Designation: D 2433 – 93 (Reapproved 2002)

# Standard Test Methods for Rubber Thread[1]

This standard is issued under the fixed designation D 2433; 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 These test methods cover the testing of both round extruded latex and rectangular cut rubber thread products in which the base material used in manufacture may be natural rubber or synthetic rubber, alone or in combination. These tests are to be made only on the bare uncovered rubber thread.

1.2 Owing to the comparatively small cross section of the material and also because of the unusual conditions of service of this material, certain special test methods have been developed and take the place of the tests for other rubber products.

1.3 Comparisons may only be made on new rubber threads or those of identical processing histories. In the interpretation of results from threads which have been subjected to spooling, fabrication, or other process, the previous history is important, and what is known of this and any relaxation treatments used should be stated.

1.4 The test methods appear in the following sections:

| | Sections |
|---|---|
| Density | 7-11 |
| Count | 12-16 |
| Metric Yield (Length per Unit Weight) | 17-19 |
| Tensile Strength | 20-22 |
| Elongation at Break | 23 and 24 |
| Stress at Predetermined Elongation | 25-27 |
| Elongation Under Fixed Force (Method A) | 28-30 |
| Elongation Under Fixed Force (Method B) | 31-34 |
| Stress Retention | 35-39 |

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 1566 Terminology Relating to Rubber[2]

D 4483 Practice for Determining Precision for Test Method Standards in the Rubber and Carbon Black Industries[2]

E 171 Specification for Standard Atmospheres for Conditioning and Testing Flexible Barrier Materials[3]

## 3. Significance and Use

3.1 For adequate service performance, rubber threads must be tested by appropriate test methods. This standard gives a number of test methods that are known to be important in rubber thread technology.

## 4. Interferences

4.1 Samples or test specimens shall not be allowed to come into contact with copper, manganese, or their compounds during sample preparation or testing.

## 5. Sample Preparation

5.1 The samples and test specimens derived therefrom shall be kept in a relaxed state and conditioned for not less than 16 h before testing. The test specimen selected should be clean, dry, and free from any visual defects.

## 6. Test Conditions

6.1 The test shall be performed in a standard atmosphere having a temperature of 23 ± 1°C (73.4 ± 1.8°F) and a relative humidity of 50 ± 2 %, as defined in Specification E 171.

## DENSITY

## 7. Terminology

7.1 *Definitions of Terms Specific to This Standard:*

7.1.1 *density of a rubber thread*—the mass of a unit volume of thread measured at a temperature of 23 ± 1°C (73.4± 1.8°F) expressed as megagrams per cubic metre.

## 8. Summary of Test Method

8.1 The density of a rubber thread is determined by employing two liquids of known density. These liquids are mixed together in such a proportion that, during immersion, a test specimen of the thread under examination remains suspended, that is, neither floats nor sinks. The density of this mixture is measured and this value taken as the density of the specimen.

## 9. Apparatus

9.1 *Glass Cylinder*, having a capacity of about 1000 $cm^3$.

[1] These test methods are under the jurisdiction of ASTM Committee D11 on Rubber and are the direct responsibility of Subcommittee D11.37 on Coated Fabrics and Rubber Thread.

Current edition approved Dec. 10, 2002. Published February 2003. Originally approved in 1965. Last previous edition approved in 1998 as D 2433 – 93 (1998).

[2] *Annual Book of ASTM Standards*, Vol 09.01.

[3] *Annual Book of ASTM Standards*, Vol 15.09.

9.2 *Hydrometer or Hydrostatic Balance* (0.001 $m^3$), to measure the density of the liquids to an accuracy of not less than 0.005 $Mg/m^3$.

## 10. Suitable Mixtures

10.1 Most of the rubber threads on the market have a density in the range from 0.90 to 1.11 $Mg/m^3$. It is necessary, therefore, to have a series of liquids having densities within this range. Mixtures of ethanol (0.79 $Mg/m^3$) and distilled water are suitable. A saturated solution of zinc chloride in distilled water is suitable for densities greater than 1.00 $Mg/m^3$.

10.1.1 Before the mixtures are used they shall be homogeneous and free from air bubbles. They shall be kept in closed containers so as to avoid evaporation. They should be used at a temperature of 23 ± 2°C.

## 11. Procedure

11.1 Take four test specimens approximately 10 mm long from the thread. Dip each specimen in ethanol and rub between the fingers to remove dusting powder and to eliminate any air bubbles from the surface.

