Designation: D 1907 – ~~97~~01

Standard Test Method for Linear Density of Yarn (Yarn Number) by the Skein Method[1]

This standard is issued under the fixed designation D 1907; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This test method covers the determination of the linear density of all types of yarn in package form, subject to the limitations of size and stretch given in 1.2 and 1.3. Provision is made for expressing yarn linear density in all the traditional yarn numbering systems.

1.2 This method is applicable to yarns that stretch less than 5 % when tension on the yarn is increased from 0.25 to 0.75 cN/tex (0.25 to 0.75 gf/tex). By mutual agreement, and use of a lower than specified reeling tension, this method may also be adapted to measure the linear density of yarns that stretch more than 5 %, under the above force.

1.3 This method is applicable to yarns finer than 2000 tex. However, it may be also adapted to coarser yarns by the use of skeins of shorter than specified lengths, and alternate reeling conditions, agreeable to the interested parties.

1.4 Depending on the procedure used to calculate the moisture content of the yarn being tested, and its actual moisture content, or finish content, or both, one or more of the following options may be utilized.

1.4.1 *Unscoured Yarn*:

Option 1—Yarn at equilibrium with the standard atmosphere for testing textiles.

Option 2—Oven-dried yarn.

Option 3—Oven-dried yarn, plus commercial moisture regain.

1.4.2 *Scoured Yarn*:

Option 4—Scoured yarn at equilibrium with the standard atmosphere for testing textiles.

Option 5—Oven-dried, scoured yarn.

Option 6—Oven-dried, scoured yarn, plus commercial moisture regain.

Option 7—Oven-dried, scoured yarn, plus commercial allowance (commercial moisture regain, plus an allowance for finish).

1.5 Specimens used to determine yarn linear density may also be used to determine the skein breaking strength of the yarn. Hence, this method provides the sequence of steps to be followed, to determine both these yarn properties.

NOTE 1—The linear density of yarns produced with jute, or glass, may also be determined by the following approved methods: Specifications D 541, D 578, and D 681. The linear density of short yarn segments, raveled from fabrics, may be determined by Test Method D 1059.

1.6 The values stated in SI units are to be regarded as standard. The values shown in parentheses are approximate conversions to U.S. customary unit equivalents.

1.7 *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:*

---

[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 ~~Jan.~~ September 10, ~~1997.~~ 2001. Published ~~August 1997.~~ November 2001. Originally published as D 1907 – 61 T. Last previous edition D 1907 – 9~~6~~7.

D 123 Terminology Relating to Textiles[2]
D 541 Specification for Single Jute Yarn[2]
D 578 Specification for Glass Fiber Strands[2]
D 681 Specification for Jute Rove and Plied Yarn for Electrical and Packing Purposes[2]
D 1059 Test Method for Yarn Number Based on Short-Length Specimens[2]
D 1578 Test Method for Breaking Strength of Yarn in Skeins Form[2]
D 1776 Practice for Conditioning Textiles for Testing Textiles[2]
D 1909 Table of Commercial Moisture Regains for Textile Fibers[2]
D 2257 Test Method for Extractable Matter in Textiles[2]
D 2260 Standard Tables of Conversion Factors and Equivalent Yarn Numbers Measured in Various Numbering Systems[2]
D 2258 Practice for Sampling Yarn for Testing[2]
D 2494 Test Method for Commercial Mass of a Shipment of Yarn or Man-Made Staple Fiber, or Tow[2]
2.2 *ISO Standards:* [3]
2060 Textiles—Yarn from Packages—Determination of linear density (mass per unit length) by the skein method.

3. Terminology

3.1 *Definitions:*

3.1.1 *commercial allowance, (CA)* ~~*n*~~, *n*—an arbitrary value, equal to the commercial moisture regain, plus a specific allowance for finish, used with the mass of scoured, oven-dried yarn, to compute (1) yarn linear density, (2) the commercial or legal mass of a shipment or delivery of any specific textile material (see also *commercial moisture regain*), or (3) the mass of a specific component in the analysis of fiber blends.

3.1.2 *commercial moisture regain, (CMR)* ~~*n*~~ *, n*—a formally adopted, arbitrary value, to be used with the oven-dried mass of textile fibers, when calculating the commercial mass of a shipment or delivery.

3.1.3 *direct yarn numbering system, n*—a system that expresses ~~yarn~~ the linear density ~~(number)~~ of yarn in mass per unit length.

3.1.3.1 *Discussion*—The preferred units of measurements for the direct yarn measuring system are grams and meters. Tex (~~S~~weight in grams for 1000 metres) a~~l~~nd Denier (weight in grams for 9000 metres) are recommended to show linear density to the dir~~,~~ect numbering s~~p~~ystem. These can be calculated by dividing the mass of a yarn by its length. Conversion factors to convert between direct and indirect number~~,~~ ing systems can be found in Standard Table~~x.)~~s D 2260

3.1.4 *indirect yarn numbering system, n*—a system that expresses ~~yarn~~ the linear density ~~(number)~~ of yarn in length per unit mass. ~~(S~~

3.1.4.1 *Discussion*—The preferred units of mea~~l~~surements for the indirect yarn measuring system are yards and pounds. Cotton count~~,~~ (number of 840 yard lengths per~~ic c~~ poun~~t~~d), worsted count (number of 560 yard lengths per pound), metric count (number of 1000 metre lengths per kilogram), woolen 560 yard lengths per pound), metric coun~~.~~t (number of 1000 metre lengths per kilogram), woolen run (number of 1600 yard lengths per pound) and number of yards per pound are commonly used in the indirect numbering system. These can be calculated by dividing the number of specified lengths of a yarn by its unit of mass. Conversion factors to convert between indirect and direct numbering systems can be found in Standard Tables D 2260.

