Designation: D 2591 – 01

Standard Test Method for Linear Density of Elastomeric Yarns (Short Length Specimens)[1]

This standard is issued under the fixed designation D 2591; 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 short lengths of "as produced" elastomeric yarns made from rubber, spandex or other elastomers.

NOTE 1—For the determination of linear density of elastomeric yarns using skeins, refer to Test Method D 6717.

1.2 This test method is not applicable to covered, wrapped, or core-spun yarns, or yarns spun from elastomeric staple, or elastomeric yarns removed from fabrics.

1.3 This test method is applicable to elastomeric yarns having a range of 40 to 3200 dtex (36 to 2900 denier).

1.4 The values stated in either SI units or U.S. Customary units are to be regarded separately as standard. Within the test the US Customary units are in parentheses. The values stated in each system are not exact equivalents; therefore, each system shall be used independently of the other.

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 1776 Practice for Conditioning and Testing Textiles[2]

D 2258 Practice for Sampling Yarn for Testing[2]

D 6717 Test Method for Linear Density of Elastomeric Yarns (Skein Specimens)[3]

3. Terminology

3.1 *Definitions:*

3.1.1 *denier*, *n*—the unit of linear density, equal to the mass in grams per 9000 m of fiber, yarn, or other textile strand that is used in a direct yarn numbering system.

3.1.2 *elastomeric yarn*, *n*—a nontextured yarn which can be stretched repeatedly at room temperature to at least twice its original length and which after removal of the tensile force will immediately and forcibly return to approximately its original length.

3.1.3 *linear density*, *n—for fiber and yarn*, the mass per unit length.

3.1.4 *tex*, *n*—the unit of linear density, equal to the mass in grams of 1000 metres of fiber, yarn or other textile strand, that is used in a direct yarn numbering system.

3.1.5 For definitions of other terms related to textiles used in this standard, refer to Terminology D 123.

4. Summary of Test Method

4.1 A pre-relaxed specimen is fastened in vertically mounted apparatus under a specified tension. A specified length is cut from the specimen and weighed, and the linear density calculated.

5. Significance and Use

5.1 This test method is considered satisfactory for acceptance testing of commercial shipments because current estimates of between-laboratory precision are acceptable and the method is used extensively in the trade for acceptance testing.

5.1.1 If there are differences 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 samples for such comparative tests that are as homogeneous as possible, drawn from the same lot of material as the samples that resulted in disparate results during initial testing, and randomly assigned in equal numbers to each laboratory. The test results from the laboratories involved should be compared using a statistical test for unpaired data, at a probability level chosen prior to the testing series. If 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 Linear density of elastomeric yarns is used in some calculations for tensile and elastic properties.

5.3 The test method is based on elastomeric yarns in lthe

[1] This test method is under the jurisdiction of ASTM Committee D13 on Textiles and is the direct responsibility of Subcommittee D13.58 on Yarns.

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

[3] *Annual Book of ASTM Standards*, Vol 07.02.

"as-produced" condition, but may be used for treated elastomeric yarns provided the treatment is specified. The method does not cover the removal of finish for the determination of linear density of "finish-free" elastomeric yarns.

6. Apparatus [4]

6.1 *Specimen Boards*, with short pile or plush surfaces of black or contrasting color, for storing specimens during relaxation period.

6.2 *Linear Density Apparatus*, mounted vertically on a wall or in a sturdy, stable vertical support and containing the essential parts listed below. See Fig. 1 and Annex A1 for general construction details of suitable apparatus.

6.2.1 *Steel Plate*, about 100 mm (4 in.) wide and 1.3 m (1.4 yd) long.

6.2.2 *Clamps*, three toggle-action type with rubber tips.

6.2.3 *Brass Plates*, two, with slots at right angles to be used for controlling the alignment and length of the specimen.

