



Designation: D 430 – 95 (Reapproved 2000)

Standard Test Methods for Rubber Deterioration—Dynamic Fatigue¹

This standard is issued under the fixed designation D 430; 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.

1. Scope

1.1 These test methods cover testing procedures that estimate the ability of soft rubber compounds to resist dynamic fatigue. No exact correlation between these test results and service is given or implied. This is due to the varied nature of service conditions. These test procedures do yield data that can be used for the comparative evaluation of rubber compounds or composite rubber-fabric materials for their ability to resist dynamic fatigue.

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

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:

- D 412 Test Methods for Vulcanized Rubber and Thermoplastic Rubbers and Thermoplastic Elastomers—Tension²
- D 1349 Practice for Rubber—Standard Temperatures for Testing²
- D 1682 Test Methods for Breaking Load and Elongation of Textile Fabrics³
- D 3183 Practice for Rubber—Preparation of Pieces for Test Purposes from Products²

3. Summary of Test Methods

3.1 Three test methods are covered, using the following different types of apparatus:

- 3.1.1 *Method A*—Scott Flexing Machine.
- 3.1.2 *Method B*—De Mattia Flexing Machine.

¹ These test methods are under the jurisdiction of ASTM Committee D11 on Rubber and are the direct responsibility of Subcommittee D11.15 on Degradation Tests.

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

³ *Annual Book of ASTM Standards*, Vol 07.01.

3.1.3 *Method C*—E. I. du Pont de Nemours and Co. Flexing Machine.

3.1.4 The Scott flexing machine is used principally for tests of Type I, the De Mattia flexing machine for tests of Type II, while the du Pont apparatus is adapted to tests of either Type I or II.

4. Significance and Use

4.1 Tests for dynamic fatigue are designed to simulate the continually repeated distortions received in service by many rubber articles, such as tires, belts, footwear, and various molded goods. These distortions may be produced by extension, compressive, and bending forces or combinations of them. The effect of the distortions is to weaken the rubber until surface cracking or actual rupture occurs. In the case of combinations of rubber with other flexible material such as fabric, the effect may be evidenced by separation at the interface between the materials, caused either by breaking of the rubber or failure of the adhesion or both.

4.2 These tests are, therefore, of the following two types:

4.2.1 *Type I*—Tests designed to produce separation of rubber-fabric combinations such as are used in belts and tires, involving controlled bending of the specimens.

4.2.2 *Type II*—Tests designed to produce cracking on the surface of rubber by either repeated bending or extension as occurs in service with parts such as tire treads and sidewalls, rubber soles, and shoe uppers, diaphragms, hose covers, etc.

5. Application

5.1 In case of conflict between the provisions of these methods and those of detailed specifications or methods of test for a particular material, the latter shall take precedence.

6. Preparation of Specimen

6.1 Except as may be otherwise specified in these test methods, the requirements of Practice D 3183 shall be complied with and are made a part of these methods.

7. Temperature of Test

7.1 The standard temperature for testing shall be $23 \pm 2^\circ\text{C}$ ($73.4 \pm 3.6^\circ\text{F}$). Specimens shall be conditioned for at least 12 h. Controlled temperatures outside the standard range are



acceptable and often desirable. Special note of such temperatures shall appear in the report.

NOTE 1—The standard test temperature herein specified is the same as that prescribed for the Standard Laboratory Atmosphere in Practice D 1349. Any changes or revisions hereafter in Practice D 1349 relating to the standard test temperature shall be considered effective at once for this procedure.

METHOD A: SCOTT FLEXING MACHINE⁴

8. Type of Strain

8.1 The Scott flexing machine test method is used to test for ply separation in test specimens prepared from belts, tires, or other articles composed of plies of fabric bonded together by rubber compounds.

9. Test Specimens from Belts

9.1 The specimens shall be 209.5 mm (8.25 in.) in length by 25 ± 2 mm (1 ± 0.08 in.) in width. The actual thickness shall be measured and recorded. Test specimens selected from samples of belts shall be cut lengthwise of the belt and their locations recorded. The seam area of a folded belt shall not be included in any of the test specimens and the folded edge shall be removed before cutting the specimens. The specimens shall consist of four plies for routine tests, any excess plies being removed by stripping carefully so as not to weaken the remaining bonds.

10. Test Specimens from Tires

10.1 If suitable test specimens cannot be cut from tires it is necessary to prepare special flexing pad samples as described in 10.1.1–10.1.3 from the cord fabric and rubber compounds that are to be tested:

10.1.1 *Building Unvulcanized Flexing Pad Specimen*—Solution-coated, frictioned, or bare cord fabric shall be calendered with the rubber compound to a total thickness of 1.25 mm (0.050 in.). Six plies of this material shall be assembled using a hand roller so that the plies run in alternate directions. The first, third, and fifth plies shall have the cords lengthwise and the second, fourth, and sixth plies crosswise of the pad. Care shall be taken that the same calendered side of each piece is facing up and that each alternate ply crosses at right angles. The pad, which shall have a thickness of 7.6 mm (0.300 in.), shall be cut by means of a template and knife to dimensions of 125 by 202 mm (4.94 by 7.94 in.). The long edge of the template shall be held parallel with the lengthwise cords in the pad.