3.1.5 ~~*skein*~~*linear density for fiber and yarn, n*~~—a continuous strand of yarn, wound on a hand or motorized reel.~~ —mass per unit length.

3.1.6 ~~*yarn linear density*~~*skein, n*~~—the mass per unit length~~—a continuous strand of yarn, wound on a ~~yarn. (See also *yarn number*.)~~ hand or motorized reel.

3.1.7 *yarn number, n*—a measure of the linear density of a yarn~~,~~ expressed as "mass per unit length", or "length per unit mass", depending upon the yarn numbering system used. ~~(See also~~ (Syn. *yarn count*.) (See *yarn ~~linear density~~ numbering system*.)

3.1.8 *yarn numbering system, n*—a system ~~expressing~~ that expresses the size of a yarn as a relationship between its length and associated mass. (See ~~also *yarn linear density, yarn number, direct yarn numbering system, and indirect yarn numbering system, and Appendix X1.)*~~ *.)*

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

4. Summary of Test Method

4.1 Specified lengths of yarn are wound on reels as skeins, and weighed. The linear density of the yarn is computed from the mass and length of the skein. In some options, the skein is scoured before weighing, and, depending on the option chosen, the mass of the skein may be determined after oven drying, or after conditioning.

5. Significance and Use

5.1 Test Method D 1907 is considered satisfactory for acceptance testing of commercial shipments, since it has been used extensively in the trade for that purpose.

---

[2] *Annual Book of ASTM Standards*, Vol. 07.01.
[3] ~~See Bornet, G. M., "A Study of Count Variation in Commercially Produced Single Yarns of All Types," Textile Research Journal, Vol. 36, 1996, p. 516.~~
[3] Available from American National Standards Institute, 11 West 42nd Street, 13th Floor, New York, NY 10036.

5.1.1 In case of dispute arising from differences in reported test results when using Test Method D 1907 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.

5.1.2 Competent statistical assistance is recommended for the determination of such a bias. As a minimum, the two parties should take a group of test specimens that are as homogeneous as possible, and that are from the same lot of the material 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 statistical analysis for unpaired data, and an acceptable probability level chosen by the parties before testing begins. If a bias is found, either its cause must be identified and corrected, or the purchaser and supplier must agree to interpret future test results for that material with consideration to the known bias.

5.2 This test method is intended primarily for the determination of the average linear density of yarns. However, the variations identified by the results may also provide useful information. If the coefficient of variation is to be calculated, each skein must be weighed separately, and a larger number of skeins will need to be tested (as compared to the number of skeins to be tested for the determination of the average yarn linear density alone).

5.3 This test method includes seven options, depending on whether the yarn is scoured before weighing, weighed in the conditioned or oven-dried state, or whether or not the results obtained are adjusted for commercial moisture regain, or a commercial allowance. Option 1 (unscoured, conditioned yarn) is generally used for yarns spun on the cotton system, while Options 6 and 7 (scoured, oven dried yarn, plus commercial moisture regain, or allowance are generally used for filament yarns, or yarns containing wool fibers. The specific options to be used in any instance shall be agreed upon by the parties, or as prescribed in test methods or tolerances, for filament yarns, or for yarns spun from specific fibers.

5.4 In Options 2, 3, 5, 6, and 7, an oven-dried sample is obtained by exposing the yarn in an oven with a supply of air at standard textile testing conditions, as described in 6.3.

6. Apparatus and Reagents

6.1 *Reel*:

6.1.1 *General*—A hand reel or motor driven reel having a perimeter of 1.000 m or 1.500 yd. with a tolerance of ±0.25 % is recommended. By prior agreement, reels having a perimeter of between 1.0 and 2.5 m (1.5 and 3.0 yd) may be used. The reel shall be fitted with a traversing mechanism that will avoid bunching successive wraps of yarn, and with an indicator of the length wound. A warning bell that rings at a specified length, is also recommended. And, it is advisable that one arm of the reel be collapsible, to allow for easy removal of the wound skeins.

6.1.2 *Reel Perimeter*—Determine the actual perimeter of the reel by winding a 0.6 cm. (0.25 in.) wide steel measuring tape around the reel. Tension the tape prior to directly reading the circumference of the reel, by attaching a 0.5 kg (1.0 lb) weight to the end of the tape. Repeat this measurement near each end of the bars of the reel, and in the center. If the circumference at any of these areas is outside the limits of 1.000 ± 2.5 mm (1.500 + 0.1 in.), adjust the fly wheel to bring the measurement(s) within the limits.