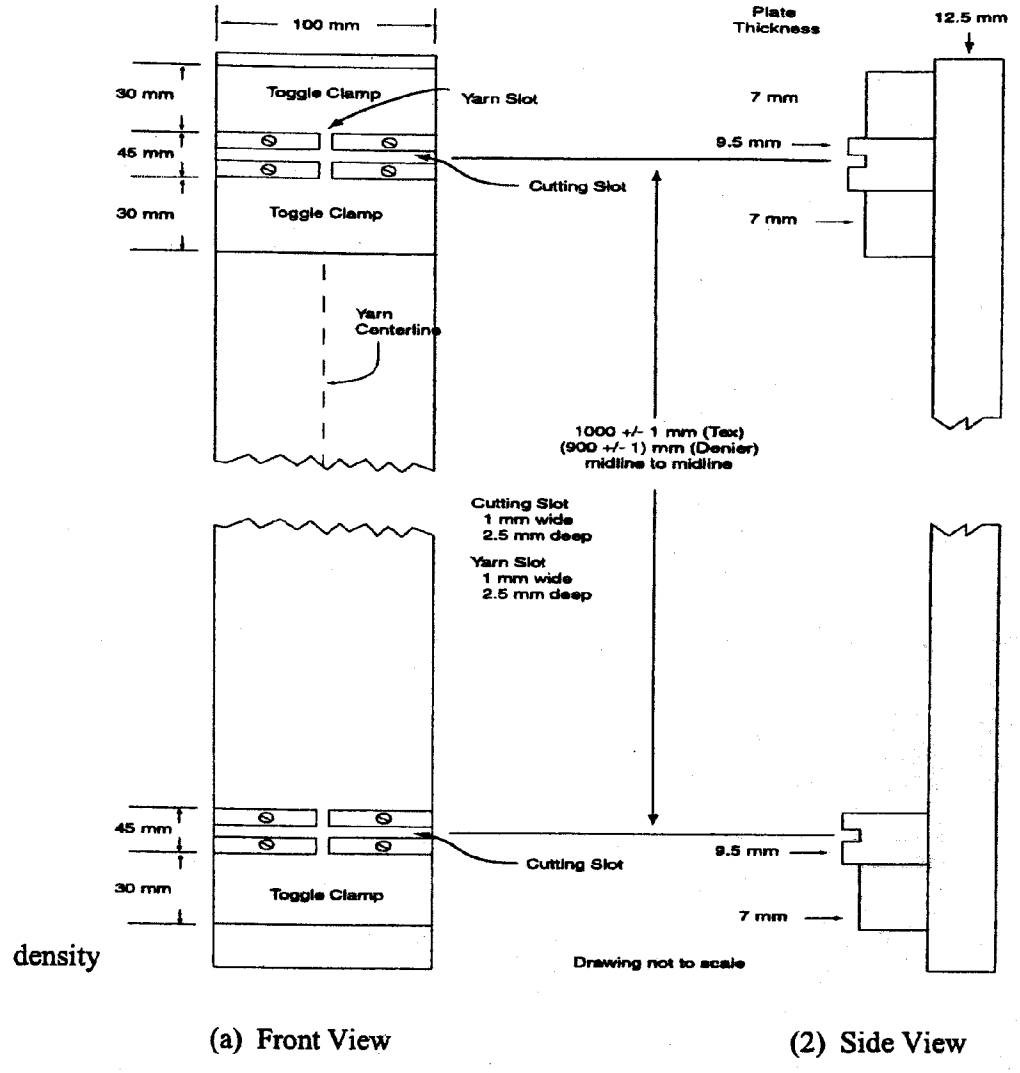
6.2.3.1 The slots are positioned such that the distance between the slot midlines provides a gage length of 1000 mm when using the tex system or 900 mm when using the denier system. If necessary, the two gage lengths can be obtained by having the upper slot assembly adjustable, or by having two separate test apparatuses.

6.3 *Tensioning Weights*, with varioius masses from 10 mg to 3 g as required, to pretension the specimens to 1.0 ± 0.1 cN/tex (0.9 ± 0.09 gf/d) tension based on the nominal linear density of the yarn.

6.4 *Razor Blades*, safety single-edge, or wood-carving type knife.

6.5 *Balance*, with an accuracy of ± 0.1% of the expected mass of the specimens.

[4] Components are commercially available.



