Designation: D 412 – 06a$^{\varepsilon 1}$

Standard Test Methods for Vulcanized Rubber and Thermoplastic Elastomers—Tension[1]

This standard is issued under the fixed designation D 412; 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.

This standard has been approved for use by agencies of the Department of Defense.

ε[1] NOTE—Added research report footnote to Section 19 editorially in October 2008.

1. Scope

1.1 These test methods cover procedures used to evaluate the tensile (tension) properties of vulcanized thermoset rubbers and thermoplastic elastomers. These methods are not applicable to ebonite and similar hard, low elongation materials. The methods appear as follows:

Test Method A—Dumbbell and Straight Section Specimens
Test Method B—Cut Ring Specimens

NOTE 1—These two different methods do not produce identical results.

1.2 The values stated in either SI or non-SI units shall be regarded separately as normative for this standard. The values in each system may not be exact equivalents; therefore each system must be used independently, without combining values.

1.3 *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:* [2]

D 1349 Practice for Rubber—Standard Temperatures for Testing
D 1566 Terminology Relating to Rubber
D 3182 Practice for Rubber—Materials, Equipment, and Procedures for Mixing Standard Compounds and Preparing Standard Vulcanized Sheets
D 3183 Practice for Rubber—Preparation of Product Pieces for Test Purposes from Products
D 3767 Practice for Rubber—Measurement of Dimensions
D 4483 Practice for Evaluating Precision for Test Method Standards in the Rubber and Carbon Black Manufacturing Industries
E 4 Practices for Force Verification of Testing Machines

2.2 *ASTM Adjunct:*

Cut Ring Specimens, Method B (D 412)[3]

2.3 *ISO Standards:*

ISO 37 Rubber, Vulcanized and Thermoplastic Determination of Tensile Stress-Strain Properties[4]

3. Terminology

3.1 *Definitions:*

3.1.1 *tensile set*—the extension remaining after a specimen has been stretched and allowed to retract in a specified manner, expressed as a percentage of the original length. (D 1566)

3.1.2 *tensile set-after-break*—the tensile set measured by fitting the two broken dumbbell pieces together at the point of rupture.

3.1.3 *tensile strength*—the maximum tensile stress applied in stretching a specimen to rupture. (D 1566)

3.1.4 *tensile stress*—a stress applied to stretch a test piece (specimen). (D 1566)

3.1.5 *tensile stress at-given-elongation*—the stress required to stretch the uniform cross section of a test specimen to a given elongation. (D 1566)

3.1.6 *thermoplastic elastomers*—a diverse family of rubber-like materials that unlike conventional vulcanized rubbers can be processed and recycled like thermoplastic materials.

[1] These test methods are under the jurisdiction of ASTM Committee D11 on Rubber and are the direct responsibility of Subcommittee D11.10 on Physical Testing.

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[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

[3] Detailed drawings are available from ASTM Headquarters, 100 Barr Harbor Drive, Conshohocken, PA 19428. Order Adjunct No. ADJD0412.

[4] Available from American National Standards Institute (ANSI), 25 W. 43rd St., 4th Floor, New York, NY 10036.

3.1.7 *ultimate elongation*—the elongation at which rupture occurs in the application of continued tensile stress.

3.1.8 *yield point*—that point on the stress-strain curve, short of ultimate failure, where the rate of stress with respect to strain, goes through a zero value and may become negative. (D 1566)

3.1.9 *yield strain*—the level of strain at the yield point. (D 1566)

3.1.10 *yield stress*—the level of stress at the yield point. (D 1566)

4. Summary of Test Method

4.1 The determination of tensile properties starts with test pieces taken from the sample material and includes the preparation of the specimens and the testing of the specimens. Specimens may be in the shape of dumbbells, rings or straight pieces of uniform cross-sectional area.

4.2 Measurements for tensile stress, tensile stress at a given elongation, tensile strength, yield point, and ultimate elongation are made on specimens that have not been prestressed. Tensile stress, yield point, and tensile strength are based on the original cross-sectional area of a uniform cross-section of the specimen.

4.3 Measurement of tensile set is made after a previously unstressed specimen has been extended and allowed to retract by a prescribed procedure. Measurement of "set after break" is also described.

5. Significance and Use

5.1 All materials and products covered by these test methods must withstand tensile forces for adequate performance in certain applications. These test methods allow for the measurement of such tensile properties. However, tensile properties alone may not directly relate to the total end use performance of the product because of the wide range of potential performance requirements in actual use.