10.1.2 *Vulcanization of Flexing Pad Specimens*—The flexing pad specimen shall be vulcanized in a steel mold having a cavity measuring 125 by 203 by 8.25 mm (5 by 8 by 0.325 in.). Uniform compression shall be applied over the entire top surface of the pad. This compression, together with slight

stretching produced by the unvulcanized pad being cut slightly smaller than the cavity, ensures straight cords in the cured pad. In order to obtain the compression it is necessary to make up the difference between the pad thickness and the mold depth by means of filler layers of holland cloth or aluminum foil which are placed on top of the pad. These filler layers shall be added until the total thickness of the assembly, measured by means of a dial micrometer gage using a little pressure with the fingers on both sides of the gage foot, is 7.75 mm (0.305 in.). A sheet of rubber compound containing curing ingredients and measuring 0.5 by 152 by 228 mm (6 by 9 by 0.02 in.) shall be placed on top of the flexing pad and filler layers over the cavity of the mold before the mold cover is placed in position. The total thickness of the material in the mold is then 8.25 mm (0.325 in.) and expansion will produce the correct pressure to make a compact, undistorted pad. The purpose of the top rubber layer is to fill the overflow space and seal the mold. In placing the flexing pad in the mold, care shall be taken to keep uppermost that side of the pad having the cords running crosswise. Vulcanization shall be carried out by heating the mold under pressure at a known temperature for the required time in a rubber vulcanizing press. After curing, the filler layers shall be removed and the pad allowed to cool and rest at a room temperature between 21 and 32°C (70 and 90°F) for not less than 36 h before being tested. Pads made in this manner shall be 203 mm (8 in.) in length by 127 mm (5 in.) in width and shall have a thickness of 7.0 to 7.1 mm (0.275 to 0.280 in.). Any pads having wrinkled cords shall not be tested.

10.1.3 *Cutting Tire Test Specimens*—Four strips each 203 mm (8 in.) in length by 25 mm (1 in.) in width shall be cut from the tire flexing pad. On the first cut, a strip 0.250 to 12.5 mm (0.50 in.) in width from the edge along the long side of the pad shall be removed and discarded. Care shall be taken to cut the strips straight, with smooth edges and as closely to the exact width as possible. If reasonable care has been taken in preparing the pads and in cutting the specimens, there should not be more than five or six cut longitudinal threads showing on the two edges of a six-ply specimen. An excessive number of such cut threads indicates that many of the threads of alternate plies are not parallel.

11. Number of Test Specimens

11.1 At least five specimens from each belt sample or four specimens from each tire pad shall be tested and the results averaged. The precision of the final value may be increased by testing a greater number of specimens.

12. Scott Flexing Machine

12.1 The essential features of the apparatus, illustrated in Fig. 1, are as follows: The flexing machine has five hubs and is capable of testing five specimens at one time. Each hub rotates on a double row, radial type, ball bearing of the grease-sealed type with double shields. The test specimens shall be bent around the hubs having an arc of contact of about 165°, and the ends shall be gripped by clamps that are oscillated up and down by rocker arms driven through a chain of gears by a 190 W (0.25 hp) 1750 r/min motor. The action on the specimen is a flexing back and forth over the hub while pulled taut by the loading lever and weight. The specimen hubs are arranged in

⁴ Method A was originated by General Laboratories, U.S. Rubber Co. For further information concerning this test see Gibbons, W. A., "Flexing Test for Tire Carcass Stocks," *Industrial and Engineering Chemistry*, Analytical Edition, Vol 2, No. 1, Jan. 15, 1930, p. 99; also Sturtevant, W. L., "Rubber Power Transmission Belting, Part III—Flexing Machine and Dynamometers for Testing Belting Quality," *India Rubber World*, Vol 83, No. 3, 1930, p. 67.

