Designation: D 623 – 99

Standard Test Methods for Rubber Property—Heat Generation and Flexing Fatigue In Compression[1]

This standard is issued under the fixed designation D 623; 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 may be used to compare the fatigue characteristics and rate of heat generation of different rubber vulcanizates when they are subjected to dynamic compressive strains.

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 395 Test Methods for Rubber Property—Compression Set[2]

D 1349 Practice for Rubber—Standard Temperatures for Testing[2]

D 3182 Practice for Rubber—Materials, Equipment, and Procedures for Mixing Standard Compounds and Preparing Standard Vulcanized Sheets[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 The test consists of subjecting a specimen of rubber of definite size and shape to rapidly oscillating compressive stresses under controlled conditions. Although heat is generated by the imposed oscillating stress, the more convenient parameter, the temperature rise, is measured. The measured temperature rise is one of two types: (*1*) to an equilibrium temperature or (*2*) the rise in a fixed time period. Additional measured performance properties are the degree of permanent set or other specimen dimensional changes, or both, and for certain test conditions, the time required for a fatigue failure by internal rupture or blow out.

3.2 Two test methods are covered, using the following different types of apparatus:

3.2.1 *Test Method A*— Goodrich Flexometer.

3.2.2 *Test Method B*— Firestone Flexometer.

4. Significance and Use

4.1 Because of wide variations in service conditions, no correlation between these accelerated tests and service performance is given or implied. However, the test methods yield data that can be used to estimate relative service quality of different compounds. They are often applicable to research and development studies.

5. Preparation of Sample

5.1 The sample may consist of any vulcanized rubber compound except those generally classed as hard rubber, provided it is of sufficient size to permit preparation of the test specimen required for the test method to be employed. The sample may be prepared from a compound mixed experimentally in the laboratory or taken from process during manufacture, or it may be cut from a finished article of commerce.

5.2 If prepared in the laboratory, the procedure should preferably be essentially as specified in Practice D 3182, except that when vulcanization is required, the sample should preferably be molded in block form of sufficient size to permit cutting of the required test specimens rather than in the form of the standard test slab.

5.2.1 The direct molding of the specimen for Test Method A is allowed (see 9.4) but is not recommended because the quality of the test specimen is affected more by the method and the care used in the preparation of the raw stock for the molding than it is when a large block is molded.

5.3 Samples from commercial articles shall consist of a piece slightly larger than the required test specimen and shall subsequently be cut or buffed to size.

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[1] These test methods are under the jurisdiction of ASTM Committee D-11 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.

5.4 Comparison of results shall be made only between specimens of identical size and shape.

TEST METHOD A—GOODRICH FLEXOMETER[3]

6. Nature of Test

6.1 In this test method, which uses the Goodrich Flexometer, a definite compressive load is applied to a test specimen through a lever system having high inertia, while imposing on the specimen an additional high-frequency cyclic compression of definite amplitude. The increase in temperature at the base of the test specimen is measured with a thermocouple to provide a relative indication of the heat generated in flexing the specimen. Specimens may be tested under a constant applied load, or a constant initial compression. The change in height of the test specimen can be measured continuously during flexure. By comparing this change in height with the observed permanent set after test, the degree of stiffening (or softening) of the test specimen may be estimated. Anisotropic specimens may be tested in different directions producing measurable differences in temperature rise due to the anisotropy.

7. Apparatus

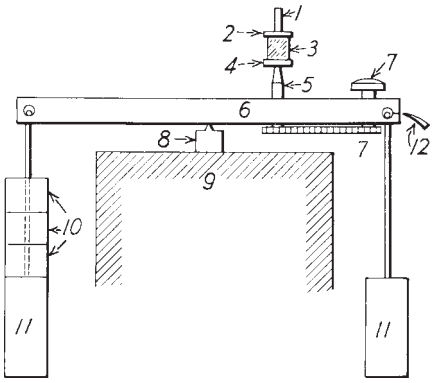
7.1 The essential parts of the apparatus are shown in Fig. 1. The test specimen is placed between anvils faced with inserts of a black NEMA Grade XX Paper-Phenolic, for heat-insulation purposes. The top anvil or hammer is con-nected to an adjustable eccentric usually driven at 30 ± 0.2 Hz (1800 rpm). The load is applied by means of a lever resting on a knife edge. The moment of inertia of the lever system is increased, and its natural frequency reduced, by suspending masses of approximately 24 kg (53 lb) at each end of the lever system. The lower anvil may be raised or lowered relative to the lever by means of a calibrated micrometer device. This device permits the lever system to be maintained in a horizontal position during the test as determined by a pointer and a reference mark on the end of the bar. The increase in temperature at the base of the specimen is determined by means of a thermocouple placed at the center of the bottom anvil.

