Designation: D 3629 – 99

Standard Test Method for Rubber Property—Cut Growth Resistance[1]

This standard is issued under the fixed designation D 3629; 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 a procedure for measuring the cut growth resistance of precut vulcanizate specimens, under controlled conditions of environment, temperature, frequency, and severity.

1.2 The values stated in SI units are to be regarded as the standard.

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 3185 Test Methods for Rubber—Evaluation of SBR (Styrene-Butadiene Rubber) Including Mixtures With Oil[2]

D 3767 Practice for Rubber—Measurement of Dimensions[2]

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

3. Summary of Test Method

3.1 T-shaped, grooved specimens are pierced, mounted circumferentially along the periphery of rotating disks and bent or flexed as they strike against freely rotating deflector bars at a controlled frequency. The growth of the cut is measured and expressed as the number of kilocycles required for a 5- or 10-fold increase in cut length.

4. Significance and Use

4.1 Fatigue life tests on rubber show notoriously high variance. Therefore, they are not well-suited for specifications or regulatory statutes. This test method, however, has been shown to be useful for development studies of polymer, compounding variables, and test temperature on cut growth resistance, and it has also been shown in numerous instances to relate qualitatively to tire cut growth.

5. Apparatus

5.1 *Flex Tester*— The tester is shown in Fig. 1 and Fig. 2. The entire mechanism is enclosed in a temperature controlled test chamber capable of maintaining temperatures between 25 and 125°C (77 and 257°F). Slotted disks, with spring-loaded

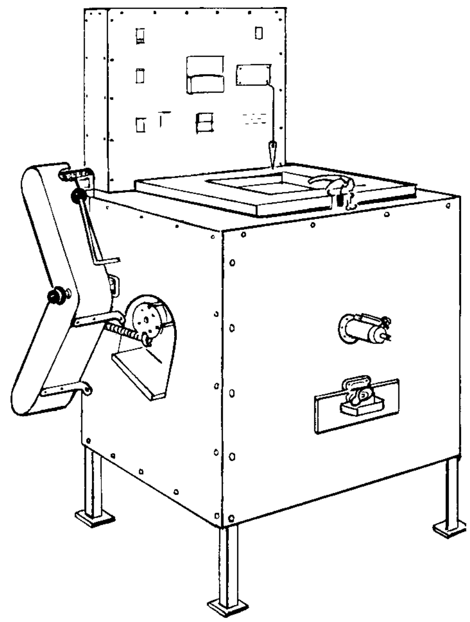

FIG. 1 TEXUS® Flex Tester (The TEXUS Flex Tester is a trademark of Texas-U.S. Chemical Company)

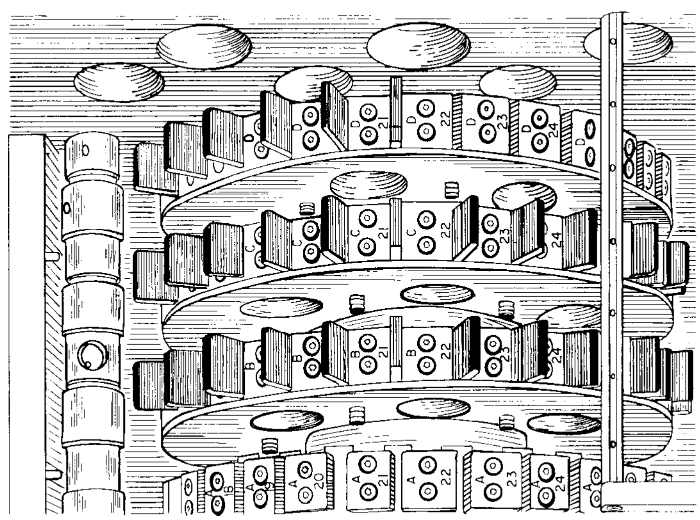

FIG. 2 Rotating Disks

[1] This test method is under the jurisdiction of ASTM Committee D-11 on Rubber and is the direct responsibility of Subcommittee D11.15 on Degradation Tests.

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

specimen-mounting locations, are connected to a variable-speed drive that is controllable between 10.5 and 89.0 rad/s (100 and 800 rpm). Test severity can be varied further by adjusting the flexing angle, which is accomplished by varying the gap width between the revolving disks and the two deflector bars using the micrometer screws attached to the deflector bars.

NOTE 1—There are two flexes for each revolution of the disk. Therefore, the total number of flexes or cycles will be twice the machine revolutions as registered on the counter.

