Designation: D4482 – 11 (Reapproved 2021)

Standard Test Method for Rubber Property—Extension Cycling Fatigue[1]

This standard is issued under the fixed designation D4482; 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 fatigue life of rubber compounds undergoing a tensile-strain cycle. During part of the cycle, the strain is relaxed to a zero value. The specimens are tested without intentionally initiated flaws, cuts, or cracks. Failure is indicated by a complete rupture of the test specimen.

1.2 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 for their ability to resist (dynamic) extension cycling fatigue.

1.3 The values stated in SI units are to be regarded as 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, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.5 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

D3182 Practice for Rubber—Materials, Equipment, and Procedures for Mixing Standard Compounds and Preparing Standard Vulcanized Sheets

D3767 Practice for Rubber—Measurement of Dimensions

D4483 Practice for Evaluating Precision for Test Method Standards in the Rubber and Carbon Black Manufacturing Industries

2.2 *British Standard:*

BS5324 Guide to Application of Statistics to Rubber Testing[3]

3. Terminology

3.1 *Definitions of Terms Specific to This Standard:*

3.1.1 *extension ratio*—the ratio of the extended length of a specimen, L, to the unextended length, L_o, calculated as follows:

$$\lambda = \frac{L}{L_o} \tag{1}$$

3.1.2 *fatigue life (sample)*—the geometric mean or median value of the number of cycles required to cause failure for a number of specimens of the sample.

3.1.3 *fatigue life (specimen)*—the total number of cycles required to cause failure of a specimen, defined as a complete rupture or separation of the specimen.

3.1.4 *strain energy*—the energy per unit of volume required to deform the specimen to the specified strain. It is measured by the area under a stress-strain curve and expressed in kJ/m3 (see Annex A1).

4. Summary of Test Method

4.1 The dumbbell test specimens are cyclically strained at a fixed frequency and a series of fixed maximum extension ratios such that little or no temperature rise is induced. This cyclical straining action is called flexing. As a result of the flexing, cracks usually initiated by a naturally occurring flaw, grow and ultimately cause failure which is defined as complete rupture of the test specimen. The number of cycles to failure (fatigue life) is recorded.

4.2 Fatigue, as used in this test method, implies a rupture failure mechanism that results from the growth of flaws in the specimen. Fatigue does not refer to the drastic alteration of the physical-chemical rubber structure characteristic of high frequency flexing tests that give rise to a substantial temperature increase.

[1] This test method is under the jurisdiction of ASTM Committee D11 on Rubber and Rubber-like Materials and is the direct responsibility of Subcommittee D11.15 on Degradation Tests.

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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] Available from British Standards Institute, 2 Park St., London W1A 2BF, United Kingdom.

4.3 Fatigue life may be determined at each of a number of different extension ratios and the log (fatigue life) plotted as a function of either extension-ratio or log (strain energy). A single extension-ratio or log (strain energy) may be used for limited comparisons of rubber vulcanizates having similar stress-strain properties and the same polymer system (see Annex A1).

5. Significance and Use

5.1 This test method covers one procedure for determining fatigue life at various extension-ratios. The strain cycle is characteristic of the type of test apparatus specified. Experience in fatigue testing shows that fatigue life may have a wide, non-normal distribution and, therefore, a large standard deviation that is compound dependent. Natural rubber, for example, has shown a narrower distribution than many synthetic rubbers. A large number of specimens may, therefore, be required to yield the desired precision. Comparison of different rubber compounds should be made with due consideration to the standard deviation for each (see 7.1).

5.2 Fatigue data, as generated in this test method, give primarily an estimate of the crack initation behavior of a rubber vulcanizate and only a very approximate measure of the crack propagation rate. The information obtained may be useful in predicting the flex-life performance of a compound in active service; however, the user should be aware that in actual use, products are subjected to many other fatigue factors not measured in this test method.

6. Apparatus

6.1 *Fatigue Tester,* consisting of framework capable of containing two or more sets of multi-place specimen racks or crossheads that hold specimens in a vertical position, side-by-side, in suitable grips. A crosshead or rack set is comprised of one stationary bar to which grips are attached and one moveable bar that is cycled by a cam at 1.7 ± 0.17 Hz (100 ± 10 cpm). Specimens are mounted in the grips, one specimen in each set of upper and lower grips.

