Designation: D 3106 – 01

Standard Test Method for Permanent Deformation of Elastomeric Yarns[1]

This standard is issued under the fixed designation D 3106; 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 permanent deformation of bare, continuous elastomeric monofilaments and filament yarns made from rubber, spandex, anidex, or other elastomers subjected to prolonged periods of tension. This test method is applicable to elastomeric yarns having a linear density in the range from 4 to 320 tex (36 to 2900 den.).

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

1.3 This test method was developed using yarns in the "as-received" condition, but may be used for treated yarns provided the treatment is specified.

1.4 The values stated in SI units are to be regarded as the standard. The values given in parentheses are for information only.

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 Textile Materials[2]

D 2433 Test Method for Rubber Thread[3]

3. Terminology

3.1 *Definitions*—For definitions of textile terms used in this test method, refer to Terminology D 123.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *breaking force*, *n*—the maximum force applied to a material carried to rupture.

3.2.1.1 *Discussion*—Force is commonly expressed in pounds-force (lbf), newtons (N), or millinewtons (mN). Newtons or millinewtons are preferred units.

3.2.2 *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.

3.2.2.1 *Discussion*—The elastic properties of the yarn are produced by the use of filaments, or a core, made from polymers having a special chemical composition or molecular structure, for example, filaments made from spandex or from cut or extruded rubber.

3.2.3 *elongation*, *n*—the ratio of the extension of a material to the length of the material prior to stretching.

3.2.3.1 *Discussion*—In a tensile test of elastomeric yarns, the percent elongation is usually calculated on the basis of the nominal gage length of a pretensioned specimen.

3.2.4 *elongation at break*, *n*—the elongation corresponding to the breaking force.

3.2.4.1 *Discussion*—Elongation at the breaking force is the change in length of the specimen which results from stretching the specimen to rupture.

3.2.5 *extension*, *n*—the change in length of a material due to stretching.

3.2.6 *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.

3.2.7 *linear density*, *n—in fiber and yarn,* mass per unit length.

3.2.7.1 *Discussion*—The preferred units of measurement are grams per metre, or multiples or submultiples of these. The tex unit, grams per kilometre, is recommended for yarns.

3.2.8 *length distribution*, *n—of staple fibers,* a graphic or tabular presentation of the proportion or percentage (by number or by weight) of fibers having different lengths.

3.2.9 *permanent deformation*, *n*—the net long-term change in a dimension of a specimen after deformation and relaxation under specified conditions.

3.2.9.1 *Discussion*—Permanent deformation is usually expressed as a percentage of the original dimension. Permanent deformation is also commonly referred to as "permanent set," "nonrecoverable deformation," and "nonrecoverable stretch."

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

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

[3] *Annual Book of ASTM Standards*, Vol 09.02.

3.2.10 *velveteen*, *n*—a woven fabric in twill or plain weave made with a short closely packed filling pile in imitation of velvet.

4. Summary of Test Method

4.1 The nominal linear density of the sample is known or determined and the elongation at the breaking force is determined from representative specimens.

4.2 A specimen from the sample is placed in a pair of line-contact clamps and held at a selected elongation for a specified period of time. The permanent deformation or nonrecoverable stretch is measured after a specified recovery period.

5. Significance and Use

5.1 Test Method D 3106 for testing permanent deformation of elastomeric yarns is considered satisfactory for acceptance testing of commercial shipments when there is prior agreement as to the exact value of elongation to be used for testing, since current estimates of between-laboratory precision are acceptable.

5.1.1 If there are differences or practical significance between reported test results for two laboratories (or more) comparative tests should be performed to determine if there is a statistical bias between them, using competent statistical assistance. As a minimum, test samples that are as homogeneous as possible, drawn from the material from which the disparate test results were obtained, and randomly assigned in equal numbers to each laboratory for testing. The test results from the two laboratories should be compared using a statistical test for unpaired data, at a probability level chosen prior to the testing series. If 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 Yarns are subjected to long periods of tension resulting in an appreciable amount of stretch during normal use. A portion of the induced stretch may be permanent. The amount of permanent deformation is influenced by the amount of tension, the time the yarn is under tension and the time available for recovery between successive uses.