6.1.3 *Yarn Tensioning*—The reel shall be fitted with either a positive fee system at a controlled tension of 0.5 cN/tex (0.05 gf/tex) or with an adjustable tension device. The length of the skeins should be checked, and variations in length not be allowed to exceed ±0.25 % (See Annex A1).

6.2 *Balance*—For the determination of average yarn linear density, a balance of suitable capacity, graduated in grams or grains, with a sensitivity of 1 part in 1000 should be used. If single skeins are weighed, a balance graduated directly in yarn linear density may be used.

NOTE 2—The 1:1000 balance sensitivity is needed to ascertain the completion of conditioning, or oven drying. For subsequent weighings of skeins, a 1:500 sensitivity has been found to be sufficient.

NOTE 3—For the calculation of the variation of yarn linear density, a 1:100 balance sensitivity is sufficient to weigh individual skeins, after the skeins are conditioned, or oven-dried.

6.3 *Drying Oven*—An oven, ventilated and capable of being controlled in a temperature range of 105 ± 3°C (221 ± 5°F), is required to dry the skeins. The oven should be of sufficient design to facilitate the free passage of air through the specimens, and should be supplied with a current of air sufficient to change the air in the oven once every 4 min. The specimens shall be protected from any direct heat, radiating from the heating units of the oven. Air supplied to the oven shall be at the standard atmosphere for testing textiles. The oven may be provided with facilities to shut off the air current and weigh the specimens, without removing them from the oven.

6.4 *Facilities for Scouring* (Options 4, 5, 6, and 7), as indicated in X2.2, or in Sections 6.1 and 6.3 of Test Method D 2494.

6.5 *Weighing Cans*, with tight fitting lids, and of sufficient size to hold all skeins, or groups of skeins (Options 2, 3, 5, 6, and 7), if the weighing is to be done outside the oven. Weighing bottles with ground-glass stoppers may also be used.

6.6 *Auxiliary Facilities*, suited to the specimens and options used, such as sample supports, tared wire gauze baskets of corrosion resistant metal, dessicators of sufficient size to hold the weighing cans or bottles, and an efficient dessicant.

7. Sampling

7.1 *Lot Sample*—As a lot sample for acceptance testing, take at random the number of shipping units directed in an applicable material specification, or other agreement between the purchaser and supplier, such as an agreement to use Practice D 2258.

Consider cartons or other shipping units to be the primary sampling units.

NOTE 4—An adequate specification or other agreement between the purchaser and the supplier requires taking into account the variability between shipping units, between packages or ends within a shipping unit, and between specimens from a single package, to provide a sampling plan with a meaningful producer's risk, user's risk, acceptable quality level, and limiting quality level.

7.2 *Laboratory Sample*—As a laboratory sample for acceptance testing, take at random from each shipping unit in the lot sample the number of packages or ends directed in an applicable material specification, or as agreed to between purchaser and supplier (such as an agreement to use Practice D 2258). Preferably, the same number of packages should be taken from each shipping unit in the lot sample.

7.2.1 *Average of Yarn Linear Density*—When only the average of the yarn linear density is to be determined, take a laboratory sample as follows:

Filament yarns	— 5 packages
Yarns spun on Worsted or Cotton systems	— 10 packages
Yarns spun on Bast, or Woollen systems	— 20 packages

7.2.2 *Average and Variability of Yarn Linear Density*—When both the average and variability of the linear density of yarn are to be determined, take a laboratory sample of 30 packages. If possible, take an equal number of randomly selected packages from each case in the lot sample.

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

NOTE 5—Since the variation in yarn linear density is usually higher between packages than within packages, no appreciable improvement in precision can be expected by testing more than one skein from each package.

7.3.1 An exception to the information provided in Note 5 may occur in packages of filament yarns; consistent differences in yarn linear density are sometimes present between yarn on the outside of the package, as compared to yarn on the inside. If such differences are suspected, test more than one skein from each package, without reducing the number of packages sampled for testing, taking skeins at intervals throughout the packages.

8. Conditioning

8.1 Before reeling test skeins, condition yarn in skein form in the standard atmosphere for testing textiles for a minimum of 1 h, and yarn on packages for a minimum of 3 h. Additionally, prior to testing, preconditioning of the test skeins may be required for Option 1, but is not necessary for Options 2 through 7.

NOTE 6—For Options 2 through 7, where the yarn is scoured or oven-dried after reeling, the conditioning prior to reeling is required to ensure a correct skein length.

9. Procedure

9.1 *General*:

9.1.1 The procedure used depends on the options selected; Table 1 shows the steps to be followed for each option.

9.1.2 If both the breaking load and linear density are to be determined, test conditioned skeins for breaking strength before scouring, as directed in Test Method D 1578.

For Option 1, condition the yarn prior to reeling test skeins. Pre-condition, then condition the test skeins; perform skein breaking load tests prior to weighing the skeins. For all the other Options, condition the yarn prior to reeling test skeins. Precondition, then condition the test skeins, break them, then proceed with oven drying or scouring, or both, and the subsequent steps shown in Table 1.