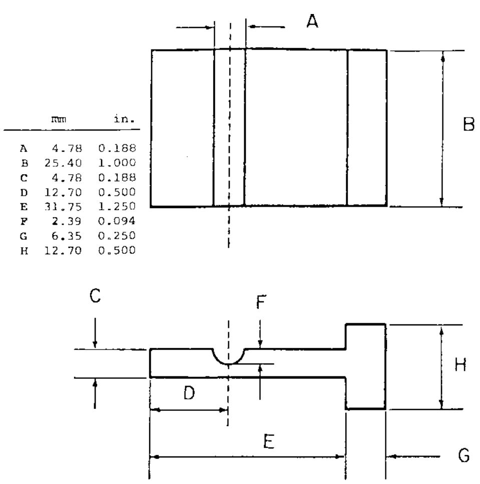
5.2 *Mold*—A mold is required, preferably of a multiple-cavity design and having adequate overflow cavities (Fig. 3).

5.3 *Thickness Gage*—The gage used for measuring the thickness of the specimens shall be in accordance with the specifications in Practice D 3767.

5.4 *Piercing Instrument*—A precision piercing instrument, shown in Fig. 4 and Fig. 5, is used to initiate a 2.0-mm (0.08-in.) cut in the exact center of the groove of the specimen. The instrument consists of a holder that keeps the specimen precisely in the desired position for piercing and a spring-mounted plunger with a sharp 2.0-mm wide flat blade at the end.

6. Preparation of Specimen

6.1 Sheet the compound to 5.8 ± 0.3 mm (0.23 ± 0.01 in.), and mark the direction of the mill grain. Cut a rectangular piece 45 ± 0.3 mm (1.75 ± 0.01 in.) long by 25.4 ± 0.3 mm (0.5± 0.01 in.) wide from the sheeted stock with the mill grain parallel to the width. Then cut 1.3 ± 0.3 mm (0.5 ± 0.01 in.) off from the length and load a "T" shaped preform into the mold and cure. The grain orientation of the final specimen should be parallel to the molded groove.



Dimensions

	in.	mm
A	0.19 ± 0.004	4.8 ± 0.1
B	1.00 ± 0.05	25.4 ± 1.25
C	0.19 ± 0.004	4.8 ± 0.1
D	0.50 ± 0.04	12.7 ± 1.0
E	1.25 ± 0.06	31.8 ± 1.5
F	0.09 ± 0.001	2.4 ± 0.025
G	0.25 ± 0.01	6.4 ± 0.25
H	0.50 ± 0.04	12.7 ± 1.0

FIG. 3 Test Specimen

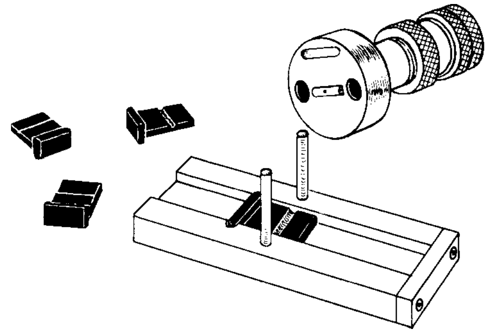
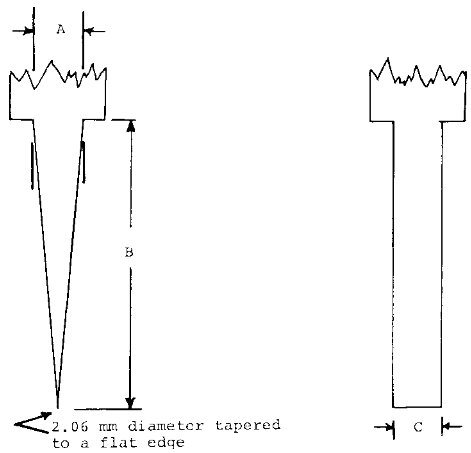


FIG. 4 Piercing Instrument



Dimensions

	in.	mm
A	0.08 ± 0.001	2.0 ± 0.02
B	0.50 ± 0.002	12.7 ± 0.05
C	0.08 ± 0.001	2.0 ± 0.02

FIG. 5 Piercing Instrument

NOTE 2—Using typical passenger tire tread formulations, a sample mass of 8 to 9 g is obtained. Recipe 1A of Methods D 3185 can be used for a typical tire tread compound. Care should be taken in the preparation of preforms, since excess compound prevents proper mold closure and results in cured specimens exceeding the dimensions shown in Fig. 3.

6.2 Specimens shall have smooth surfaces and be free of surface irregularities and defects in the groove and adjacent area. Measure the thickness in the area adjacent to the grooves. The thickness shall be 4.75 ± 0.1 mm (0.188 ± 0.005 in.).