11.2 Take a sufficient quantity of suitable liquids and thoroughly mix. Take care not to form air bubbles. Introduce a test specimen of thread and by small additions of one or the other of the liquids, obtain the mixture in which the specimen remains suspended, that is, neither floats nor sinks.

11.3 Introduce a further three specimens, treated as in 11.1 into this mixture. If at least two specimens reach equilibrium between 3 and 10 min after immersion, assume that the thread has the same density as that of the mixture. Determine the density of the mixture to the nearest 0.005 $Mg/m^3$.

# COUNT

## 12. Terminology

12.1 *Description of Term Specific to This Standard and Commercial Usage:*

12.1.1 *count of a rubber thread*—the number of threads that when placed side by side measures 25.4 mm (1 in.). The count of a round thread is calculated by dividing 25.4 by its diameter in millimetres. The count of a square thread is calculated by dividing 25.4 by the length of one of its sides expressed in millimetres. The count of a rectangular thread is generally quoted as the count of a square thread of equivalent cross-sectional area. Thus, in the case of a round thread, the number 100 is the count of a thread having its diameter equal to 0.254 mm (1⁄100 in.); in the case of a square thread, the number 40 is the count of a thread having its sides equal to 0.635 mm (1⁄40 in.).

12.2 It is customary to quote the count of round thread, followed by the whole even number which is nearest to the actual count of the square thread of equivalent cross-sectional area (count of round thread × 1.13 = the actual count of the square thread). For example, a round thread of count 50 is indicated as 50/56.

12.3 The count of a multifilament round thread is expressed by stating successively, the number of components, the count of the single round thread which would have the same total cross-sectional area as the component threads, and the count of the corresponding square thread. Thus, the count of a thread made up of three components equal in total cross-sectional area to a round thread of count 32 is indicated as 3/32/36.

## 13. Summary of Test Method

13.1 The count of a rubber thread is calculated as described in Section 16, based on the density and weight of 1 m of thread.

13.2 The density is determined by the test method described in Section 11.

## 14. Test Specimens

14.1 The specified number of straight thread samples shall be cut to approximately 1.05 m in length.

NOTE 1—Kinked or curved thread will introduce errors.

14.2 If these samples are taken from bobbins or from any other type of presentation in which the thread is under tension, they should be heat treated for 30 min in a thermostatically controlled oven at a temperature of 60 ± 5°C. Where greater accuracy is required, the sample should then be allowed to relax for at least 48 h in accordance with the conditions in 6.1.

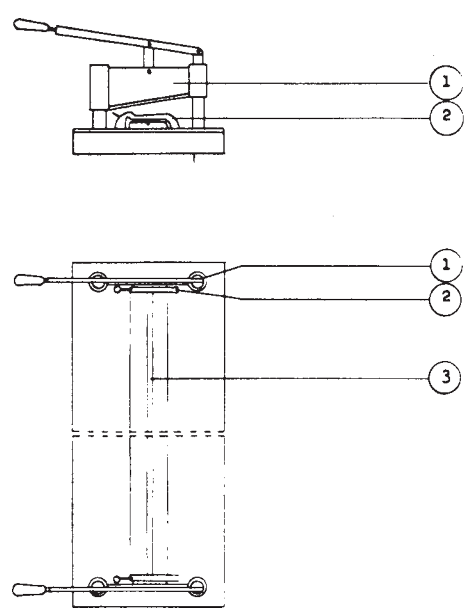
14.3 *Cutting*—Two types of apparatus may be used for cutting to size. With the first (Test Method A) the cut is made with the test piece placed in a groove of a horizontal base. With the second (Test Method B) the thread is suspended and maintained in a vertical position by its own weight.

14.4 *Test Method A* (see Fig. 1):

14.4.1 *Apparatus*:

14.4.1.1 *Horizontal Flat Metallic Base*, rectangular in shape, having one or more longitudinal grooves.

14.4.1.2 *Clamp*, fixed at a position a few centimetres from the end of the groove. The grooves should have an equilateral triangular cross section with a base not less than 2 mm.




1—Cutting Device
2—Clamps
3—Groove

**FIG. 1 Apparatus for Cutting Test Specimens (Test Method A)**

14.4.1.3 *Cutting Device*, fitted to each end of the groove such that the distance between the cutting device blades is 1 m ± 1 mm.