9.2 *Tension for Reeling*:

9.2.1 To establish the required tension for reeling, reel a skein from each of two packages, and immediately check their lengths, as prescribed in Appendix. If the length of either skein departs from the set length by more than 0.25 %, adjust the reeling tension and repeat the reeling measurement until both skeins fall within the ±0.25 % tolerance. If yarn is supplied on more than one type of package, check two skeins from each type of package as above. It may be necessary to use different reeling tensions for each package type.

9.2.2 If, when reeled under the least possible tension, skeins are more than 0.25 % shorter than the nominal length, reel skeins longer than specified in Table 2, and allow them to relax in the standard atmosphere for testing textiles for at least 3 h. Then reel test skeins from the relaxed skeins, for the determination of yarn linear density.

9.2.3 Once the correct tension for reeling has been established for a specific type of yarn and package, subsequent testing of that yarn on the same reel does not require rechecking of skein lengths.

9.3 *Length of Test Skein*:

9.3.1 For reels with perimeters of 1 m or 1.5 yd, select the number of wraps and skein length from Table 2. If a reel with a different perimeter is used by agreement, select the number of wraps based on a whole number of turns of the reel, that will give approximately one of the skein lengths shown in Table 2.

NOTE 7—If both the skein breaking force and yarn linear density are to be determined, note that in certain cases, skein lengths shorter than those shown

TABLE 1 General Procedures

	Referenced Sections
Step 1	
All Options:	
Selection of lot sample, and packages	7
Conditioning prior to reeling	8.1
Setting of skein gage, and reeling of skeins	9.3 to 9.6
Step 2	
Option 1—Unscoured yarn in standard atmosphere for testing textiles:	
Preconditioning and conditioning	9.7, and 9.8
Weighing of skeins, and calculation of yarn linear density	9.10, 10.1, and 10.2
Option 2—Unscoured, moisture free yarn, and,	
Option 3—Unscoured, moisture free yarn, with commercial moisture regain:	
Oven drying	9.9
Weighing of skeins, and calculation of yarn linear density	9.10, and 10
Option 4—Scoured yarn, in standard atmosphere for testing textiles:	
Scouring	9.6, and X2
Preconditioning, and conditioning	9.7, and 9.8
Weighing of skeins, and calculation of yarn linear density	9.10, 10.1, and 10.2
Option 5—Scoured, oven-dried yarn	
Option 6—Scoured, oven-dried yarn, with commercial moisture regain:	
Option 7—Scoured, oven-dried yarn, with commercial allowance:	
Scouring	9.6, and X2
Oven drying	9.9
Weighing of skeins, and calculation of yarn linear density	9.10, 10.1, and 10.2

TABLE 2 Number of Wraps and Lengths of Skeins

	1 m Reel Perimeter	1.5 yd Reel Perimeter
All yarns finer than 100 tex	100 wraps = 100 m	80 wraps = 120 yd
Spun yarns coarser than 100 tex[A]	50 wraps = 50 m	40 wraps = 60 yd
Filament yarns coarser than 100 tex	10 wraps = 10 m	8 wraps = 12 yd

[A] See 9.3.2.

in Table 2 are permitted. For example, Option 1 of Test Method D 1578 specifies a skein length of 110 m (120 yd), but permits the use of shorter skeins, to allow the breaking force to remain within the capacity of the tensile testing machine. In such cases, reel an additional skein from each package in the laboratory sample so that the total length of the skeins (additional skein plus skein used to determine the skein breaking force), reeled from each package, equals the values listed in Table 2. Weigh the two skeins from each package together, to determine the linear density of the yarn.

9.3.2 When reeling very coarse yarns, wind a single layer, to avoid a build up on the reel. Specifically, use no more than 25 wraps for yarns between 500 and 1000 tex, and no more than 10 wraps for yarns between 1000 and 2000 tex. Obtain the required length of skeins (approximately 50 m, or 60 yd) either by reeling two or more contiguous short skeins, or by using a reel with a perimeter larger than 1 m (1.5 yd).

9.4 *Reeling*—Since the speed of reeling can affect reeling tension, reel all skeins at the speed used in reeling preliminary skeins (see Annex A1). Avoid jerks and undue acceleration or deceleration.

9.5 *Scouring* (Options 4, 5, 6, and 7 only)—Scour the skeins as directed in Appendix X2. Alternatively, the scouring procedures listed in Sections 7.8, 7.9, and 7.12 of Test Method D 2494 may also be used.

9.6 *Preconditioning* (Options 1 and 4 only)—Precondition skeins of the as received yarn, reeled for Option 1, or scoured and air-dried skeins for Option 4, for at least 3 h in an atmosphere that does not exceed a temperature of 50°C (122°F), and with a relative humidity between 10 and 25 %.

9.6.1 If preconditioning is carried out in an oven, ensure that the yarn does not become too dry.

NOTE 8—In Option 1, preconditioning and conditioning of yarn may be done before reeling. However, it is usually not convenient to precondition large packages in an oven or a cabinet. Therefore, it may be preferable to precondition the yarn in skein form.