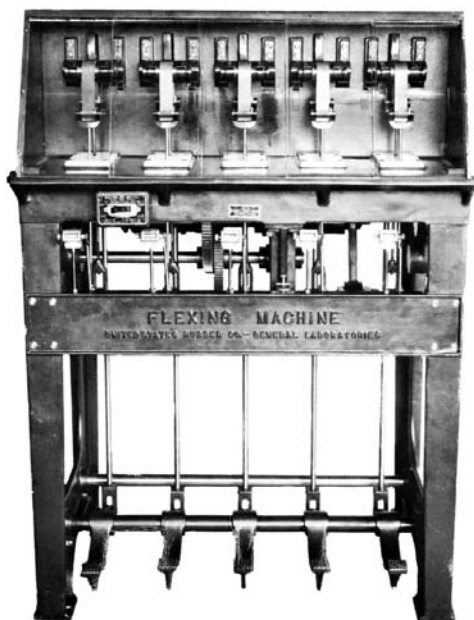


FIG. 1 Scott Flexing Machine with Five Hubs

direction of 66.5 mm (2.62 in.) and a full-cycle travel of 132.0 mm (5.2 in.). The speed of operation is approximately 2.7 Hz (160 cpm) the exact number of cycles in each test being recorded on a counter affixed to each rocker arm. The entire machine is approximately 1.27 m (50 in.) in height and occupies a floor space of about 0.66 by 0.97 m (26 by 38 in.).

13. Hub Size and Flexing Load

13.1 Specimens of belts shall be tested using hubs 31.7 mm (1.250 in.) in diameter with a 445 N (100-lbf) flexing load. Specimens of tire cord shall be tested using hubs 14.3 mm (0.563 in.) in diameter with a 445 N (100-lbf) flexing load.

14. Procedure for Belt Specimens

14.1 Bend the belt test specimens around the hubs with the pulley side of the belt against the metal and the ends clamped in the grips. Carefully apply the flexing load without shock, set the counter at zero, and start the machine. Allow it to run until some fine particles dislodged by friction may be seen on the white plate beneath the hub, which indicates that separation of the plies has started. Frequent inspection of the specimens undergoing test is imperative if reliable results are to be expected. When the first indication of ply separation appears, note the counter reading; thereafter watch the specimen more closely and increase the frequency of the inspection to ensure proper determination of the end point. When there is a clear separation across the width of the specimen it shall be considered to have failed. Record the minimum counter reading for this failure as the end point. Also note the location of the separation. When a test is started, continue to completion without interruption. Do not stop the machine and allow it to remain inactive for any length of time and then start it again. However, for examining the specimen, each hub may be released momentarily from its weight by means of the foot lever provided. Only experienced operators should make this determination.

15. Procedure for Tire Specimens

15.1 Mount the tire test specimens with the lengthwise outer ply cords against the hub of the machine and test in a manner similar to the procedure for belts (Section 13). In the case of tire specimens, after the specimen has been run about 10 min, brush a thick coat of molten carnauba wax on the outer side of the specimen at the flexing region. As soon as separation begins, the temperature of this section increases very rapidly and the wax melts. The melting of the wax starts with a small area and gradually spreads as separation increases. This serves as a warning that complete separation will occur shortly thereafter. The interval between the melting of the wax (the time at which separation actually starts) and complete separation across the specimen may not always be the same.

NOTE 2—A specimen with a short flexing life will show complete separation soon after the wax melts, whereas a sample with a greater flexing life might require a time interval two or three times as long. However, with specimens having similar flexing life, the time interval between the melting of the wax and complete separation is fairly constant.

16. Calculation

16.1 Calculate the result of the test of any sample as the average of the number of flexing cycles required to produce complete separation of each test specimen as determined from the counter readings.

METHOD B: DE MATTIA FLEXING MACHINE⁵

17. Type of Strain

17.1 The De Mattia flexing machine test method may be used to test rubber specimens for resistance to cracking produced either by extension or bending, depending on the relative adjustment of the stationary and movable grips, and the distance of travel of the latter. The choice of type of strain is optional (Note 3) but notation shall be made of the type actually used, giving full details of the relative positions of the grips and of the travel.

NOTE 3—In choosing the type of strain, it should be remembered that the phenomenon of cracking starts on the surface of the rubber and rapidly progresses inward as new surface is exposed. Since rubber is practically noncompressible but highly extensible, the rupture of the surface fibers in both types of strain must come from disturbances due to elongation. The magnitude of the extension, however, may differ and the internal distribution of force in the specimens is not the same in the two cases. The choice, therefore, will depend considerably on the purpose of the test and the kind of service for which correlation of the test results may be sought.

18. Test Specimens for Extension Fatigue Cracking

18.1 When the extension type of strain is used the standard test specimen shall be the dumbbell-shape tension specimen shown in Fig. 1 (Die C) of Test Methods D 412. The actual thickness shall be measured and recorded, and results shall be compared only when obtained using specimens of substantially the same thickness. The specimens shall be prepared in the same manner as for tension tests, and special care shall be

⁵ See Cooper, L. V., "Laboratory Evaluation of Flex-Cracking Resistance," *Industrial and Engineering Chemistry, Analytical Edition*, Vol 2, No. 1, Oct. 15, 1930, p. 391.