier. Break one or more preliminary skeins, and adjust the speed as necessary until the time-to-break conforms to the specified limits. If the time-to-break for the preliminary skeins is within the specified limits and no adjustment is required, the observed values for the preliminary skeins may be included in the test report data.

10.3 Handle each skein carefully as directed in 9.3 and transfer it to the testing machine as directed as follows:

10.3.1 Place the skein over the top spool with the yarns lying flat and parallel over the spool.

10.3.2 Then place the lower part of the skein under the lower spool.

10.3.3 Move the skein around the spools, maintaining a gentle tension, to ensure that the yarns are lying flat and parallel with no bunching or twisting.

10.4 Start the machine and maintain the tension on the skein by gentle pressure of the hand (not by gripping or pinching the

yarn) until the machine takes up the slack. Keep hands well away from the spools.

10.5 Stop the machine when the scale indicator reaches the maximum force.

10.6 Record the breaking force to the nearest 2 N or 0.5 lbf if under 450 N or 100 lbf, or to the nearest 5 N or 1.0 lbf if 450 N or 100 lbf or more.

10.7 Continue as directed in 10.3-10.6 until the required number of skeins have been tested.

10.8 If the skein breaking tenacity or break factor is to be calculated, or if skein breaking strength is to be corrected for yarn number, weigh the broken skeins and determine the average yarn number as directed in Test Method D 1907.

11. Calculation of Results

11.1 *Skein Breaking Strength*:

11.1.1 Calculate the average breaking force from the values observed for all specimens in a laboratory sample, and record this as the breaking strength for that sample.

11.1.2 Calculate the average breaking strength for the lot.

11.2 *Breaking Strength Adjusted to Specified Yarn Number*:

11.2.1 If the average observed yarn number does not differ from the specified yarn number by more than 10 %, an approximate adjusted breaking strength can be calculated using Eq 1 or Eq 2:

$$S_2 = (T_2/T_1)S_1 \quad (1)$$

or

$$S_2 = (N_1/N_2)S_1 \quad (2)$$

where:

S_1 = observed average breaking strength,
S_2 = adjusted breaking strength,
T_1 = observed yarn number in a direct system,
T_2 = specified yarn number in a direct system,
N_1 = observed yarn number in an indirect system, and
N_2 = specified yarn number in an indirect system.

NOTE 6—For plied yarns, the yarn numbers used throughout these calculations are the resultant yarn numbers, that is, the yarn number of the plied yarn, calculated from the mass of a given length, in the same manner as for single yarns.

11.2.2 For cotton yarns a more accurate adjustment can be made over a wide range of yarn numbers by use of Eq 3 or Eq 4:

$$S_2 = (T_2/T_1)S_1 + K[(T_2/T_1) - 1] \quad (3)$$

or

$$S_2 = (N_1/N_2)S_1 + K[(N_1/N_2) - 1] \quad (4)$$

where:

K = a constant, to be selected from experience with the particular type of cotton, usually 18 for strength expressed in lbf.[3]

NOTE 7—In publications of the U.S. Dept. of Agriculture,[4] Eq 3 above is given in the form shown in Eq 5.

$$S_2 = [N_1S_1 - K(N_2 - N_1)]/N_2 \quad (5)$$

There are indications that K varies with staple length and possibly with other fiber properties. Since N_1S_1 is usually between 1800 and 2400, the use of a value of K between 18 and 24 results in an additional adjustment of breaking strength of approximately 1 % per unit difference between N_1 and N_2, beyond that obtained by the simple proportional conversion given in 11.2.1. Hence, an error of 10 % in selecting a value for K will make a difference of about 0.1 % in the resulting adjusted skein breaking strength per unit difference between N_1 and N_2. For breaking strengths in kilograms-force, K is 0.454 times the K for breaking strengths in pounds-force. This may be rounded to the nearest whole number. No information is available on values of K for yarns of other fibers than cotton.

11.3 *Skein Breaking Tenacity*:

11.3.1 Calculate the average skein breaking tenacity using Eq 6 or Eq 7:

$$\text{Skein breaking tenacity, mN/tex} = L/(2 \times W \times T) \quad (6)$$

or

$$= 4448S/(2 \times W \times T) = 2224S/(W \times T) \quad (7)$$

where:

L = breaking strength, mN,
S = breaking strength, lbf,
W = number of wraps in skein, and
T = average yarn number, tex.