9.7 *Conditioning* (Options 1 and 4 only)—Condition skeins that have been preconditioned as directed in Section 9.6 in a standard atmosphere for testing textiles, 21 ± 1°C (70±2°F) and 65 ± 2 % relative humidity, until moisture equilibrium is reached, that is, until the mass of the specimen increases by no more than 0.1 % after 2 h in that atmosphere.

9.8 *Oven Drying* (Options 2, 3, 5, 6, and 7)

9.8.1 Place the skeins as reeled, or after scouring, in an oven, maintained at 105±3°C (221±5°F). Arrange the skeins to permit free air access.

9.8.2 Dry the skeins to constant mass, that is, until they lose no more than 0.1 % of their mass at 15 min. intervals if weighed in the oven, or at 30 min. intervals if weighed outside the oven.

9.8.2.1 Cooling in hot, closed containers in a dessicator frequently creates a vacuum in the container. For metal containers, quickly remove and replace the cover to release the vacuum before weighing. For glass bottles, cool the container with the cover resting sideways on the container, to prevent development of vacuum, and put covers in place upon opening the dessicator, before weighing.

9.9 *Weighing*:

9.9.1 If the variation in yarn linear density is to be determined of if the mass of individual skeins is needed, weigh each skein separately.

9.9.2 To determine average yarn linear density, weigh all skeins together at each step, even if weighed separately earlier.

NOTE 9—A higher degree of accuracy is obtained when all skeins are weighed together as compared to when each skein is weighed separately. Hence, this method provides for the determination of the average yarn linear density by weighing all the skeins together.

9.9.3 If the pan of the balance is too small to accommodate all the skeins at one time, weigh them separately in groups, and add the results of each weighing.

9.9.4 If weighing dried skeins in an oven, shut off the current of air in the oven. If the weighing is done outside the oven, transfer the skein or skeins to a weighing can or bottle, close and place in a dessicator to cool. Weigh when cool. If weighing bottles are used, loosen their covers from time to time, while cooling.

10. Calculation

10.1 *Calculation of Average Yarn Linear Density*:

10.1.1 Calculate the average mass of a single skein from the total mass of all skeins.

10.1.2 From the average mass of a skein, calculate the yarn linear density in one step, for Options 1, 2, 4, and 5, and in two steps for Options 3, 6, and 7. The first step, applicable to all Options, consists of calculating yarn linear density from the mass and length of skeins. The second step consists of making an adjustment for moisture (Options 3 and 6), or an adjustment for both moisture and finish (Option 7) to the yarn linear density calculated by the first step.

10.1.3 *Equations for Yarn Linear Density from Mass and Length of Skeins*—A number of equations can be used to determine yarn linear density. The type of equation to be used depends on: (1) the length of skeins (which, in turn, depends on the perimeter of the reel and the number of wraps used), (2) the units of mass (grams or grains), and (3) the type of yarn numbering system that the linear density is calculated in. It is not feasible to give the equations for all the possible combinations of the above. The lengths and masses that form the basis of several yarn numbering systems, as well as the basic equations are given in Appendix X1. A selection of constants, required for calculations, and examples of the derivation of the equations that apply for various yarn numbering systems are listed in Table 3.

10.1.4 The equations for yarn linear density have the following general form:

$$\text{Yarn Linear Density (direct system)}, D = (M/L) \times (A/B) \quad (1)$$

$$\text{Yarn Linear Density (indirect system)}, I = (L/W) \times (B/A) \quad (2)$$

where:

M = average mass of skeins, in grams or grains,
L = length of skein as read from skein gage (or calculated by the number of wraps × perimeter of the reel), in m or yd,
A = constant, depending on the yarn numbering system used, and
B = constant, depending on the unit of mass used.

10.1.5 *Use of Direct Reading Balances*—If balances calibrated directly in yarn linear density are used, obtain the values directly by reading the scale on the balance, and calculate the average yarn linear density, using Eq 3 or Eq 4, depending on the yarn numbering system used:

$$D = \Sigma\, Ti/n \quad (3)$$

~~$I = n/[\Sigma(1/Ti)]$~~ (4)

$$I = n/[\Sigma(1/Ti)] \quad (4)$$

where:

D = yarn linear density in the direct system,
I = yarn linear density in the indirect system,
n = number of skeins, and,
i = 1, 2, 3, ... n.

10.1.6 *Adjustment for Moisture and Finish* (Options 3, 6, and 7)—Adjust the results for average yarn linear density, obtained as directed in 10.1.4 and 10.1.5, by adding the commercial moisture regain for Options 3 and 6, and the commercial allowance

