



# Standard Test Methods for Rubber Properties in Compression<sup>1</sup>

This standard is issued under the fixed designation D 575; 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 ( $\epsilon$ ) indicates an editorial change since the last revision or reapproval.

## 1. Scope

1.1 These test methods cover two test procedures for determining the compression-deflection characteristics of rubber compounds other than those usually classified as hard rubber and sponge rubber.

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 3183 Practice for Rubber—Preparation of Pieces for Test Purposes from Products<sup>2</sup>

D 3767 Practice for Rubber—Measurement of Dimensions<sup>2</sup>

D 4483 Practice for Determining Precision for Test Method Standards in the Rubber and Carbon Black Industries<sup>2</sup>

E 4 Practices for Force Verification of Testing Machines<sup>3</sup>

## 3. Summary of Test Methods

3.1 These tests constitute one kind of compression stiffness measurement. Deflection is the change in thickness of the specimen upon application of a compressive force. The two different procedures are as follows:

3.1.1 *Test Method A—Compression Test of Specified Deflection*—A compression test in which the force required to cause a specified deflection is determined.

3.1.2 *Test Method B—Compression Test at Specified Force*—A compression test in which the specified mass or compressive force is placed on the specimen and the resulting deflection is measured and recorded.

## 4. Significance and Use

4.1 These test methods are useful in comparing stiffness of

rubber materials in compression. They can be used by rubber technologists to aid in development of materials for compressive applications.

## 5. Apparatus

5.1 *Compression Testing Machine*—A compression testing machine conforming to the requirements of Practices E 4, and having a rate of head travel of  $12 \pm 3$  mm/m ( $0.5 \pm 0.1$  in./min), may be used for either type of test. Any other type machine that will meet these requirements may be used. For example, a platform scale equipped with a yoke over the platform and a hand-operated screw to apply the force will serve if it will conform to the requirements prescribed for accuracy and rate of travel. Compression tests at specified forces may be performed on any machine that applies minor and major forces gently, without impact, or by placing specified masses gently on the specimen. The machine shall be equipped to permit measurement of the deflection caused by the increase from minor force to major force.

5.2 *Deflection Gage*—The deflection shall be read on a gage of dial type graduated in hundredths of millimetres (or thousands of an inch).

5.3 *Micrometer*—The thickness of the specimen shall be measured in accordance with Test Method A of Practice D 3767.

## 6. Test Specimens

6.1 The test may be performed either on rubber products or on standard test specimens, as specified.

NOTE 1—Comparable results are obtained only when tests are made on specimens of exactly the same size and shape, tested to the same percentage deflection, or tested under the same force.

6.2 Standard test specimens shall be  $28.6 \pm 0.1$  mm ( $1.129 \pm 0.005$  in.) in diameter ( $650 \text{ mm}^2$  ( $1.000 \text{ in.}^2$ ) in area) and  $12.5 \pm 0.5$  mm ( $0.49 \pm 0.02$  in.) in thickness, from which all molded surface layers have been removed.

## 7. Preparation of Specimens

7.1 The standard test specimens may be prepared as follows: A slab approximately 13 mm (0.51 in.) in thickness may be cut from a product or may be molded from the same compound used in the preparation of the product and ground on both sides to obtain smooth parallel surfaces and the standard thickness of  $12.5 \pm 0.5$  mm ( $0.49 \pm 0.02$  in.). The grinding shall be carried out as prescribed in Section 5 of Practice

<sup>1</sup> 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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<sup>2</sup> *Annual Book of ASTM Standards*, Vol 09.01.

<sup>3</sup> *Annual Book of ASTM Standards*, Vol 03.01.

D 3183 and shall be done without overheating the rubber. The specimens may then be cut from the slabs by means of a suitable rotating hollow cutting tool similar to that illustrated in Fig. 1. In cutting the specimen, the die shall be suitably rotated in a drill press or similar device and lubricated with soapy water so that a smooth-cut surface having square edges is obtained. The cutting pressure shall be kept sufficiently low to avoid “cupping” of the cut surface.

NOTE 2—The cutting tool is larger in diameter than the specimen to allow for cutting pressure.

7.2 When rubber products are subjected to these tests, the surfaces that will contact the platens of the testing machine shall be cleaned of any dust, bloom, grease, or other foreign material. Grinding is not required because tests on products are intended to be nondestructive.

**8. Test Conditions**

8.1 The temperature of the testing room shall be maintained at  $23 \pm 2^\circ\text{C}$  ( $73.4 \pm 3.6^\circ\text{F}$ ). The specimens to be tested shall be kept in this room for at least 3 h prior to the time of testing. Specimens that have compression properties affected by atmospheric moisture shall be conditioned in an atmosphere controlled to  $50 \pm 6\%$  relative humidity for at least 24 h.