6.3 Deflash without rounding edges or pitting the specimens and initiate a 2.0 ± 0.02-mm (0.08 ± 0.001-in.) cut with the piercing instrument.

7. Equipment Adjustment

7.1 Before starting a test, check the instrument to assure that the axes of the deflector bars and rotating disks are parallel. This is accomplished by measuring the gap width between the surfaces of the rotating disks and deflector bars using a telescopic thickness gage. Make any adjustments required. The micrometer head at each end must be calibrated and adjusted so its readings correspond directly to the gap width.

NOTE 3—For frequent checking and setting of specific flex angles such as 45 and 60°, a spacer block of 21.1 by 17.7 mm (0.830 by 0.700 in.) may be fabricated.

8. Procedure

8.1 Mount the specimens onto the peripheries of the rotating disks by sliding them into the slots of the spring-loaded sample holders. The grooves must face the direction of revolution of the disk and face the deflector bars. Space the samples symmetrically around the periphery to eliminate vibration. It is advisable to have at least four slots on each disk opposite the deflector bars vacant, so as to avoid bending of any sample during the preheating period.

8.1.1 Test at least six specimens of each sample or article and average the results. It is desirable, when possible, to test a standard compound as a control. For greater test precision, twelve samples may be tested.

8.2 Set the temperature selector to the desired test temperature.

8.3 Set the flex angle by adjusting the gap widths to the desired settings. The relationship between gap width and the flex angle is shown in Fig. 6.

8.4 Set the frequency of revolution by adjusting the speed control to the desired percent of maximum speed which is 83.8 rad/s (800 rpm). Frequency of revolution is adjustable between 10.5 and 62.8 rad/s (100 and 600 rpm) to within ±0.5 %.

8.5 The test chamber is equipped with gas inlets so that any desired atmosphere can be introduced.

8.6 Turn on the drive motor as soon as the test temperature is attained.

8.7 Measure the cut growth to the nearest 0.25 mm (0.01 in.) using a pivoted scale mounted within the chamber or other suitable measuring scale that can be held adjacent to the specimen. After the motor is stopped at various predetermined numbers of revolutions, make measurements by bringing the scale down alongside each specimen. Repeat this process as often as desired or until all specimens have failed (Note 4). A specimen is considered to have failed when the cut length reaches 20 mm (0.8 in.).

NOTE 4—Testing typical passenger car tire tread compounds in the 7 to 10-MPa (1000 to 1200-psi), 300 % modulus range, at 100°C (212°F), 31.4 rad/s (300 rpm), and 60° flex angle, it is recommended that measurements be made every 10 000 revolutions or 20 kilocycles. Under these conditions the test will usually not exceed 18 h or 400 kilocycles.

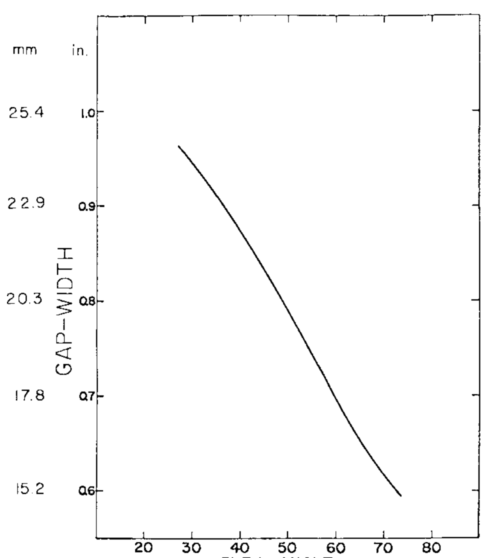


FIG. 6 Relationship Between Gap-Width and Flex Angle

9. Treatment of Data

9.1 *Reporting of Test Results*—The cut growth data may be reported as the number of cycles required to reach a specified cut length of either 10 or 20 mm (0.4 or 0.8 in.). Average the cut growth results of at least six specimens for each compound and determine their standard deviation. Report the cut growth resistance as the average value.

9.2 The test report shall include the following:

9.2.1 Indentification of the sample,

9.2.2 Number of specimens,

9.2.3 Flex angle,

9.2.4 Flex frequency,

9.2.5 Test temperature, and

9.2.6 Test atmosphere.

10. Precision and Bias

10.1 These precision statements have been prepared in accordance with Practice D 4483. Please refer to this practice for terminology and other testing and statistical concepts.

10.2 An interlaboratory test program was conducted on three (3) materials (compounds). Six laboratories participated and replicate tests were conducted on two separate days. For each compound and on each of the two days, twelve (12) specimens were tested and their average flex-life to a 10 mm cut growth constitutes one test result.