TABLE 3 Constants A and B for General Equation 1 and Equation 2

Length of skein: Mass of skien in:		meters grams	yards grams	yards grains
Direct Systems:				
Tex	*A/B*	1000/1 = 1000	1094/1 = 1094	1094/15.43 = 70.86
Denier	*A/B*	9000/1 = 9000	9842/1 = 9842	9842/15.43 = 637.8
Spyndle	*A/B*	13167/453.6 = 29.03	14400/453 6 = 31.75	14400/453.6 = 2.057
Indirect Systems:				
Cotton count	*B/A*	453.6/768.1 = 0.5905	453.6/840 = 0.5400	7000/840 = 8.333
Worsted count	*B/A*	453.6/512.1 = 0.8858	453.6/560 = 0.8100	7000/560 = 12.5
Woolen run	*B/A*	453.6/1463 = 0.3100	453.6/1600 = 0.2835	7000/1600 = 4.375
100-yd hanks/lb	*B/A*	453.6/91.44 = 4.961	453.6/100 = 4.536	7000/100 = 70

Example 1—1-m reel, 100 wraps = 100-m skein, mass (W) in grams:

$$\textit{Yarn Linear Density in tex} = \frac{W}{100} \times \frac{1000}{1} = 10\ W$$

Example 2—1.5-yd reel, 80 wraps = 120-yd skein, mass (W) in grams:

$$\textit{Yarn Linear Density in cotton count} = \frac{120}{W} \times \frac{7000}{840} = \frac{1000}{W}$$

Example 3—1.5-yd reel, 40 wraps = 60-yd skein, mass (W) in grams:

$$\textit{Yarn Linear Density in worsted count} = \frac{60}{W} \times \frac{453.6}{560} = \frac{48.6}{W}$$

Example 4—1.125-m reel, 80 wraps = 90-m skein, mass (W) in grams:

$$\textit{Yarn Linear Density in denier} = \frac{W}{90} \times \frac{9000}{1} = 100\ W$$

for Option 7. Unless otherwise agreed, use the values listed in Table D 1909.

10.1.7 Calculate the adjusted yarn linear density, using Eq 5 or Eq 6, as follows:

$$D' = D[(100 + C)/100] \tag{5}$$

~~$$I' = I[100/(100 + C)]$$~~ (6)

$$I' = I[100/(100 + C)] \tag{6}$$

where:

D' = adjusted yarn linear density in the direct system,
I' = adjusted yarn linear density in the indirect system,
D = linear density of oven-dried yarn in the direct system,
I = linear density of oven-dried yarn in the indirect system, and,
C = commercial moisture regain, from Table 1909, or commercial allowance, or other value, as agreed upon, %.

10.1.7.1 If the yarn is a blend of different fibers, with different commercial regains or allowances, then calculate the applicable commercial regain or allowance by Eq 7, as follows:

$$C = (1/100)(F_aC_a + F_aC_b + \ldots) \tag{7}$$

where:

$F_a\ F_b \ldots$ = content of fiber *a*, *b*, . . ., %, and,
$C_a\ C_b \ldots$ = commercial moisture regain, for fiber *a*,*b*,. . ., %.

Example—Calculation of the adjustment for commercial moisture regain for a yarn composed of 80 % rayon (commercial regain of 11 %), and 20 % secondary acetate (commercial regain of 6.5 %):

$$C = (1/100)(80 \times 11 + 20 \times 6.5) = (1/100)(880 + 130) = 10.1 \tag{8}$$

And, the adjusted yarn linear density (Option 3) will then be either:

$$D' = D[(100 + 10.1)/100] = D \times 1.101, \tag{9}$$

or:

~~$$I' = I[100/(100 + 10.1)] = I/1.101$$~~ (10)

$$I' = I[100/(100 + 10.1)] = I/1.101 \tag{10}$$

10.2 *Calculation of the Variation of Yarn Linear Density*

10.2.1 Calculate the coefficient of variation for yarn linear density, or the mass of skeins, for the laboratory and lot samples, using Eq 11, as follows:

$$V = \frac{100}{\bar{x}} \sqrt{\frac{\Sigma x^2 - [(\Sigma x)^2/n]}{n - 1}} \tag{11}$$

where:
v = coefficient of variation, %,
x = yarn linear density for individual packages, or the mass of individual skeins,
$\bar{x}$ = average value of the x's, and,
n = number of packages.

NOTE 10—The coefficient of variations of yarn linear density depends on the length of yarn in test skeins, and increases as the length decreases. However, the coefficients of variation obtained with skeins of from 90 to 110 m in length have been found to be comparable.

11. Report

11.1 State that the specimens were tested as directed in Test Method D 1907. Describe the materials or products sampled, and the method of sampling used.

11.2 Report the following information:

11.2.1 Average yarn linear density, with identification of the yarn numbering system used,

11.2.2 Coefficient of variation of yarn linear density, if calculated,

11.2.3 Perimeter of the reel used,

11.2.4 Length of test skeins,

11.2.5 Option used, and,

11.2.6 Number of specimens tested.

12. Precision and Bias

12.1 *Within Laboratory Test Data*[4]—The results of extensive tests, carried out between 1961 and 1964, in which 291 laboratories in 26 countries determined the average, and coefficients of variation of yarn linear densities, together with the results of the variations in these results within these laboratories, for 1015 different types of yarns, are summarized in Table 4. Since each type of yarn exhibited a wide range of variations, both the average and standard deviations for each yarn type are listed in that Table.

12.2 *Within Laboratory Precision*—For the components of variance reported in the above described study, two averages of observed values would be considered significantly different at the 95 % probability level, if the critical differences in the reported averages equal or exceed the critical differences listed in Table 5.