5.2 Tensile properties depend both on the material and the conditions of test (extension rate, temperature, humidity, specimen geometry, pretest conditioning, etc.); therefore materials should be compared only when tested under the same conditions.

5.3 Temperature and rate of extension may have substantial effects on tensile properties and therefore should be controlled. These effects will vary depending on the type of material being tested.

5.4 Tensile set represents residual deformation which is partly permanent and partly recoverable after stretching and retraction. For this reason, the periods of extension and recovery (and other conditions of test) must be controlled to obtain comparable results.

6. Apparatus

6.1 *Testing Machine*—Tension tests shall be made on a power driven machine equipped to produce a uniform rate of grip separation of 500 ± 50 mm/min (20 ± 2 in./min) for a distance of at least 750 mm (30 in.) (see Note 2). The testing machine shall have both a suitable dynamometer and an indicating or recording system for measuring the applied force within ±2 %. If the capacity range cannot be changed for a test (as in the case of pendulum dynamometers) the applied force at break shall be measured within ±2 % of the full scale value, and the smallest tensile force measured shall be accurate to within 10 %. If the dynamometer is of the compensating type for measuring tensile stress directly, means shall be provided to adjust for the cross-sectional area of the specimen. The response of the recorder shall be sufficiently rapid that the applied force is measured with the requisite accuracy during the extension of the specimen to rupture. If the testing machine is not equipped with a recorder, a device shall be provided that indicates, after rupture, the maximum force applied during extension. Testing machine systems shall be capable of measuring elongation of the test specimen in minimum increments of 10 %.

NOTE 2—A rate of elongation of 1000 ± 100 mm/min (40 ± 4 in./min) may be used and notation of the speed made in the report. In case of dispute, the test shall be repeated and the rate of elongation shall be at 500 ± 50 mm/min (20 ± 2 in./min).

6.2 *Test Chamber for Elevated and Low Temperatures*—The test chamber shall conform with the following requirements:

6.2.1 Air shall be circulated through the chamber at a velocity of 1 to 2 m/s (3.3 to 6.6 ft/s) at the location of the grips or spindles and specimens maintained within 2°C (3.6°F) of the specified temperature.

6.2.2 A calibrated sensing device shall be located near the grips or spindles for measuring the actual temperature.

6.2.3 The chamber shall be vented to an exhaust system or to the outside atmosphere to remove fumes liberated at high temperatures.

6.2.4 Provisions shall be made for suspending specimens vertically near the grips or spindles for conditioning prior to test. The specimens shall not touch each other or the sides of the chamber except for momentary contact when agitated by the circulating air.

6.2.5 Fast acting grips suitable for manipulation at high or low temperatures may be provided to permit placing dumbbells or straight specimens in the grips in the shortest time possible to minimize any change in temperature of the chamber.

6.2.6 The dynamometer shall be suitable for use at the temperature of test or it shall be thermally insulated from the chamber.

6.2.7 Provision shall be made for measuring the elongation of specimens in the chamber. If a scale is used to measure the extension between the bench-marks, the scale shall be located parallel and close to the grip path during specimen extension and shall be controlled from outside the chamber.

6.3 *Dial Micrometer*—The dial micrometer shall conform to the requirements of Practice D 3767 (Method A). For ring specimens, see 14.10 of these test methods.

6.4 *Apparatus for Tensile Set Test*—The testing machine described in 6.1 or an apparatus similar to that shown in Fig. 1 may be used. A stop watch or other suitable timing device measuring in minute intervals for at least 30 min, shall be provided. A scale or other device shall be provided for measuring tensile set to within 1 %.

