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AMERICAN SOCIETY FOR TESTING AND MATERIALS
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Standard Test Method for Thermal Shrinkage Force of Yarn and Cord With the Testrite Thermal Shrinkage Force Tester[1]

This standard is issued under the fixed designation D 5591; 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 preparation and procedures for use of the Testrite Shrinkage-Force Tester to measure the thermal shrinkage force of yarns and cords in air.

1.2 This test method is applicable to measurement of the thermal shrinkage force of yarns and cords whose shrinkage force at 177± 2°C in air does not exceed 20 N. This test method is applicable to nylon, polyester, and aramid yarns and cords within the applicable range of thermal shrinkage force, as well as to comparable yarns and cords from other polymers.

1.2.1 Yarns or cords for testing may be taken from yarn or cord packages or retrieved from fabrics.

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

1.4 *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.* Specific hazards statements are given in Section 8.

2. Referenced Documents

2.1 *ASTM Standards:*

D 123 Terminology Relating to Textiles[2]

D 885 Methods for Testing Tire Cords, Tire Cord Fabrics, and Industrial Filament Yarns Made from Manufactured Organic-Base Fibers[2]

D 2258 Practice for Sampling Yarn for Testing[2]

D 2906 Practice for Statements on Precision and Bias for Textiles[2]

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 *adhesive-treated tire cord*, *n*—a tire cord whose adhesion to rubber or other elastomer has been improved by the application of a dip followed by rapid drying and (normally) additional heat treatment.

3.2.2 *atmosphere for testing textiles*, *n*—*for tire cords and industrial yarns*, air maintained at a relative humidity of 55 ± 2 % and at a temperature of 24 ± 1°C (75 ± 2°F).

3.2.3 *cord*, *n*—a twisted or formed structure composed of one or more single or plied filaments, strands, or yarns of organic polymer or inorganic materials.

3.2.3.1 *Discussion*—*for the manufacture of pneumatic tires or other industrial fabrics*, the direction of twist used to combine single or plied yarn elements into a cord construction is in a direction opposite to that used in the yarns. Tire and other reinforcing cords frequently consist of a single yarn strand having little or no twist. These cords, as well as single monofilaments, are used synonymously with twisted and plied cords in this test method.

3.2.4 *greige cord*, , *n*—in tire cords, a cord that has not received adhesive treatment, heat treatment, or other finishing treatment.

3.2.5 *greige tire cord*, *n*—a tire cord that has not been dip treated or heat treated before use (see *tire cord*).

3.2.6 *pneumatic tire*, *n*—a hollow tire that becomes load-bearing upon inflation with air, or other gas, to a pressure above atmosphere.

3.2.7 *retraction*, *n*—*in yarns and cords*, the reduction in length when previous restraint is removed and relaxation is allowed, thus causing a directionally proportional increase in linear density.

3.2.8 *thermal shrinkage force*, *n*—that force induced when a restrained material is restricted from shrinking upon exposure to heat.

3.2.9 *thermal shrinkage force tester*, *n*—an apparatus that measures the force achieved when a yarn or similar specimen, held at constant (fixed) length, is subjected to a temperature above that at which the specimen was mounted in the apparatus.

3.2.10 *tire*, *n*—a load-bearing, ground-contacting circumferential attachment to a vehicle wheel.

3.2.11 *yarn*, *n*—a generic term for a continuous strand of textile fibers, filaments, or material in a form suitable for knitting, weaving, or otherwise intertwining to form a textile fabric.

[1] This test method is under the jurisdiction of ASTM Committee D-13 on Textiles and is the direct responsibility of Subcommittee D13.19 on Tire Cord and Fabrics.

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

4. Summary of Test Method

4.1 A specified length of yarn or cord is relaxed, conditioned, and pretensioned with a specific mass to induce a specified pretension force in the yarn or cord.

4.2 A conditioned specimen is exposed for 120 ± 5 s to dry heat at a temperature of 177 ± 2°C.

4.3 The shrinkage force induced in the specimen is read from the tester.

5. Significance and Use

5.1 This test method may be used for the acceptance testing of commercial shipments of yarns and cords, but caution is advised since information on between-laboratory precision is incomplete.

5.1.1 In case of a dispute arising from differences in reported test results when using this test method for acceptance testing of commercial shipments, the purchaser and the supplier should conduct comparative tests to determine whether 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 that are as homogeneous as possible and that are from a lot of material of the type in question. The test specimens should then be assigned randomly in equal numbers to each laboratory for testing. The average results from the two laboratories should be compared using the Student's *t*-test for unpaired data and an acceptable probability level chosen by the two parties before the 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 view of the known bias.