5.3 For optimum processing of elastomeric yarns, the permanent deformation value should be low or zero.

6. Apparatus

6.1 *Line-Contact Clamps*, with one fixed clamp and one movable clamp, assembled as directed in Appendix X1, and as shown in Fig. 1.

6.2 *Tensioning Weights*, 10 mg to 3 g, to pretension the specimens before final clamping.

NOTE 1—Aluminum foil has been found to be suitable for use as tensioning weights; the foil may be attached to the yarn by folding it over the yarn.

6.3 *Stop Watch or Timer*.

7. Sampling

7.1 *Lot Sample*—As a lot sample for acceptance testing, take at random the number of shipping cartons of elastomeric yarn as directed in the applicable material specification or other agreement between the purchaser and supplier. Consider the material shipping carton to be the primary sampling unit.

7.2 *Laboratory Sample*—As a laboratory sample for acceptance testing, take at random the number of packages from each shipping carton in the lot sample as directed in the applicable material specification or other agreement between the purchaser and the supplier. If differing numbers and packages are to be taken from the shipping cartons in the lot sample, determine at random which shipping cartons are to have each number of packages drawn.

NOTE 2—An adequate specification or other agreement between the purchaser and the supplier requires taking into account the variability between shipping cartons, and the variability of the material within the shipping carton, to provide a sampling plan with a meaningful producer's risk, consumer's risk, acceptable quality level, and limiting quality level.

7.3 *Test Specimens*—From each package in the laboratory sample, take the number of specimens directed in Section 8. Inspect each package after withdrawing at least five layers of yarn from the outside of the package. If there is evidence of damage, continue to withdraw units of five layers and reinspect until there is no discernible damage. Withdraw yarn over the end of the package and cut specimens approximately 150 mm long. Discard specimens that are damaged during withdrawal or cutting. Withdraw at least 2 m of yarn between specimens from a single package.

8. Specimens Per Package

8.1 Take a number of specimens per package such that the user may expect at the 95 % probability level that the test result is no more than 0.55 percentage points above or below the true average of the package. Determine the number of specimens as follows:

8.1.1 *Reliable Estimate of s*—When there is a reliable estimate of *s* based on extensive past records for similar materials tested in the user's laboratory as directed in the test method, calculate the required number of specimens per package using (Eq 1):

$$n = (ts/E)^2 \quad (1)$$

where:

- n = number of specimens per package (rounded upward to a whole number),
- s = reliable estimate of the standard deviation of individual observations on similar materials in the user's laboratory under conditions of single-operator precision,
- t = value of Student's t for two-sided limits, a 95 % probability level, and the degree of freedom associated with the estimate of s (see Table 1), and
- E = 0.55 percentage points, the value of the allowable variation.

8.1.2 *No Reliable Estimate of s*—When there is no reliable estimate of *s* for the user's laboratory, (Eq 1) should not be used directly. Instead, specify the fixed number of ten specimens. This number of specimens is calculated using $s = 0.87$ percentage point, which is a somewhat larger value of *s* than is usually found in practice. When a reliable estimate of *s* for the user's laboratory becomes available, (Eq 1) will usually require fewer than ten specimens.