NOTE 8—Breaking tenacity in grams-force per denier is equal to breaking tenacity in millinewtons per tex divided by 88.3.

Example 1—Breaking strength = 55 lbf, average yarn number = 40.2 cotton count (14.7 tex), and number of wraps = 80.

Skein breaking tenacity $= (2224 \times 55)/(80 \times 14.7) = 104$ mN/tex

11.3.2 Calculate the average for the lot.

11.4 *Skein Break Factor (Count-Strength Product)*:

11.4.1 Calculate the break factor using Eq 8:

$$\text{Skein break factor} = (80 \times S \times N)/W \quad (8)$$

where:

S = average breaking load, lbf,
N = average yarn number in an indirect system, and
W = number of wraps in skein.

11.4.1.1 For skeins of 80 wraps the equation becomes:

$$\text{Break factor} = S \times N \quad (9)$$

Example 2—Skein breaking strength = 55 lbf, average yarn number = 40.2 cotton count, and number of wraps = 80.

$$\text{Break factor} = 55 \times 40.2 = 2211$$

NOTE 9—The skein break factor equals the breaking tenacity in grams-force per denier multiplied by 1877 or the breaking tenacity in millinewtons per tex multiplied by 21.26.

11.4.2 Calculate the average for the lot.

11.5 Calculate the coefficient of variation if requested.

12. Report

12.1 State that the specimens were tested as directed in Test Method D 1578. Describe the product or material being sampled and the method of sampling used.

12.2 Report the following information:

12.2.1 Skein breaking strength and the average for the lot.

12.2.2 Coefficient of variation, if determined.

12.2.3 Average yarn number, and the numbering systems, if determined.

[3] Webb and Richardson, "An Evaluation of the Significance and Use of the *K* Factor of Yarn Strength," U.S. Dept. of Agriculture, June 1953.

[4] *Circular 413*, U.S. Dept. of Agriculture.

TABLE 1 Components of Variance as Coefficients of Variation, % of Average

Name of the Property	Single-Operator Component	Within Laboratory Component	Between Laboratory Component
Skein Breaking Strength (lb), Cotton System			
10/1 c.c.-100 % cotton, open end	2.6	0	3.5
10/1 c.c.-65/35 polyester/cotton, open end	1.8	1.4	5.3
40/1 c.c.-100 % cotton, ring spun	2.8	0	7.9
37.5/1 c.c.-65/35 polyester/cotton ring spun	1.5	2.2	3.8
19.5/1 c.c.-100 % rayon, ring spun	2.7	2.1	5.1
Yarn Count, Cotton System			
10/1 c.c.-100 % cotton, open end	2.4	0	0
10/1 c.c.-65/35 polyester/cotton, open end	2.3	0	0
40/1 c.c.-100 % cotton, ring spun	1.4	0	1.2
37.5/1 c.c.-65/35 polyester/cotton, ring spun	0.7	0	1.7
19.5/1 c.c.-100 % rayon, ring spun	2.2	0	6.1
Skein Break Factor			
10/1 c.c.-100 % cotton, open end	1.6	0	3.4
10/1 c.c.-65/35 polyester/cotton, open end	1.5	1.2	3.3
40/1 c.c.-100 % cotton, ring spun	2.5	0	7.4
37.5/1 c.c.-65/35 polyester/cotton, ring spun	2.7	1.7	4.9
19.5/1 c.c.-100 % rayon, ring spun	2.5	1.4	5.0

12.2.4 Any derived values, such as skein breaking strength adjusted to specified yarn number (including method of calculation), skein breaking tenacity, or skein break factor.

12.2.5 Number of packages or ends tested,

12.2.6 Circumference of reel and number of wraps per skein,

12.2.7 Type of testing machine, and

12.2.8 Capacity and rate of operation of testing machine (Option 1 or 2) or average time-to-break (Option 3).

TABLE 2 Components of Variance as Coefficients of Variation, % of Average[A]

Names of the Properties	Single-Operator Component
Skein breaking strength, worsted system	5.4
Skein breaking strength, woolen system	7.9

[A] Comparable estimates of precision have been in use since 1967.