5.1.2 Yarn and cord may contract in length over a period of time due to room temperature retraction. Thermal shrinkage force values are reduced proportionately by the amount of room temperature retraction.

5.1.3 Experience shows that retractive forces are present in most wound packages. This may be observed directly as a shortening of length (or indirectly as an increase in linear density) in unrestrained yarn or cord that is not relaxed fully. After retraction, such relaxed yarns exhibit lower thermal shrinkage force values.

5.1.4 Retractive forces vary widely by polymer type, being almost nil within aramids and significant within most nylons. For example, the exposure of untensioned skeins of nylon yarn or cord to 95 to 100 % relative humidity at room temperature for two days and reconditioning under standard laboratory conditions will cause most of the length change that is possible at room temperature to occur within a sample. This reduction in length is accompanied by some lowering of thermal shrinkage force.

5.2 The thermal shrinkage force of nylon, polyester, and aramid fiber is related to the polymer of origin and its manipulation in processing. Thermal shrinkage force measurement can be used to control product uniformity.

5.3 The level of thermal shrinkage force is critical in the user's subsequent operations, such as the drum-set (original length of cord) required to build a tire of a particular size.

5.4 The thermal shrinkage force is critical to the final shape and size of fiber-reinforced articles. For example, thermal shrinkage force affects the final size of V-belts and their ability to maintain tension during their operation.

5.5 This test method is in agreement with the nominal procedures of Methods D 885 for the determination of thermal shrinkage force in yarns and cords.[3]

5.5.1 Shrinkage force is measured while the specimen is within an oven at a specified temperature and after a specified length of time.

6. Interferences

6.1 Because the chamber in which the specimen is heated is open on three sides, air drafts can effectively shorten the length of specimen experiencing the prescribed temperature environment. The results obtained without a shield are generally lower than those obtained with a shield.

6.2 The accurate control of temperature at any prescribed setting is one of the manufacturer's strongest claims. Nevertheless, for a number of reasons, it is possible for a difference to exist from tester to tester in the actual temperature developed in the specimen. An intralaboratory comparison is the preferred method to determine whether a bias exists between the results from one tester to another. If a bias is found, its cause may be related to any number of factors. To ensure that either the temperature induced in the specimen is the same between instruments, or the temperature on the specimen matches the set-point temperature of a given instrument, or both, use the procedures given in the Annex to calibrate Mark III Testrite ovens.

6.3 The differences in the amount of pre-relaxation of yarns can cause differences in thermal shrinkage force, as noted in 5.1.2.

6.4 Shrinkage force as measured by the Testrite Shrinkage Force Tester is a combination of pretension force and the force that is developed in the specimen as a result of the specimen being heated.

6.5 Shrinkage force can be affected by the length of specimen exposure, improper location of the specimen within the oven, and oven-surface contact of any part of the specimen. Specimens that are spun, textured, or crimped (such as those removed from a fabric) may allow filaments to come into contact with interior surfaces of the thermal shrinkage force oven. Such physical contact will cause inaccurate readings of the thermal shrinkage force.

7. Apparatus

7.1 *Testrite Thermal Shrinkage Force Tester Mark III and Mark V*,[4] software version 5.12 and later (Fig. 1).[3]

7.2 *Stopwatch or Time*, capable of reading to ± 1.0 s.[5]

[3] Besides the apparatus specified in Section 7, there is a Mark IV and Mark V with software version 5.01 that do not fit the requirements of this test method. These models eliminate the pretension force via electronic circuitry. Thermal shrinkage force readings that include pretension differ from readings that do not include pretension.

[4] "Testrite" Thermal Shrinkage Force Tester and clip-on tensioning masses are available from Testrite, Ltd. Woodfield Works, Old Lane, Halifax, England, HX3 6TF.

[5] Stopwatch manufactured by Galco, Jules Racine & Co., Dept 2, 85 Executive Boulevard, Elmsford, NY 10523, has been found to be satisfactory for this purpose.