7.2 The machine may be equipped with a well-insulated oven to permit running at elevated temperatures.

8. Adjustment

8.1 Locate the machine on a firm foundation. Adjust the leveling screws in the base to bring the machine into a level position in all directions at a point just to the rear of the fulcrum of the loading lever. With the loading lever locked in place with the pin, place a level on the lever bar and verify the level setting.

8.2 Adjust the eccentric to give a stroke of 4.45 ± 0.03 mm (0.175 ± 0.001 in.) (Note 1). This is best accomplished by means of a dial micrometer resting on either the cross bar of the upper anvil or by means of adapters attached to the loading arm of the eccentric.



1—Connection to eccentric which drives top anvil.
2—Top anvil.
3—Test specimen.
4—Lower anvil.
5—Support for lower anvil.
6—Lever through which load is applied.
7—Calibrated micrometer device.
8—Knife-edge.
9—Supporting base.
10—Test load.
11—Inertia mass of 24 kg (53 lb).
12—Pointer and reference mark for leveling of lever.

FIG. 1 Goodrich Flexometer

NOTE 1—The 4.45-mm (0.175-in.) stroke is selected as the standard for calibration purposes. When strokes other than 4.45 mm (0.175 in.) are to be used, the displacement of the lower anvil should be maintained within the tolerance specified for its height above the loading lever. The tolerance for all stroke settings shall be ±0.03 mm (±0.001 in.).

8.3 Raise the top anvil as far as the eccentric will permit by its rotation. Place a calibrating block (Note 2) 25.40± 0.01 mm (1.000 ± 0.0005 in.) in height on the lower anvil. Raise the anvil by means of the micrometer until the bottom side of the metal cup holding the thermocouple is 67 ± 3 mm (2⅝ ± ⅛ in.) above the top of the loading lever. The loading lever is to be in the locked position. Adjust the cross bar of the upper anvil, maintaining a parallel setting with the lower anvil and a firm contact with the calibrating block. The micrometer should now be set at zero. This may require disengagement of the gear train nearest the vernier scale of the micrometer. Remove the calibrating block and recheck the stroke for a 4.45-mm (0.175-in.) setting. Set the pointer on the mark on the end of the lever bar to mark the level position.

NOTE 2—A suitable block may be made from brass having a diameter of 17.8 mm (0.7 in.). The end to be placed on the lower anvil should be counterbored for clearance of the thermocouple disk.

8.4 Remove the locking pin from the loading lever and gently oscillate the lever system to determine the point of rest. If the bar does not come to rest in approximately the level position, slowly return it to its level position and release. If the movement from the level position is observed, add or remove a slight amount of weight to the required inertia weight to obtain a balance.

8.5 The rate of cyclic compression, usually 30 ± 2 Hz (1800 ± 10 rpm) is maintained by means of the adjustable shive or shives for the V-belt drive.

8.6 A Type J (IC) couple using 0.40 mm (0.0159 in.) wire is centered in the face of the lower anvil. The black NEMA Grade

[3] Lessig, E. T., *Industrial and Engineering Chemistry,* IENAA, Analytical Edition, Vol 9, 1937, pp 582-588.

XX Paper-Phenolic face is backed up with a hard rubber disk. The thermocouple may be connected either to a recorder or indicating potentiometer. A minimum of 100 mm (4 in.) of wire shall be retained in the oven when used at elevated temperatures.

8.7 A suitable oven for measurements at elevated temperatures may be purchased with the machine or constructed. The inside dimensions should be approximately 100 mm (4 in.) in width, 130 mm (5 in.) in depth, and 230 mm (9 in.) high. The top of the floor of the oven shall be 25.4 ± 2.5 mm (1.0 ± 0.1 in.) above the loading lever.