*Test Method A—Compression Test at Specified Deflection*

**9. Nature of Test**

9.1 In this test method the compressive forces are applied and removed in three successive cycles. The first two cycles are for the purpose of conditioning the specimen, and the readings are taken during the third application of force.

**10. Procedure**

10.1 After measuring the thickness of the test specimen, place the specimen between the platens of the testing machine. Place sheets of sandpaper<sup>4</sup> between the rubber surfaces and the testing machine platens. The sandpaper resists lateral slippage of the rubber at the contact surfaces and should be slightly larger than the specimen. Omit the sandpaper when the surface of the specimen is bonded to metal.

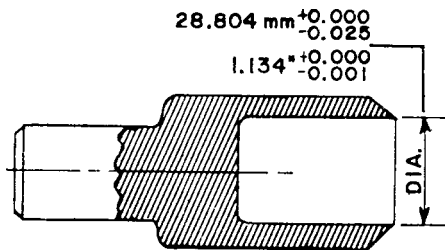


FIG. 1 Cutting Tool

10.2 Apply the force to produce a deflection rate of  $12 \pm 3$  mm/min ( $0.5 \pm 0.1$  in./min) until the specified deflection is reached, after which release the force immediately at the same rate. Repeat this loading cycle a second time. Apply the force

a third time until the specified deflection is again reached. Read and record the force required.

10.3 If desired, the machine may be stopped at intervals of 5% deflection during the third application and the force recorded for each deflection so that a stress-strain curve may be drawn.

10.4 Deflection percentage shall be based on the thickness of the specimen prior to the first force application.

10.5 Report the median of values taken from three specimens.

*Test Method B—Compression Test at Specified Force*

**11. Nature of Test**

11.1 This test is intended for rapid testing with a constant force type of machine, although it can be performed on the other machines described in 5.1. Because speed with reasonable accuracy is desired, a single force application cycle is used.

**12. Procedure**

12.1 Apply a specified minor mass or force for a period long enough to adjust the deflection gage, after which apply the major force for 3 s. Read the deflection on the dial gage at the end of the 3-s period. The reading shall not include any deflection caused by the minor force. Calculate the percent deflection on the basis of the original thickness of the specimen.

12.2 Report the median of values taken from three specimens.

**13. Report**

13.1 Report the following information:

13.1.1 Deflection expressed as a percentage of the original thickness of the specimen,

13.1.2 Force in kilopascals or pounds-force per square inch, based on original cross section,

13.1.3 Description of sample and type of test specimen, including dimensions,

13.1.4 Description of test method and apparatus, and

13.1.5 Date of test.

**14. Precision and Bias<sup>5</sup>**

14.1 This precision and bias section has been prepared in accordance with Practice D 4483. Refer to Practice D 4483 for terminology and other statistical calculation details.

14.2 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 this section. 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 are included in this test method.

<sup>5</sup> The full details and test results of the interlaboratory test program used for this precision section are contained in RR: D11-1058, available from ASTM Headquarters.

<sup>4</sup> 400 Grit waterproof sandpaper has been found satisfactory.

14.3 Two separate precision programs were conducted for this test method, one in 1983 and a second in 1989.

14.3.1 A Type 1 (interlaboratory) precision was evaluated in both programs. Both repeatability and reproducibility are short term; a period of a few days separates replicate test results. A test result is the value, as specified by this test method, obtained on a single determination(s) or measurement(s) of the property or parameter in question. The third deflection cycle is used for the measurement. For the 1983 program, three different materials were used; these were tested in three laboratories on two different days.

14.4 For the 1989 program seven materials were tested in nine laboratories on two separate days.

14.4.1 The results of the precision calculations for repeatability and reproducibility are given in Tables 1-4, in ascending order of material average or level, for each of the materials evaluated. Table 1 and Table 2 are for the 1983 program (No. 1), and Table 3 and Table 4 are for the 1989 program (No. 2).

14.5 The precision of this test method may be expressed in the format of the following statements that use an "appropriate value" of  $r$ ,  $R$ ,  $(r)$ , or  $(R)$ , to be used in decisions about test results. The appropriate value is that value of  $r$  or  $R$  associated with a mean level in the precision tables closest to the mean level under consideration at any given time for any given material in routine testing operations.

14.6 *Repeatability*—The repeatability,  $r$ , of this test method has been established as the appropriate value tabulated in the precision tables. 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 non-identical sample populations.

14.7 *Reproducibility*—The reproducibility,  $R$ , of this test method has been established as the appropriate value tabulated in precision tables. 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 non-identical sample populations.

14.8 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  $(R)$

**TABLE 1 Program 1, 1983 Precision,<sup>A</sup>  
Type 1 Precision—Method A (kPa)<sup>B</sup>**

NOTE 1— $Sr$  = repeatability standard deviation, in measurement units,  $r$  = repeatability, in measurement units,  $(r)$  = repeatability, (relative) percent,  $SR$  = reproducibility standard deviation, in measurement units,  $R$  = reproducibility, in measurement units, and  $(R)$  = reproducibility (relative) percent.