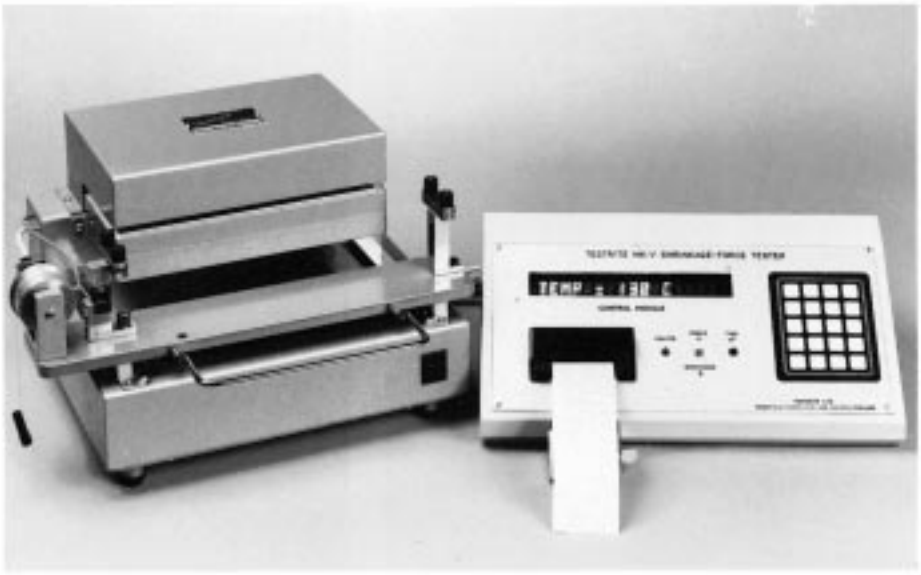

FIG. 1 Testrite Thermal Shrinkage Force Tester

7.3 *Clip-On Tensioning Masses.*[4]

7.4 *Draft Shield for Testrite Shrinkage Oven,* as shown in Figs. 2 and 3 (dimensions in SI and inch-pound units, respectively) or equivalent. Testrite Ltd. stated in 1992 that subsequent Testrite ovens would have draft shields as an integral part.

8. Hazards

8.1 Do not touch the oven while it is in operation because it can reach temperatures up to 200°C.

8.2 Do not leave the oven unattended if a specimen is installed.

9. Sampling

9.1 *Lot Sample*—As a lot sample for acceptance testing, take at random the number of primary sampling units directed in an applicable material specification or other agreement between the purchaser and the supplier. In the absence of such an agreement or material specification, proceed as directed in Practice D 2258. Consider shipping containers of cord and rolls of fabric to be the primary sampling units.

NOTE 1—A realistic specification or other agreement between the purchaser and the supplier requires taking into account the variability between and within primary shipping units so as to provide a sampling plan with meaningful producer's risk, consumer's risk, acceptable quality level, and limiting quality level.

9.2 *Laboratory Sample*—As a laboratory sample for acceptance testing, proceed as follows:

9.2.1 For yarn or cord, take at random the number of packages per shipping container in the lot sample as directed in an applicable material specification or other agreement between the purchaser and the supplier. In the absence of such an agreement or material specification, proceed as directed in Practice D 2258.

9.2.2 For fabric, take a full-width swatch at least 1-m (1-yd) long from the outside of each roll of fabric in the lot sample, after first discarding all fabric from the outside of the rolls that contains creases, fold marks, disturbed weave, or contamination by foreign material.

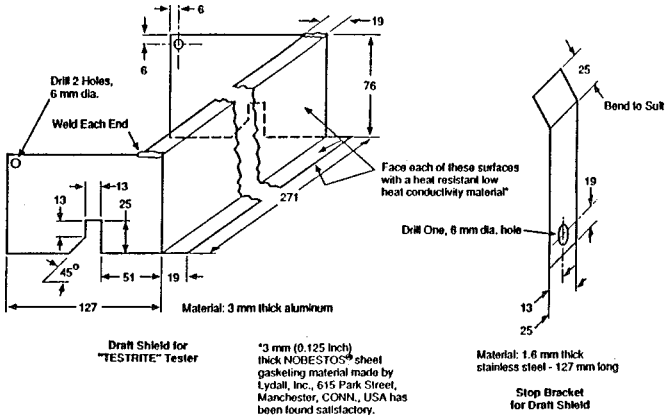

FIG. 2 Draft Shield for Testrite Shrinkage Oven (Dimensions in Millimetres Unless Specified)

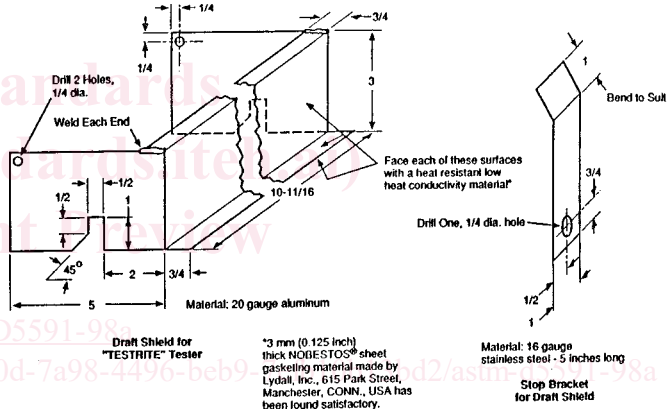

FIG. 3 Draft Shield for Testrite Shrinkage Oven (Dimensions in Inches Unless Specified)