6.1.1 The fatigue tester shall be capable of nominal specimen extension ratios of 1.6 to 2.4. The extension ratio is controlled by the use of a cam attached to a rotating drive shaft. The eccentricity of the cam imports the characteristic strain cycle to the specimen. Each cycle consists of:

6.1.1.1 Increasing strain for one quarter of the cycle time,

6.1.1.2 Decreasing strain for one quarter of the cycle time, and

6.1.1.3 Zero imposed strain for one half of the cycle time.

6.1.2 The specimen grips shall not cause premature failure outside the restricted portion of the test specimen. This is achieved by using a dumbbell test specimen with a thick beaded edge molded at each end of the specimen. This specimen is placed into grips that loosely hold it at the bead but impose no compressive stress on it (see Fig. 1).

6.2 *Mold,* sheets, to be used to cut specimens, can be vulcanized in a single cavity compression mold of two piece construction with a hard chrome finish (see Fig. 1). The cavity is 254 mm (10 in.) by 78.54 mm, and has a 6.35-mm (0.25-in.) diameter bead along each lengthwise edge. Cutting guides should be included at 14.3 mm (0.56 in.) intervals along the beaded edges.

6.3 *Press,* as described in accordance with Practice D3182.

6.4 *Specimen Cutter*—The cutting die shall conform to Fig. 2. The inside faces of the reduced section shall be polished and perpendicular to the plane formed by the cutting edges for a depth of at least 5 mm (0.2 in.).

6.5 *Vernier Calipers*—Calipers capable of making measurements in accordance with Practice D3767, with a minimum range of 15 mm (0.6 in.), and precision of 0.05 mm (0.002 in.).

6.6 *Stress-Strain Measuring Apparatus*—Either of two types may be used:

6.6.1 A machine in which the actual extension is measured at a given dead-weight force. A stand enables masses to be suspended from the specimen. A set of masses that includes at least one 50, one 100, two 200, two 500, and one 1000-g mass shall be available.

6.6.2 Alternatively, a tensile testing machine may be used that is capable of extending the specimen at a rate of 50.0 mm/min (2.0 in./min). It should automatically measure elongation to an accuracy of ±5 % of the specimen's original length.

6.7 *Micrometer*—The micrometer or thickness gauge shall conform to the specifications in Practice D3767.

6.8 *Bench Marker,* with two parallel straight marking surfaces ground smooth in the same plane. The surfaces shall be between 0.05 and 0.08-mm (0.002 and 0.003-in.) wide and 23-mm (0.9-in.) long. The angle between the marking surfaces and sides shall be at least 75°. The distance between the marking centers shall be 25 ± 0.50 mm (0.984 ± 0.020 in.).

7. Sampling

7.1 Sampling shall be done in a way that justifies the conclusions drawn from any particular test program in declaring one compound to be superior to another. In fatigue-life measurement, a sampling variance that includes mix and curing variance components shall be used.

8. Specimen Preparation

8.1 Compounds shall be prepared in accordance with Practice D3182 and vulcanized in the specified mold with the milling-grain direction parallel to the beaded edge.

8.2 The molded sheet shall be conditioned in an unstrained state for at least 24 h at test temperature before testing.

8.3 Specimens shall be cut with the die cutter at right angles to the beaded edge. The die cutter shall be sharp and free from nicks and oil prior to cutting. Support the sheets on a suitable cutting surface (cardboard, linoleum, etc.) covered with a thin plastic film to prevent inclusions. Cut the sheets with a single, smooth stroke.

8.4 Discard specimens having obvious flaws. Before testing, physically randomize the specimens from all sheets of the same compound.