14.4.2 *Procedure*—Take the specified number of samples of thread, cut, and condition in accordance with 6.1. Lay each sample in a groove of the apparatus being careful to avoid stretching. Clamp and cut to length by means of the cutting device described in 14.4.1.3.

14.5 *Test Method B* (see Fig. 2):

14.5.1 *Apparatus*:

14.5.1.1 *Rectangular Vertical Frame*, at the upper and lower ends of which are mounted two metallic plates having the inside edges parallel and sharp.

14.5.1.2 *Two Cutting Devices*, the fixed blade of which consists of the inside edge of the metallic plate.

14.5.1.3 *Two External Clamps*—The clamps should be of a spring-loaded type, and the distance between the internal edges of the metallic plates should be 1 m ± 1 mm.

14.5.2 *Procedure*—Take the specified number of samples of thread, cut, and prepare in accordance with Section 14. Then suspend each sample from the upper clamp when it has settled in the vertical position without stretch, fix it by means of the lower clamp. Then cut the test specimen to length with the two cutting devices, using the lower one first.

## 15. Weighing Specimens

15.1 Use specimens already cut to the proper length and freed from any loose dusting powder by shaking or brushing them gently for the weight determination.

15.2 Determine the mass to an accuracy of ±1 %.

## 16. Calculation

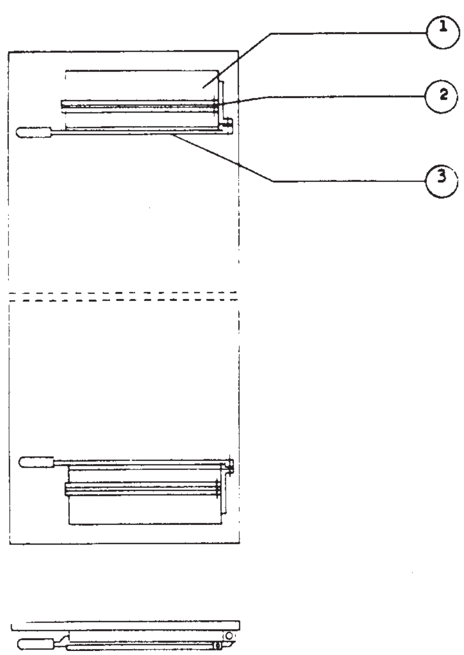
16.1 Calculate the count of rubber thread as follows:

$$\text{Round thread } C = 22.51\sqrt{d/w} \quad (1)$$

$$\text{Square thread } C = 25.40\sqrt{d/w} \quad (2)$$

where:
$C$ = count of rubber thread,
$d$ = density of thread, $Mg/m^3$, and
$w$ = mass of 1 m of thread, g.

16.2 Make five determinations on different test specimens. Calculate the count of the specimen under examination from the arithmetic mean of the masses of the test specimens. Also state the maximum and minimum values obtained from the individual weighings.




1—Metallic Plate
2—Clamp
3—Cutting Device

**FIG. 2 Apparatus for Cutting Test Specimens (Test Method B)**

### METRIC YIELD (LENGTH PER UNIT WEIGHT)

## 17. Terminology

17.1 *Definitions of Terms Specific to This Standard:*

17.1.1 *metric yield (metres per kilogram) of a rubber thread*—the unstretched length in metres of 1 kg of the thread.

## 18. Procedure

18.1 Condition and cut the test specimen in accordance with Sections 6 and 14. The metric yield calculation is based on the weight of a test specimen 1.00 m ± 1 mm long.

18.2 Weigh the test specimens in accordance with Section 15.

18.3 Make five determinations on different test specimens. Calculate the metric yield from the arithmetic mean of the weights of the test specimens.

## 19. Calculation

19.1 Calculate the metric yield of a rubber thread as follows:

$$\text{Metric yield} = 1000/w \quad (3)$$

where:
$w$ = average mass of 1 m of thread, g.

19.2 Calculate yards per pound as follows:

$$\text{Yards per pound} = 0.496 \times \text{metric yield.} \quad (4)$$

### TENSILE STRENGTH

## 20. Terminology

20.1 *Definitions of Terms Specific to This Standard:*

20.1.1 *tensile strength of a rubber thread*—the stress at which the thread breaks when it is stretched under the specified conditions. The value is expressed in pascals (pounds-force per square inch of the initial cross-sectional area.)