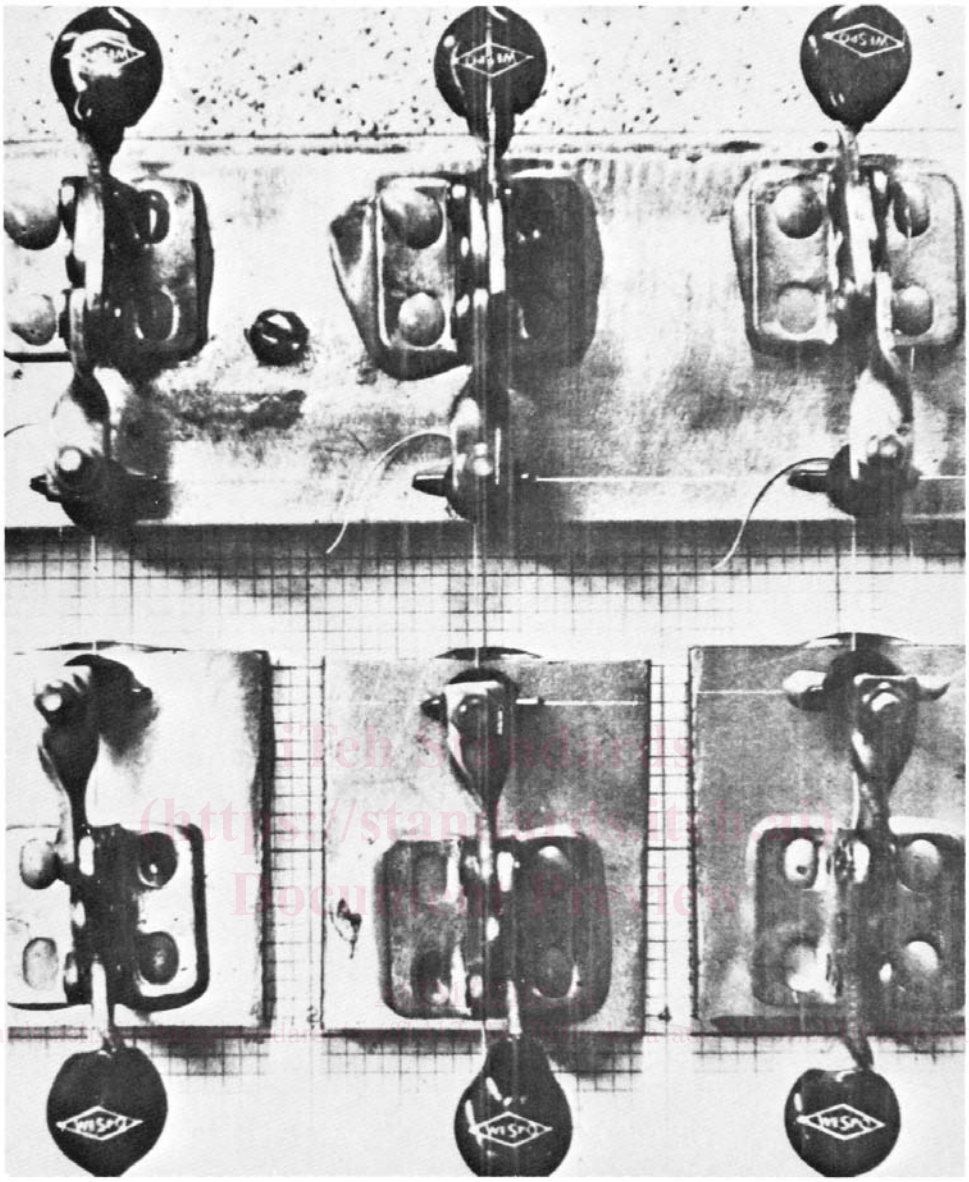

FIG. 1 Test Apparatus for Permanent Set

TABLE 1 Values of Student's t^A for One-Sided and Two-Sided Limits and the 95 % Probability Level

dF	One-sided	Two-sided	dF	One-sided	Two-sided	dF	One-sided	Two-sided
1	6.314	12.706	11	1.796	2.201	22	1.717	2.074
2	2.920	4.303	12	1.782	2.179	24	1.711	2.064
3	2.353	3.182	13	1.771	2.160	26	1.706	2.056
4	2.132	2.776	14	1.761	2.145	28	1.701	2.048
5	2.015	2.571	15	1.753	2.131	30	1.697	2.042
6	1.943	2.447	16	1.746	2.120	40	1.684	2.021
7	1.895	2.365	17	1.740	2.110	50	1.676	2.009
8	1.860	2.306	18	1.734	2.101	60	1.671	2.000
9	1.833	2.262	19	1.729	2.093	120	1.658	1.980
10	1.812	2.228	20	1.725	2.086	∞	1.645	1.960

^{A} Values in this table were calculated using Hewlett Packard HP 67/97 Users' Library Programs 03848D, "One-sided and Two-sided Critical Values of Student's *t*" and 00350D," Improved Normal and Inverse Distribution." For values at other than the 95 % probability level, see published tables of critical values of Student's *t* in any standard statistical test (2), (3), (4), and (5).