12.3 *Bias*—Test Method D 1907 has generally been used as a referee method, and has no known bias. Freedom from all bias is possible only when all the components used for measurement, that is, reels, balances, ovens, etc., are absolutely precise, and free from error.

13. Keywords

13.1 yarn linear density, yarn number

[4] See Bornet, G. M., "A Study of Count Variation in Commercially Produced Single Yarns of All Types," Textile Research Journal, Vol. 36, 1996, p. 516.

TABLE 4 Coefficients of Variation for Yarn Linear Density Within Laboratories, Based on One Skein Per Package[A]

Type of Yarn	Number of		Average CV, %	Standard Deviation
	Yarns	Mills		
Filament	48	17	1.33	0.65
Worsted system	125	46	2.89	1.12
Cotton system	616	133	3.41	1.31
Linen, hemp, manila and sisal	51	21	4.34	1.53
Jute	48	19	7.11	1.65
Woolen system	127	55	5.39	1.89

[A] Length of skeins in the range of 90 to 110 m, selected according to the practice of the mill.

TABLE 5 Critical Differences (in Percent) in Average Yarn Linear Density

Type of Yarn	Number of Observations		
	1	5	10
Filament yarns	3.7	1.6	1.2
Yarns spun on worsted systems	8.0	3.6	2.5
Yarns spun on cotton systems	9.5	4.2	3.0
Linen, hemp, manila, and sisal yarns	12.0	5.4	3.8
Jute yarns	19.7	8.8	6.2
Yarns spun on woolen systems	14.9	6.7	4.7

ANNEX

(Mandatory Information)

A1. MEANS FOR CHECKING THE LENGTH OF YARN IN SKEINS

A1.1 Summary of Procedure

A1.1.1 A skein is mounted under a specified tension between two vertically aligned pegs, one of which is movable. The length of the skein is read directly from a scale, mounted adjacent to the pegs. The length of the skein, the number of wraps in the skein, and the physical dimensions of the apparatus are used to calculate the length of the yarn in the skein.

A1.2 Apparatus

A1.2.1 The skein gage, for checking the length of a test skein under prescribed conditions of load, consists of two round metal pegs, each about 12.5 mm (0.50 in.) in diameter, and 50 to 60 mm (2 to 2.5 in.) long, located in the same vertical plane. One of the pegs is fixed to the rigid frame of the apparatus, and the other is carried on the lever of a simple loading system, with a low friction bearing mounted on the frame acting as the fulcrum for the system. At least one of the pegs shall be free to rotate about its axis. One half of the length of the skein is indicated on a scale mounted on the frame, by a pointer attached to the lever arm, or by an index line on the end of the lever arm.

A1.3 Procedure

A1.3.1 Taking care to avoid bunching, place the skein around the two pegs, and apply the appropriate load, by hanging a weight on the lever arm, or by moving a sliding weight along the lever arm. Record the length of the skein by reading the distance between the pegs on the scale with the skein under a tension of 0.5 cN/tex (0.05 gf/tex). Calculate the length of the yarn in the skein, using Eq A1.1, as follows:

$$L = 2(D + 1.25\,\pi) \times n \tag{A1.1}$$

where:

L = length of yarn in the skein, in cm,
D = distance between the axes of the pegs, as registered on the scale, in cm, and,
n = number of wraps in the skein.

A1.3.2 If the value of the length of the yarn in the skein falls outside the limits of ±0.25 %, prepare a new skein after adjusting the winding tension, check the length of yarn in that skein, and, if within limits, reel skeins for testing, as necessary, using the new (adjusted) winding tension.

NOTE A1.1—Yarn linear density is determined from the mass of a specific length of yarn. Since yarns are extensible to varying degrees, it is essential that skeins be reeled under controlled tension, to obtain specific yarn lengths every time. However, yarn reels are not equipped to read reeling tensions. Hence, the simple apparatus described above allows for the determination of the precise length of yarns in skeins, and adjustment of the reeling tension, to ensure that the length of yarn in skeins is within acceptable tolerances.

APPENDIXES

(Nonmandatory Information)