## 21. Apparatus

21.1 *Constant Rate of Extension (CRE) Type Tensile Testing Machine*, with a load capacity selected such that the rubber thread breaks within 30 to 80 % of full-scale deflection. A machine with capacities ranging from 0.1 to 20 N (10 to 2000 gf) is generally adequate.

21.2 *Clamping Assembly*—Pneumactically operated clamps with one jaw having a flat steel face nominally 25 by 25 mm (1 by 1 in.) and the other jaw being one described in 21.3 and 21.4.

21.3 *Acrylic Face*, a convex clamp approximately 7.1 mm (0.28 in.) in radius by 25 by 12.5 mm (1 by 0.5 in.)[4], or

21.4 *Steel Face*, a convex clamp 2.3 to 3.3 mm (0.09 to 0.13 in.) in radius nominally 25 by 5.6 ± 0.1 mm (1 by 0.22 ± 0.044 in.).

21.5 *Black Rubber Tubing*, 1.6-mm (0.063-in.) bore with 0.8-mm (0.031-in.) wall.

21.6 *Needle Threader, an Air Suction Nozzle, or Equivalent*, for threading yarn through a rubber hose.

## 22. Procedure

22.1 Determine the cross-sectional area of representative specimens in square millimetres (square inches).

22.2 Cut representative specimens to approximately 125-mm (5-in.) lengths.

22.3 Test the conditioned specimens in the standard atmosphere in accordance with Section 6.

22.4 Adjust the tensile machine as follows:

22.4.1 Gage length 50 mm (2 in.).

22.4.2 Cross-head speed, 0.5 m (20.0 in.)/min.

22.4.3 Chart speed, 0.5 m (20.0 in.)/min.

22.4.4 Air pressure for pneumatic clamps, 414 kPa or 60 psi.

22.5 Locate the clamps so the convex surfaces, acrylic or steel, are horizontal.

22.6 If required, cut two pieces of tubing approximately 12.5 mm (0.5 in.) long. Thread the test specimen through one piece of tubing using the needle threader of the air suction nozzle, so that approximately 25 mm (1 in.) of rubber thread extends beyond one end of the tubing. Secure on the top clamp. Thread the free end through the second piece of tubing and secure in the bottom clamp.

22.7 Set the full-scale load of the tensile testing machine so that the estimated force to rupture the thread falls between 30 and 80 % of the full-scale deflection.

22.8 Start the machine; observe and record the breaking force and elongation. If the specimen breaks within 3.0 mm (0.125 in.) of knot, disregard the result and test another specimen from the same package.

22.9 Repeat 22.6-22.8 until the required number of thread specimens have been broken.

# ELONGATION AT BREAK

## 23. Terminology

23.1 *Definitions of Terms Specific to This Standard:*

23.1.1 *elongation at break of a rubber thread*— the increase in length of the thread at break when it is stretched under the specified conditions expressed as the percentage increase of the original length. Thus, a specimen 25 mm (1 in.) in length which increases in length to 175 mm (7 in.) at break is said to have an elongation break of 600 %.

## 24. Procedure

24.1 When using the constant-rate-of-extension-(CRE) type tensile testing machine, read the elongation at maximum force from the load-elongation chart. Calculate the percent elongation on the basis of the nominal gage length.

# STRESS AT PREDETERMINED ELONGATION

## 25. Terminology

25.1 *Definitions of Terms Specific to This Standard:*

25.1.1 *Schwartz value*—the average of the stresses in newtons per square metre (pounds per square inch) calculated on the original cross-sectional area at a specified elongation measured on extension and retraction of a massaged thread. It is denoted by the symbol $SV^{c}_{n}$, where *c* is the massaging elongation and *n* that at which readings are taken, both expressed as percentages of the initial length. *c* and *n* should be multiples of 100 and, unless otherwise specified, *c* should be (*n* + 100 %). Preferred values of *n* are 300 and 500 %, according to the type of thread under test.

25.2 *Schwartz hysteresis ratio*—the ratio of the stresses at a specified elongation measured on extension and retraction after massaging as in Section 26. It is denoted by the symbol SHR and is expressed in percent.

## 26. Massaging (Mechanical Conditioning)

26.1 In order to eliminate the effects of storage on the physical properties of a thread, and to reproduce as far as possible the conditions of use, it is necessary that the sample, prepared in accordance with Section 6, should be subjected, before any readings of force are taken, to a number of cycles of elongation to, and retraction from, an elongation greater than that at which the readings are desired.