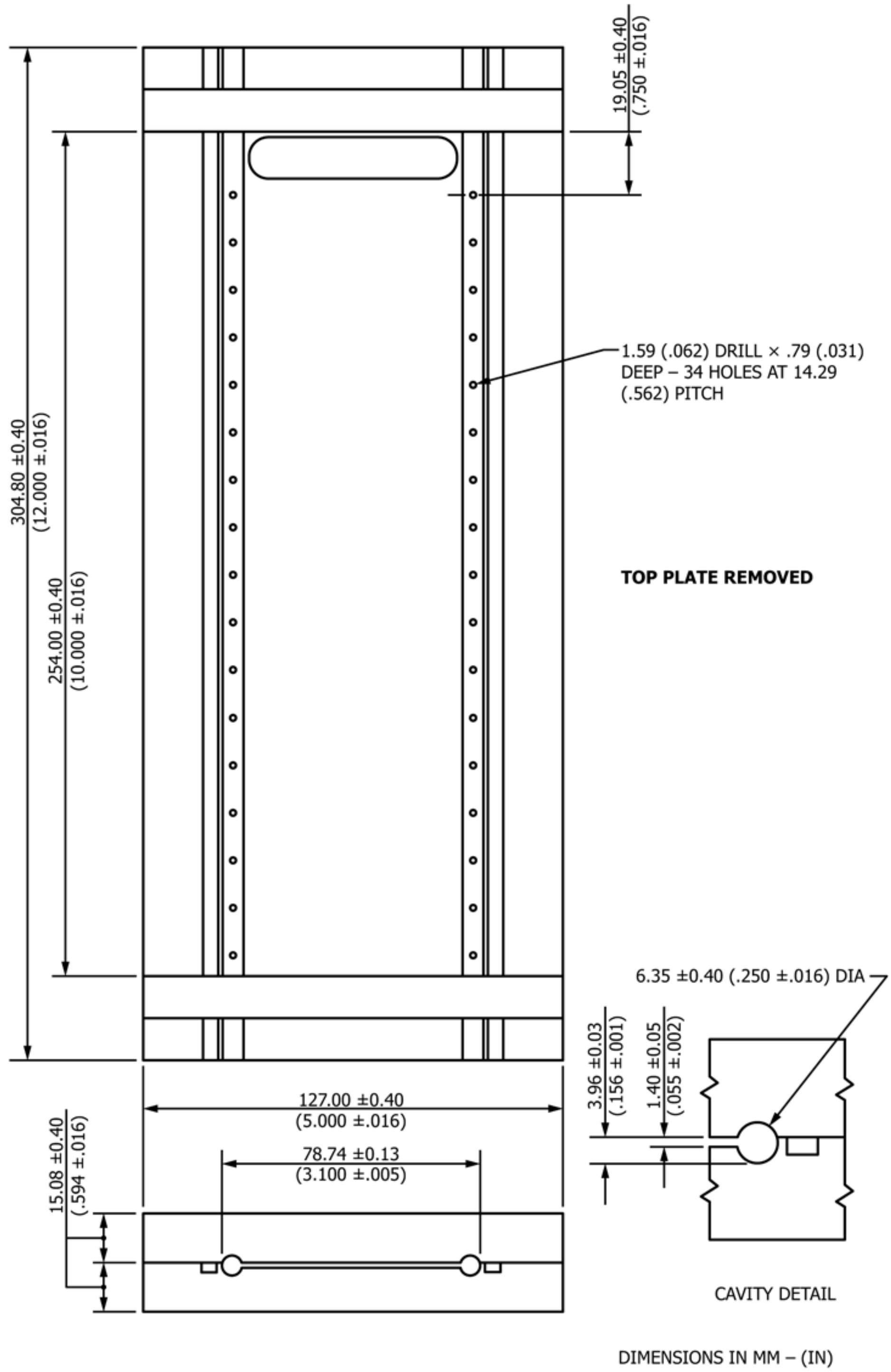

FIG. 1 Single-Cavity Compression Mold

9. Conditioning

9.1 *Test Temperature*—It is suggested that the test temperature be 23 ± 2°C.

NOTE 1—It is recommended that the laboratory room housing the fatigue tester be free of any ozone-generating equipment.

10. Procedure

10.1 *Fatigue Tester:*

10.1.1 Install the proper cam that will give the desired extension ratio.

NOTE 2—If previous knowledge about fatigue life of a particular