NOTE 1—Drawing not to scale. For conversion to U.S. customary units, divide mm by 25.4 to obtain inches

FIG. 1 Linear Density Apparatus

7. Sampling, Test Specimens, and Test Units

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

NOTE 2—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 with a meaningful producer's risk, consumer'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 directed in an applicable material specification or other agreement between the purchaser and the supplier, such as an agreement to use Practice D 2258. Preferably, take the same number of packages from each of the shipping units selected. If differing numbers of packages are to be taken from the shipping units, determine at random which shipping units are to have each number of packages for testing.

7.3 *Test Specimens* —From each package or end in the laboratory sample, prepare six specimens, as directed in 7.3.1.

7.3.1 Remove the outer layer of yarn from the package. Avoid any damaged areas in selecting segments for testing. Carefully unwind yarn from the package with as low a tension as possible to avoid stretching. Cut five approximately 1300 mm (50 in.) length segments of yarn from the package, taking them at irregular intervals of at least 2 m (2 yd).

7.3.2 Place the specimens without tension on a specimen board. Allow the segments to relax without stress for at least 4 h as directed in 9.2.

8. Conditioning

8.1 Preconditioning is not necessary for currently produced rubber and other elastomeric yarns.

8.2 Condition the specimens, without tension, on specimen boards in the standard atmosphere for testing textiles which is 21 ± 1 °C (70 ± 2 °F) and 65 ± 2 % relative humidity for a minimum of 4 h.

9. Procedure

9.1 Test all specimens in the standard atmosphere for testing textiles.

9.2 Select a tension weight that will apply 1.0 ± 0.1 cN/tex (0.9 ± 0.09 gf/d) tension based on the nominal linear density of the yarn.

9.3 Remove the conditioned specimen from the board and fasten one end in the top clamp of the apparatus. Attach the selected tension weight to the opposite end of the test specimen.

9.4 Carefully lower the specimen and tension weight and allow the specimen to hang freely in the vertical slots of the test apparatus. Do not allow the tension weight to drop suddenly as this will put abnormal tension on the specimen affecting the length.

NOTE 3—Release of the weight from the palm of the hand has less effect on the tension than releasing the weight from between thumb and finger.

9.5 After approximately 5 s, close the bottom clamp and then the middle clamp. Cut the specimen centrally in the bottom slot and then in the top slot, using a straight-on perpendicular cutting action without lateral action. Lateral action may cause stretching. The actual length of the test specimen after cutting is 1 m (1000 mm) ± 1 mm or 0.9 m (900 mm) ± 1 mm depending upon the yarn numbering system used.

9.6 Weigh the specimen and record its mass to within 0.1 %.

9.7 Calculate the linear density as directed in 10.1, then compare the calculated linear density to the nominal density given and proceed as follows:

9.7.1 If the calculated density is within 5 % of the given nominal density, test 4 additional specimens as directed in 9.3-9.6, for a total of five.

9.7.2 If the calculated density is different from the given nominal density by more than 5 %, discard the result, change the tension weight to meet 1.0 ± 0.1 cN/tex (0.9 ± 0.09 gf/d) tension based on the calculated linear density of the yarn. Test a total of 5 specimens as directed in 9.3-9.6, under the newly determined tension.

10. Calculation or Interpretation of Results

10.1 Calculate the linear density for each specimen to the nearest 0.1 dtex (0.1 denier), using Eq 1 or Eq 2.

$$T_d = 10000 \times M / L \quad (1)$$

$$D = 9000 \times M / L \quad (2)$$

where:

T_d = linear density, dtex,
D = linear density, denier,
M = mass of specimen, g, and
L = length of specimen, m. (For tex system L = 1 m—For denier system L = 0.9 m)

10.2 Calculate the average linear density for each laboratory sampling unit and for the lot.

10.3 If requested, calculate the coefficient of variation, standard deviation, or both for each laboratory sampling unit and for the lot.

11. Report

11.1 State that the samples were tested as directed in Test Method D 2591. Describe the material or product sampled and the method of sampling used.