13. Precision and Bias

13.1 *Summary*—Interlaboratory test data have shown that the variation in breaking force test data is dependent upon the material being tested; therefore, no general statement can be made about critical differences. A user can get a general idea from the data in 13.1.1 and 13.1.2 of the critical differences associated with typical yarns. If more nearly exact information is needed or if other materials are involved, a single laboratory test on the specific yarn is recommended. Sections 13.2-13.4 explain the basis of this summary and evaluations made under other conditions.

13.1.1 *Cotton System*—In comparing two averages of ten observations each for yarns spun on the cotton system, the differences should not exceed the following critical differences in 95 cases out of 100 when all of the observations are taken by the same well-trained operator using the same piece of test equipment and specimens randomly drawn from the same sample of material:

10/1 c.c., 100 % cotton, open-end spun	4.4 lb
10/1 c.c., 65/35 polyester/cotton, open end spun	4.2 lb
40/1 c.c., 100 % cotton, ring-spun	1.4 lb
37.5/1 c.c., 65/35 polyester/cotton, ring spun	0.9 lb
19.5/1 c.c., 100 % rayon, ring spun	4.4 lb

Larger differences are likely to occur under all other circumstances.

13.1.2 *Worsted and Woolen Systems*—In comparing two averages of ten observations each for yarns spun on the worsted or woolen systems, the differences should not exceed the following critical differences in 95 cases out of 100 when all of the observations are taken by the same well-trained operator using the same piece of test equipment and specimens randomly drawn from the same sample of material.

Yarns spun on worsted system	4.7 % of the grand average
Yarns spun on woolen system	6.9 % of the grand average

Larger differences are likely to occur under all other circumstances.

TABLE 3 Critical Differences[A,B] % of Grand Average, for Conditions Noted

Names of the Properties	Number of Observations in Each Average	Single-Operator Precision
Skein breaking strength, worsted system	5	6.7
	10	4.7
	20	3.3
	40	2.4
Skein breaking strength, woolen system	5	9.7
	10	6.9
	20	4.9
	40	3.4

[A] The critical differences were calculated using $z = 1.960$.

[B] To convert the tabulated 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 decimal fractions.

TABLE 4 Critical Differences for Conditions Noted

Name of the Property	Number of Observations in Each Average	Single Operator Precision	Within Laboratory Precision	Between Laboratory Precision
Skein Breaking Strength (lb)				
10/1 c.c.-100 % cotton, open end	1	13.6	13.6	23.0
	2	9.6	9.6	21.0
	4	6.8	6.8	19.8
	8	4.8	4.8	19.2
	10	4.4	4.4	19.1
	16	3.4	3.4	18.9
	20	3.1	3.1	18.8
10/1 c.c.-65/35 polyester/cotton, open end	1	13.3	16.9	42.5
	2	9.4	14.0	41.5
	4	6.6	12.3	41.0
	8	4.7	11.4	40.7
	10	4.2	11.1	40.4
	16	3.3	10.9	40.3
	20	2.9	10.7	40.3
40/1 c.c.-100 % cotton, ring spun	1	4.3	4.3	12.8
	2	3.0	3.0	12.4
	4	2.1	2.1	12.3
	8	1.5	1.5	12.2
	10	1.4	1.4	12.1
	16	1.1	1.1	12.1
	20	0.6	0.6	12.0
37.5/1 c.c.-65/35 polyester/cotton, ring spun	1	2.9	5.2	9.1
	2	2.0	4.8	8.9
	4	1.4	4.6	8.8
	8	1.0	4.5	8.7
	10	0.9	4.4	8.7
	16	0.7	4.4	8.7
	20	0.7	4.4	8.7
19.5/1 c.c.-100 % rayon, ring spun	1	14.0	17.7	31.6
	2	9.9	14.7	30.0
	4	7.0	12.9	29.1
	8	5.0	11.9	28.7
	10	4.4	11.6	28.7
	16	3.5	11.4	28.5
	20	3.1	11.2	28.5
Yarn Count, Cotton System				
10/1 c.c.-100 % cotton, open end	1	0.7	0.7	0.7
	2	0.5	0.5	0.5
	4	0.3	0.3	0.3
	8	0.2	0.2	0.2
	10	0.2	0.2	0.2
	16	0.2	0.2	0.2
	20	0.1	0.1	0.1
10/1 c.c.-65/35 polyester/cotton, open end	1	0.7	0.7	0.7
	2	0.5	0.5	0.5
	4	0.3	0.3	0.3
	8	0.2	0.2	0.2
	10	0.2	0.2	0.2
	16	0.2	0.2	0.2
	20	0.1	0.1	0.1
40/1 c.c.-100 % cotton, ring spun	1	1.5	1.5	2.0
	2	1.1	1.1	1.7
	4	0.8	0.8	1.6
	8	0.5	0.5	1.5
	10	0.5	0.5	1.4
	16	0.4	0.4	1.4
	20	0.3	0.3	1.4
37.5/1 c.c.-65/35 polyester/cotton, ring spun	1	0.8	0.8	2.0
	2	0.5	0.5	1.9
	4	0.4	0.4	1.9
	8	0.3	0.3	1.9