X1. MOST COMMON YARN NUMBER SYSTEMS

System	Length	Mass	Equation[A]
Direct Systems (Mass per unit length), General Symbol: *D*			
~~Tex~~	~~1000 m~~	~~1 g~~	~~$D = \frac{M}{L}$~~
Tex	1000 m	1 g	$D = \frac{M}{L}$
~~Denier~~	~~9000 m~~	~~1 g~~	~~$D = \frac{M}{L}$~~
Denier	9000 m	1 g	$D = \frac{M}{L}$
~~Spyndle~~	~~14400 yd~~	~~1 lb~~	~~$D = \frac{M}{L}$~~
Spyndle	14400 yd	1 lb	$D = \frac{M}{L}$
Indirect Systems (Length per Unit Mass), General Symbol: *I*			
~~Cotton count~~	~~840 yd~~	~~1 lb~~	~~$I = \frac{L(\text{yd})}{M}$~~
Cotton count	840 yd	1 lb	$I = \frac{L(\text{yd})}{M}$
~~Glass~~	~~100 yd~~	~~1 lb~~	~~$I = \frac{L(\text{yd})}{M}$~~
Glass	100 yd	1 lb	$I = \frac{L(\text{yd})}{M}$
~~Linen~~	~~300 yd~~	~~1 lb~~	~~$I = \frac{L(\text{yd})}{M}$~~
Linen	300 yd	1 lb	$I = \frac{L(\text{yd})}{M}$
~~Metric~~	~~1000 m~~	~~1 kg~~	~~$I = \frac{L(\text{m})}{M}$~~
Metric	1000 m	1 kg	$I = \frac{L(\text{m})}{M}$
~~Woolen run~~	~~1600 yd~~	~~1 lb~~	~~$I = \frac{L(\text{yd})}{M}$~~
Woolen run	1600 yd	1 lb	$I = \frac{L(\text{yd})}{M}$
~~Worsted count~~	~~560 yd~~	~~1 lb~~	~~$I = \frac{L(\text{yd})}{M}$~~
Worsted count	560 yd	1 lb	$I = \frac{L(\text{yd})}{M}$

[A] M = Mass of skeins, and, L = Length of skeins.

X2. RECOMMENDED PROCEDURES FOR SCOURING YARNS TO REMOVE FINISH, AND OTHER NONFIBROUS MATERIALS

X2.1 Summary of Procedures

X2.1.1 Test skeins are scoured under conditions designed to remove all oils, finishes, or other nonfibrous materials that will normally be removed during the wet processing of fabrics produced from the yarn being tested.This condition is considered to be reached when a suitable solvent extraction of the scoured yarn shows the residual nonfibrous materials to be less than 0.1 %.

NOTE X2.1—Care should be taken to ensure that the solvent(s) used do not swell or dissolve the fiber(s).

X2.2 Apparatus and Reagents

X2.2.1 *Kettle*—A kettle made of corrosion resistant material such as Monel, aluminum, stainless steel, or enameled steel, heated by a closed, gas, or electric, steam coil or jacket, equipped with a drain and supply of soft water, and designed to permit rinsing by overflowing, is recommended.

NOTE X2.2—In place of the kettle, a household-type automatic washing machine, or appropriately sized noncorrodible containers such as glass or stainless steel beakers may be substituted.

X2.2.2 *Roller Wringer, or Centrifugal Extractor*.

X2.2.3 *Bags*—Bags, produced with polyester fabric or of similar material, that have been previously scoured, and whose weight

in the oven dried state is known, are recommended. Each bag should be large enough to permit free access of the scour solution to yarn in the skein.

X2.2.4 *Analytical Balance*—See 6.2.

X2.2.5 *Drying Oven*, maintained at 105 ± 3°C (221 ± 5°F). (See 6.3).

X2.2.6 *Weighing Cans or Bottles*—See 6.5.

X2.2.7 *Neutral Soap, or Non-Ionic Detergent*, or some other emulsifying agents, as agreed upon by the purchaser and supplier.

X2.2.8 *Soft Water*, of 10 ppm or less calcium carbonate hardness.

X2.3 Scour Procedure

X2.3.1 Place one or more properly identified skeins whose mass in the oven dried state is known, in a bag. Immerse the bags with skeins in the scour bath containing 0.5 g/L (0.07 oz/gal) of soap, neutral detergent, or other emulsifying agent, and using a bath ratio of at least 25 times the mass of the skeins being scoured. Heat and hold the scour bath containing bags of skeins to be scoured, at the boil, with agitation, for 30 min. After the scour, rinse by overflowing with soft water at 75 ± 3°C (140 to 149°F), until all surface scum is removed, and the water in the vessel is clear.

X2.3.2 Drain off the excess water, wring the skeins dry, and then rinse the skeins thoroughly by agitating them for 10 min at 75 ± 3°C (167 ± 5°F). Wring dry, then rinse the skeins once more, by agitation for 10 min. in a fresh bath at 60 to 65°C (140 to 149°F). Wring dry, and rinse a final time, by agitation for 10 min. in a fresh bath at room temperature, then wring dry the skeins a final time. For Option 4, air dry, precondition, then condition the scoured skeins; for Options 5, 6, and 7, dry the skeins by placing bags with skeins in the drying oven.

X2.3.3 Test the efficacy of the boil-off by extracting some boiled-off and dried yarn with a solvent that does not dissolve the fiber content of the yarn being tested. If the amount of extractable matter thus obtained exceeds 0.1 %, increase the severity of the scouring procedure by (a) using a higher amount of the same soap or detergent, or (b) using a stronger soap or detergent, or (c) using greater agitation during the boil-off, or (d) using a longer time of boil-off, or (e) using a double boil-off, as appropriate.

X2.4 Procedure—Evaluation by Extraction

X2.4.1 When it can be shown that solvent extraction, or another scouring procedure gives the same results, that procedure may be used for routine testing of known production, but should not be substituted for the above described boil-off on new or unknown materials. For procedures to determine the extractable matter in yarns, refer to Test Method D 2257.