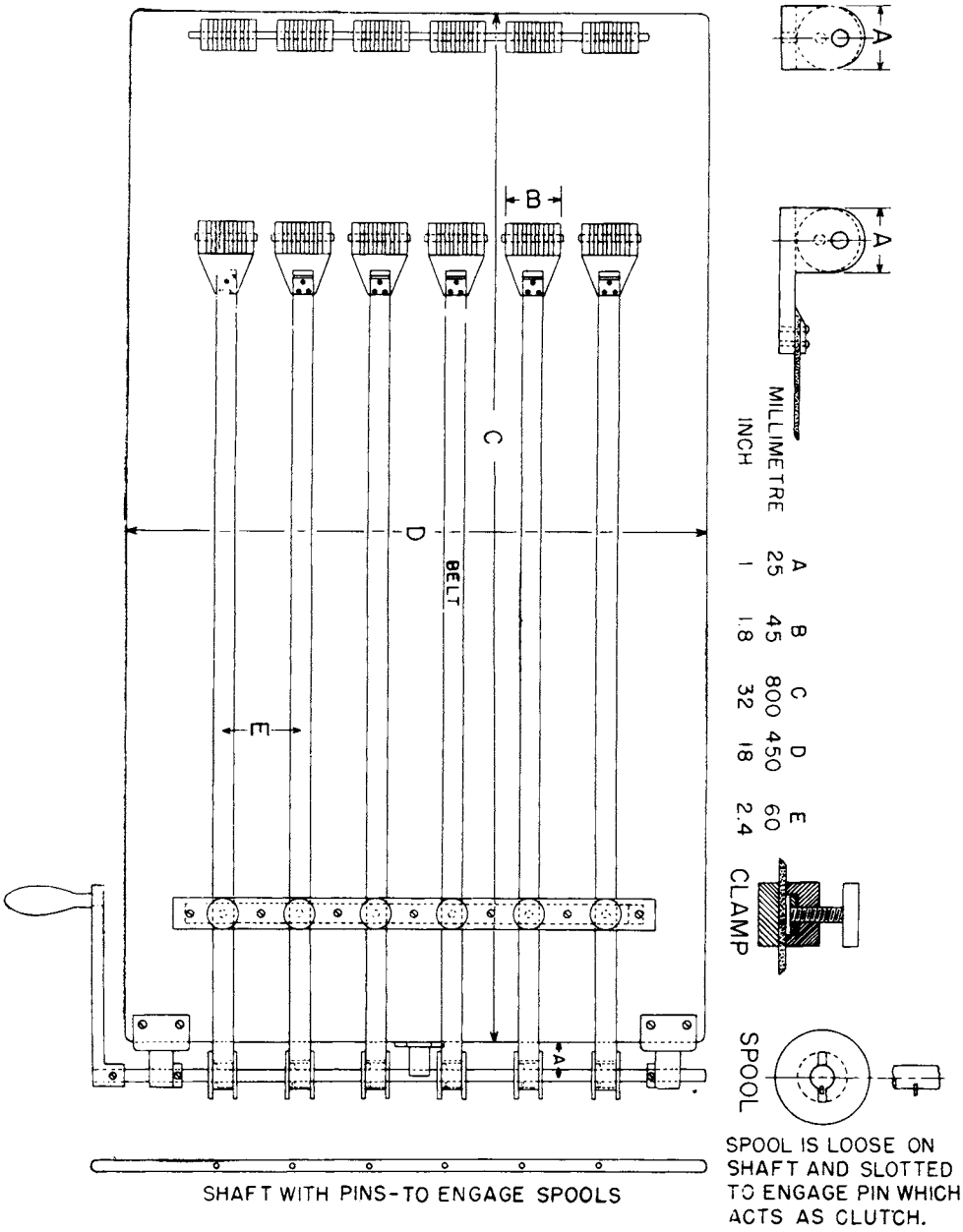

FIG. 1 Apparatus for Tensile Set Test

7. Selection of Test Specimens

7.1 Consider the following information in making selections:

7.1.1 Since anisotropy or grain directionality due to flow introduced during processing and preparation may have an influence on tensile properties, dumbbell or straight specimens should be cut so the lengthwise direction of the specimen is parallel to the grain direction when this direction is known. Ring specimens normally give an average of with and across the grain properties.

7.1.2 Unless otherwise noted, thermoplastic rubber or thermoplastic elastomer specimens, or both, are to be cut from injection molded sheets or plaques with a thickness of 3.0 ± 0.3 mm. Specimens of other thickness will not necessarily give comparable results. Specimens are to be tested in directions both parallel and perpendicular to the direction of flow in the mold. Sheet or plaque dimensions must be sufficient to do this.

7.1.3 Ring specimens enable elongations to be measured by grip separation, but the elongation across the radial width of the ring specimens is not uniform. To minimize this effect the width of the ring specimens must be small compared to the diameter.

7.1.4 Straight specimens tend to break in the grips if normal extension-to-break testing is conducted and should be used only when it is not feasible to prepare another type of