10.3 Table 1 lists the precision results obtained based on flex-life in kilocycles to 10 mm growth.

10.4 Table 2 lists the precision results obtained based on the log of flex-life in kilocycles to 10 mm growth. The log of flex-life is used to give an indication of the change in variation by making this transformation, which is often used in an attempt to normalize raw data that are suspected to have a non-normal distribution. The among laboratory standard deviation of log flex-life is essentially equal for all three materials, although the flex-life varies by a factor of 1.32 for log flex-life (maximum/minimum) for Material 1 versus Material 3.

10.5 The precision results in this precision and bias section give an estimate of the precision of this test method with the materials (rubbers used in the particular interlaboratory program) as described in 10.2. The precision parameters should not be used for acceptance/rejection testing of any group of materials without documentation that they are applicable to those particular materials and the specific testing protocols that include this test method.

10.6 The results of the precision calculations for repeatability and reproducibility are given in Table 1 and Table 2 in ascending order of material average (flex life or log flex life), for each of the materials evaluated.

10.7 The precision of this test method may be expressed in the form of the following statements that use what is called an *appropriate value* of *r*, *R*, (*r*), or (*R*), that is, that value to be used in decisions about test results (obtained with the test method). The appropriate value is that value of *r* or *R* associated with mean level in Table 1 or Table 2 closest to the mean level under consideration at any given time, for any given material in routine testing operation.

TABLE 1 ASTM Test Method D 3629 Type 1 Precision[A]—Flex-Life (KC to 10 mm)

Material	Mean Level	Within Laboratories[B]			Between Laboratories		
		s_r	r	(r)	S_R	R	(R)
1	46.6[C]	1.68	4.74	10.17	2.64	7.47	16.02
2	77.9	2.26	6.40	8.21	3.45	9.75	12.52
3	156.7	4.04	11.43	7.29	4.79	13.55	8.65
Pooled or Average Values	93.7	2.84	8.04	8.58	3.73	10.56	11.26

[A]This is short-term precision (days).
[B]Symbols are defined as follows:
S_r= Within laboratory standard deviation,
r = Repeatability (in measurement units),
(r) = Repeatability (in percent),
S_R= Between laboratory standard deviation,
R = Reproducibility (in measurement units), and
(R) = Reproducibility (in percent).
[C]Mean level values as Flex-Life (kilocycles to 10 mm cut growth).

TABLE 2 ASTM Test Method D 3629 Type 1 Precision[A]—Log Flex-Life (KC to 10 mm)

Material	Mean Level	Within Laboratories[B]			Between Laboratories		
		s_r	r	(r)	S_R	R	(R)
1	1.664[C]	0.157	0.44	26.7	0.264	0.75	44.9
2	1.887	0.165	0.47	24.7	0.260	0.74	39.0
3	2.19	0.226	0.64	29.2	0.258	0.73	33.4
Pooled or Average Values	1.91	0.185	0.52	27.4	0.26	0.74	38.6

[A]This is short-term precision (days).
[B]Symbols are defined as follows:
S_r= Within laboratory standard deviation,
r = Repeatability (in measurement units),
(r) = Repeatability (in percent),
S_R= Between laboratory standard deviation,
R = Reproducibility (in measurement units), and
(R) = Reproducibility (in percent).
[C]Mean level values as Log Flex-Life (log of kilocycles to 10 mm cut growth).

10.8 *Repeatability*— The repeatability, *r*, of this test method has been established as the appropriate value tabulated in Table 1 and Table 2. Two single test results, obtained under normal test method procedures, that differ by more than this tabulated *r* (for any given level) must be considered as derived from different or nonidentical sample populations.

10.9 *Reproducibility*— The reproducibility, *R*, of this test method has been established as the appropriate value tabulated in Table 1 and Table 2. Two single test results obtained in two different laboratories, under normal test method procedures, that differ by more than the tabulated *R* (for any given level) must be considered to have come from different or nonidentical sample populations.

10.10 Repeatability and reproducibility expressed as a percentage of the mean level, (*r*) and (*R*), have equivalent application statements as above for *r* and *R*. For the (*r*) and (*R*) statements, the difference in the two single test results is expressed as a percentage of the arithmetic mean of the two results.

10.11 *Bias*—In test method terminology, bias is the difference between an average test value and the reference (or true) test property value. Reference values do not exist for this test method since the value (of the test property) is exclusively defined by the test method. Bias, therefore, cannot be determined.

11. Keywords

11.1 cut growth; fatigue; fatigue life; flex; flex test; TEXUS flex tester