## 27. Determination of Schwartz Value and Schwartz Hysteresis Ratio

27.1 *Apparatus—Constant-Rate-of-Extension-Type Tensile Testing Machine* described in Section 21.

27.2 *Procedure*:

27.2.1 Use the procedure in Section 22 except allow the machine to cycle and reverse it at the desired elongation. Make six cycles of elongation and retraction without interruption to an elongation of *c* %, and readings at *n* % should be taken on the sixth cycle.

27.2.2 Make three measurements on different test specimens. The Schwartz value and Schwartz hysteresis ratio of the sample under examination should be taken as the arithmetic mean of the values obtained from the measurements.

27.3 *Examples of Calculation*—Let $S_1$ and $S_2$ be the forces at 300 % elongation (on extension and retraction) on a thread of original cross-sectional area *a*, which has been massaged by extension to and from an elongation of 400 %.
Then

Schwartz value = (5)

$$SV^{400}_{300} = \frac{S_1 + S_2}{2}$$

Schwartz hysteresis ratio = (6)

$$SHR^{400}_{300} = \frac{S_2}{S_1} \times 100$$

[4] Apparatus meeting this description obtainable from Cole Tool, Inc., 724 N. Augusta Ave., Waynesboro, VA, has been found satisfactory.

## ELONGATION UNDER A FIXED FORCE (TEST METHOD A)

### 28. Summary of Test Method

28.1 This test method measures the percent elongation obtained when a thread is stretched to a fixed force.

### 29. Apparatus

29.1 *Constant-Rate-of-Extension-Type Tensile Testing Machine*, described in Section 21.

### 30. Procedure

30.1 Proceed in accordance with 22.1-22.6.

30.2 Set the full-scale load of the tensile testing machine to 50 % of the pull in newtons corresponding to the size or count of the thread as shown in Table 1.

30.3 Read the elongation at the maximum load from the load-elongation chart.

30.4 Calculate the percent elongation on the basis of the nominal gage length.

## ELONGATION UNDER A FIXED FORCE (TEST METHOD B)

### 31. Summary of Test Method

31.1 This test method measures the percent elongation obtained when a loop of thread is stretched by a fixed force.

### 32. Apparatus

32.1 *Measuring Board*, having a scale marked on it from 0 to 1000 mm in 1-mm divisions. The zero mark shall be 100 ± 2 mm from the thread-holding clamps. The board shall be mounted in a vertical position.

### 33. Test Specimens

33.1 Five test specimens of the same size thread shall be tested. Each test specimen shall be approximately 300 mm in length so that a loop 100 ± 2 mm in length can be formed when the ends are suitably clamped.

**TABLE 1 Weights for Modulus (Tension Test)**

| Size Number | | Tension | |
|---|---|---|---|
| Extruded Thread | Cut Thread | N | gf |
| | 24 | 6.13 | 625 |
| 26 | 30 | 3.92 | 400 |
| 28 | 32 | 3.45 | 352 |
| 30 | 34 | 3.08 | 314 |
| 32 | 36 | 2.65 | 270 |
| 37 | 42 | 2.01 | 205 |
| 44 | 50 | 1.42 | 145 |
| 50 | 56 | 1.11 | 113 |
| 52 | 58 | 1.05 | 107 |
| 60 | 68 | 0.77 | 79 |
| 62 | 70 | 0.72 | 73 |
| 65 | 73 | 0.66 | 67 |
| 75 | 85 | 0.49 | 50 |
| 88 | 100 | 0.35 | 36 |
| 90 | 102 | 0.34 | 35 |
| 100 | 112 | 0.28 | 28.7 |
| 125 | 141 | 0.177 | 18 |

### 34. Procedure

34.1 Test the sample from which the test specimens are taken for size in accordance with Sections 12-16. Fasten one end of the test specimen in one side of the clamp. Bring the other end of the test specimen around the pin at the zero mark on the board and place it in the other clamp, adjust it until the thread fits loosely around the pin, and then tighten the clamps. Lift the loop of thread from around the pin with the fingers and place the hook attached to the weight specified in Table 1, through the loop. Holding the weight with the fingers, allow it to move downward at 40 mm/s, stretching the thread to its equilibrium point. Allow the weight to hang free, and immediately record the increase in length of the loop in millimetres as percent elongation.