TABLE 4 *Continued*

Name of the Property	Number of Observations in Each Average	Single Operator Precision	Within Laboratory Precision	Between Laboratory Precision
	10	0.2	0.2	1.9
	16	0.2	0.2	1.9
	20	0.2	0.2	1.8
19.5/1 c.c.-100 % rayon, ring spun	1	1.1	1.1	3.3
	2	0.8	0.8	3.2
	4	0.6	0.6	3.2
	8	0.4	0.4	3.2
	10	0.4	0.4	3.2
	16	0.3	0.3	3.2
	20	0.3	0.3	3.1
Skein Break Factor				
10/1 c.c.-100 % cotton, open end	1	80	80	192
	2	57	57	184
	4	40	40	181
	8	28	28	179
	10	26	26	178
	16	20	20	177
	20	19	19	177
10/1 c.c.-65/35 polyester/cotton, open end	1	112	144	287
	2	79	120	276
	4	56	106	270
	8	40	98	267
	10	36	97	267
	16	28	94	266
	20	25	94	266
40/1 c.c.-100 % cotton, ring spun	1	152	152	474
	2	107	107	462
	4	76	76	456
	8	54	54	453
	10	48	48	453
	16	38	38	452
	20	34	34	452
37.5/1 c.c.-65/35 polyester/cotton, ring spun	1	200	237	436
	2	142	190	412
	4	100	161	400
	8	71	145	398
	10	64	143	396
	16	50	138	394
	20	46	136	394
19.5/1 c.c.-100 % rayon, ring spun	1	240	276	545
	2	169	218	518
	4	120	182	504
	8	85	161	499
	10	75	152	498
	16	60	145	496
	20	53	143	495

13.2 *Interlaboratory Test Data*[5]—An interlaboratory test was run in 1986 in which randomly drawn specimens of five materials spun on the cotton system were tested in eight laboratories as directed in Practice D 2904. Each laboratory used two operators, each of whom tested three specimens of each material on different days. The components of variance expressed as coefficients of variation are listed in Table 1.

13.2.1 Only yarns spun on the cotton system were used in the interlaboratory test because yarns spun on the woolen and worsted systems were not readily available. The data quoted in 13.1.2 are based on the estimates of the single-operator component of variance expressed as coefficients of variation listed in Table 3.

13.3 *Precision*—For the components of variance reported in Table 1, the averages 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 4.

NOTE 10—The tabulated values of the critical differences should be considered to be 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

[5] Supporting data are available from ASTM Headquarters, 100 Barr Harbor Drive, West Conshohocken, PA 19428. Request RR: D13–1076.

data obtained on randomized specimens from one sample of the material to be tested.

13.4 *Bias*—The procedure in Test Method D 1578 for measuring the breaking force, cotton count, and break factor of yarns has no bias because the value of those properties can be defined only in terms of a test method.

14. Keywords

14.1 breaking strength; breaking tenacity; skein; skein break factor; strand; yarn