Material	(kPa) Average Level	Within Laboratories			Between Laboratories		
		$Sr$	$r$	$(r)$	$SR$	$R$	$(R)$
No. 3 Cl-Butyl	1106	28.2	79.8	7.2	40.4	114	10.3
No. 2 EPDM	1731	92.8	263	15.2	69.3	196	11.3
No. 1 SBR	1746	41.5	117	6.7	77.3	219	12.5
Pooled (average) values	1528	60.9	172	11.3	64.3	182	11.9

<sup>A</sup>Three laboratories participating.

<sup>B</sup>kPa = psi × 6.89.

**TABLE 2 Program 1, 1983 Precision,<sup>A</sup>  
Type 1 Precision—Method B (% DEF)**

NOTE 1— $Sr$  = repeatability standard deviation, in measurement units,  $r$  = repeatability, in measurement units,  $(r)$  = repeatability, (relative) percent,  $SR$  = reproducibility standard deviation, in measurement units,  $R$  = reproducibility, in measurement units, and  $(R)$  = reproducibility (relative) percent.

Material	Average Level,%	Within Laboratories			Between Laboratories		
		$Sr$	$r$	$(r)$	$SR$	$R$	$(R)$
No. 1 SBR	36.0	1.11	3.14	8.7	1.38	3.91	10.9
No. 2 EPDM	37.1	1.16	3.28	8.9	2.57	7.27	19.7
No. 3 Cl-Butyl	43.7	0.78	2.20	5.1	2.03	5.74	13.2
Pooled (average) values	38.9	1.03	2.91	7.5	2.05	5.80	14.9

<sup>A</sup>Three laboratories participating.

**TABLE 3 Program 2, 1989 Precision,<sup>A</sup>  
Type 1 Precision—Method A (kPa)<sup>B</sup>**

NOTE 1— $Sr$  = repeatability standard deviation, in measurement units,  $r$  = repeatability, in measurement units,  $(r)$  = repeatability, (relative) percent,  $SR$  = reproducibility standard deviation, in measurement units,  $R$  = reproducibility, in measurement units, and  $(R)$  = reproducibility (relative) percent.

Material	Average Level, kPa	Within Laboratories			Between Laboratories		
		$Sr$	$r$	$(r)$	$SR$	$R$	$(R)$
NR/RSS	836	20.8	58.9	7.0	74.4	211	25.2
CR	1012	14.8	41.9	4.1	72.7	206	20.3
SBR	1528	18.5	52.4	3.4	59.1	167	11.0
IIR	1564	18.8	53.2	3.4	120	340	21.7
IR	1694	40.4	114	6.8	79.2	224	13.2
EPDM	2218	45.1	128	5.8	179	507	22.8
SIR 20	2591	62.0	175	6.8	206	583	22.5
Pooled (average) values	1636	36.2	102	6.3	118.5	335	20.5

<sup>A</sup>Nine laboratories participating.

<sup>B</sup>kPa = psi × 6.89.

statements, the difference in the two single test results is expressed as a percentage of the arithmetic mean of the two test results.

14.9 The user of this test method should give greater emphasis to Program 2 (1989) precision results. This 1989 program was substantially more comprehensive and the results are more typical of the current status of this test method.

14.10 *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 this test method. Bias, therefore, cannot be determined.

## 15. Keywords

15.1 compression; compression deflection characteristics; compression test at specified deflection; compression test at specified force; compression testing of rubber; compressive force; constant force; deflection; hysteresis; rubber in compression;

**TABLE 4 Program 2, 1989 Precision,<sup>A</sup>  
Type 1 Precision—Method B**

NOTE 1— $Sr$  = repeatability standard deviation, in measurement units,  
 $r$  = repeatability, in measurement units,  
 $(r)$  = repeatability, (relative) percent,  
 $SR$  = reproducibility standard deviation, in measurement units,  
 $R$  = reproducibility, in measurement units, and  
 $(R)$  = reproducibility (relative) percent.

Material	Average Level, %	Within Laboratories			Between Laboratories		
		$Sr$	$r$	$(r)$	$SR$	$R$	$(R)$
SIR 20	6.89	0.207	0.59	8.5	0.597	1.69	24.5
EPDM	8.90	0.246	0.70	7.8	0.658	1.86	20.9
IIR	9.42	0.252	0.71	7.6	1.50	4.24	45.0
IR	10.7	0.218	0.62	5.8	0.711	2.01	18.8
SBR	11.6	0.237	0.67	5.8	1.62	4.59	39.4
CR	17.3	0.433	1.23	7.1	1.35	3.83	22.2
NR/RSS	20.6	0.561	1.59	7.7	1.66	4.71	22.8
Pooled (average) values	12.4	0.334	0.94	7.6	1.27	3.60	29.1

<sup>A</sup>Nine laboratories participating.

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