## STRESS RETENTION

### 35. Terminology

35.1 *Definitions of Terms Specific to This Standard:*

35.1.1 *stress retention of a rubber thread*—the residual force (or stress) expressed as a percentage of the original force (or stress) on the thread after the test specimen has been maintained at a constant elongation (usually 150 %) for a specified time.

### 36. Apparatus

36.1 Figure 3 shows a simple apparatus for carrying out this test. One end of the loop is passed around one peg, the other end being attached to the other peg by means of a wire clip. A spring balance is attached to the other end of the wire clip and the load required just to lift the clip off the peg measured. The distance between the two pegs should be such that the thread is subjected to the specified elongation, ±2 %.

### 37. Test Specimens

37.1 Test specimens shall be composed of loops prepared by tying the thread without tension around pegs set at a predetermined distance apart on a board using a knot that shall not slip.

### 38. Procedure

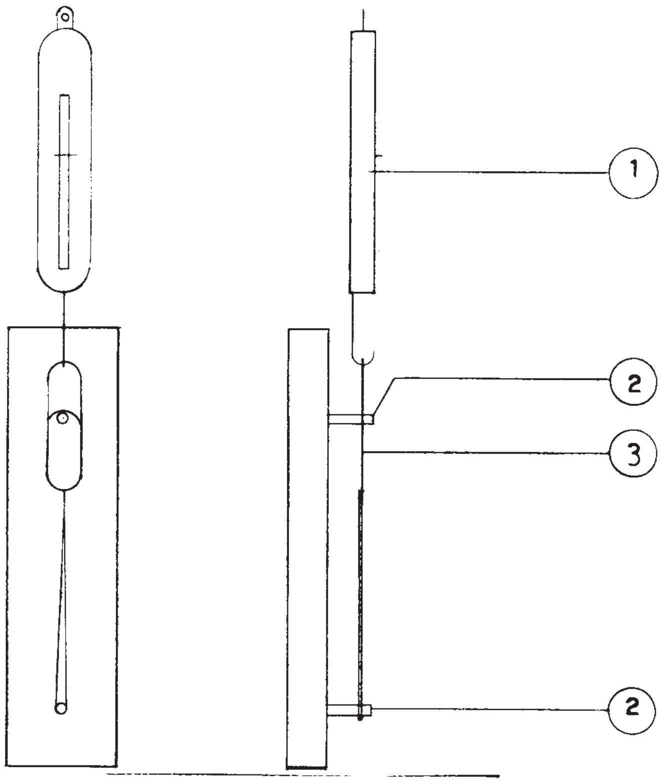
38.1 Pass one end of the test specimen around the bottom peg and attach the other end to the wire clip as shown in Fig. 3. Then place the inner loop of the wire clip over the top peg, thus subjecting the test specimen to the specified elongation of 150 ± 2 %. Maintain this extension during the test.

38.2 When a measurement of stress is to be made, attach the spring dynamometer to the outer loop of the wire clip (as shown in Fig. 3) and raise the dynamometer until the wire clip is just clear of its supporting peg. At this point, the reading of the dynamometer just counterbalances the force exerted on the rubber thread.

38.3 Take the initial reading 30 ± 1 min after the initial extension of the thread on the apparatus and further readings after 14 days and intermediately, if required.

### 39. Calculation

39.1 Calculate the stress retention of the test specimen after the stated time at the specified elongation, expressed as the percentage ratio of residual to initial forces, as follows:




1—Spring Dynamometer
2—Pegs
3—Metallic Clip

**FIG. 3 Apparatus for Determination of Stress Retention**

$$\text{Stress retention} = (S_2/S_1) \times 100 \quad (7)$$

where:
$S_1$ = initial force, N, and
$S_2$ = residual force, N.

39.2 Make five measurements on different test specimens. Take the arithmetic mean of the values obtained as the stress retention of the sample.

NOTE 2—This test may be carried out at ambient or elevated temperatures and the conditions and duration of the test should be stated.

## 40. Precision and Bias

40.1 No statements of precision or bias are given for these test methods for density, count, metric yield, tensile strength, elongation at break, stress at predetermined elongation, elongation under fixed load (Test Methods A and B), and stress retention of a rubber thread because a sufficient number of laboratories are not available to conduct reliability and reproducibility studies in accordance with Practice D 4483.

## 41. Keywords

41.1 count; density; elongation; rubber thread; tensile strength