11.2 Report the following information:

11.2.1 The linear density for each specimen, each laboratory sampling unit and the lot,

11.2.2 The coefficient of variation, or standard deviation, or both, if calculated.

11.2.3 The pretension used, and

11.2.4 Any modification to the method.

12. Precision and Bias

12.1 An interlaboratory study was performed in 1997 to estimate variability of the test method. The study included 2 operators in one laboratory. Each operator measured five specimens for five different denier elastomeric yarns on five

different dates. ANOVA was used to determine variance components:

TABLE 1 Linear Density, Average Denier and Components of Variation Expressed as Squares of the Standard Deviation

NOTE—Response = Actual Denier

Nominal Denier	Average Denier	Components of Variance		
		V(Operator)	V(Date)	V(Specimen)
20	20.55060	0.07576	0.17347	0.19202
40	40.43160	0	0.25813	1.70335
70	71.09280	0	1.83081	1.20301
280	281.22480	0	2.91513	15.01286
840	809.51580	51.45464	0	237.02252

12.2 Method repeatability is defined as the "maximum difference" that can "reasonably" be expected between two test results obtained on the same material when the test results are obtained in the same laboratory. Repeatability standard deviation, s_r, is taken to be the square root of the "specimen" variance component, and represents within-operator precision. Method reproducibility is defined as the "maximum difference" that can "reasonably" be expected between two test results obtained on the same material when the test results are obtained from different laboratories.[5] s_R, the total standard deviation, is formed by taking the square root of the sum of intra- and inter-laboratory variance components.

TABLE 2 Repeatability and Reproducibility for Linear Density of Elastomeric Yarns

NOTE—Response = Actual Denier

Nominal Denier	S_r	Repeatability	S_R	Reproducibility
20	0.43820	1.21463	0.66426	1.84124
40	1.30512	3.61762	1.40053	3.88207
70	1.09682	3.04023	1.74179	4.82799
280	3.87464	10.73996	4.23415	11.73645
840	15.39554	42.67425	16.98462	47.07895

NOTE 4—Because the interlaboratory test included less than the recommended five laboratories, estimates of precision data in Table 1 and Table 2 may be either underestimated or overestimated to a considerable extent and should be used with special caution.

12.3 *Bias*—The procedure of 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 elastomeric yarn; linear density

[5] John Mandel and Theodore W. Lashof, 1987. The Nature of Repeatability and Reproducibility. Jour. Quality Technology, 19 (1).

ANNEX

A1. CONSTRUCTION OF LINEAR DENSITY APPARATUS

A1.1 Materials

A1.1.1 *Steel Plate*, low carbon (cold-rolled), about 100 mm (4 in.) wide by at least 1300 mm (50 in.) long and about 12.5 mm (0.5 in.) thick (for rigidity).

A1.1.2 *Brass Plates*, 2, as wide as the metal plate and at least 6 mm (0.025 in.) thick. Plates need to be the same thickness. One plate is 75 mm (3 in.) long and the other is 105 mm (4 in.) long.

A1.1.3 *Machine Screws*, flathead brass for fastening the cutting blocks and round head or flathead metal to fasten the clamps to the brass plates.

A1.1.4 *Clamps*, three toggle-action type, with rubber tips. Clamps should operate easily without stiffness.

A1.1.5 *Angle Iron*, to join the metal plate and the base plate if a platform is used, or fixtures for mounting the metal plate on a wall.

A1.2 Assembly of Apparatus (See Fig. 1.)

A1.2.1 Prepare the brass plates in the form shown in Fig. 1. The depth of the slots and the thickness of the sections containing the slots are critical for controlling the length of the specimen cut and the vertical alignment of the specimen. The slots in each plate must be perpendicular to one another and to the edges of the plate.

A1.2.2 Locate and tap holes for machine screws in the brass plates and steel plate such that the center line across the cutting slots are 1000 ± 0.5 mm (39.37 in.) apart when the brass plates are fastened in place.

A1.2.3 Fasten one clamp above the slotted section of the upper brass plate, one under the slotted section of the upper brass plate and one under the slotted section of the bottom brass plate. Then, fasten the brass plates to the metal plate.

A1.2.4 Fasten the metal plate to a wall or join it to a heavy base plate with an angle iron at the back.

A1.2.5 In the finished apparatus, the following points are critical:

A1.2.5.1 The yarn specimen must hang vertically (plumb) in the vertical slots when fastened in the top clamp.

A1.2.5.2 Coarser yarns must be able to move easily in and out of the vertical slots.