8.8 The air circulation is to be maintained by a squirrel-cage type blower 75 mm (3 in.) in diameter. The air intake should have a diameter of approximately 59 mm (2 5⁄16 in.). The scroll opening for the air discharge shall be 38 mm (1½ in.) by 44 mm (1¾ in.). A motor capable of maintaining a constant rpm under load between 25.8 and 28.3 Hz (1550 and 1700 rpm) shall be used for the blower. A platform shall be provided in the base of the oven on which the specimens may be placed for conditioning. Such a platform can suitably be obtained from 6-mm (¼-in.) wire screen netting supported at least 9 mm (⅜ in.) above the floor of the oven.

8.9 A thermocouple of a matching type as that used in the lower anvil shall be used for measuring the ambient air temperature. It shall be located approximately 6 to 9 mm (¼ to ⅜ in.) to the rear of the upper and lower anvils and slightly right of center. The sensing point should be at a point about midway between the anvils. A minimum 100 mm (4 in.) of wire should be retained within the oven.

8.10 A thermostatic control shall be capable of main-taining a ambient air within ±1.1°C (2°F) of the set point.

9. Test Specimen

9.1 The test specimen as prepared from vulcanized rubber shall be cylindrical in shape, having a diameter of 17.8 ± 0.1 mm (0.700± 0.005 in.) and a height of 25 ± 0.15 mm (1.000 ± 0.010 in.).

9.2 The standard test specimen shall be cut from a laboratory slab, prepared in accordance with Practice D 3182. The cured thickness shall be such that buffing is not required.

9.3 The circular die used for cutting the specimen shall have an inside diameter of 17.78 ± 0.03 mm (0.700 ± 0.001 in.). In cutting the specimen the die shall be suitably rotated in a drill press or similar device and lubricated by means of a soap solution. A minimum distance of 13 mm (½ in.) shall be maintained between the cutting edge of the die and the edge of the slab. The cutting pressure shall be as light as possible to minimize cupping or taper in the diameter of the specimen.

9.4 An optional test method of preparing the test specimen may be the direct molding of the cylinder.

NOTE 3—It should be recognized that an equal time and temperature if used for both the slab and molded specimen will not produce an equivalent state of cure in the two types of specimen. A "tighter" cure will be obtained in the molded specimen. Adjustments, preferably in the time of cure, must be taken into consideration if comparisons between the two types of specimen are to be considered valid.[4]

NOTE 4—It is suggested, for purposes of uniformity and closer tolerances in the molded specimen, that the dimensions of the mold be specified and shrinkage compensated for therein. A plate cavity 25.78 ± 0.05 mm (1.015 ± 0.002 in.) in thickness and 18.00 ± 0.05 mm (0.709 ± 0.002 in.) in diameter, with overflow cavities both top and bottom when combined with two end plates will provide one type of a suitable mold.

9.5 Samples from a manufactured article shall consist of a piece slightly larger than the required test specimen and shall subsequently be cut or buffed to size.

10. Recommended Test Conditions

10.1 Recommended load on the specimen is given in Table 1.

10.2 The stroke may be varied to provide a satisfactory test condition in respect to the load. The recommended strokes are 4.45 mm (0.175 in.), 5.71 mm (0.225 in.), and 6.35 mm (0.250 in.).

10.3 Under certain conditions, the machine may be operated at room temperature. Precautions must be taken, however, to return the base thermocouple to equilibrium and to maintain a uniform room temperature throughout the duration of the complete test. The oven shall be removed when testing at room temperature.

10.4 Tests conducted at 50°C (122°F) and 100°C (212°F) are recommended.

11. Control Compound

11.1 The performance of a properly constructed and adjusted machine is best assured by results obtained from a control compound. The following recipe (D 623–1A) offers one such compound:

SBR-1500	100
Zinc oxide French process	5
Carbon black N330 (HAF)	45
Stearic acid	1
TMTD	3

11.2 Mixing and curing shall be in accordance with Practice D 3182. Either a mill mix or a Size B Banbury may be used. Cure 50 min at 150°C (302°F).

11.3 The ΔT value at 4.45-mm (0.175-in.) stroke, 244.6 N (55 lbf), and an ambient temperature of 100°C (212°F) should be 26.7 ± 1.1°C (48 ± 2°F).

[4] Conant, F. S., Svetlik, J. F., Juve, A. E., "Equivalent Cures in Specimens of Various Shapes" *Rubber World*, RUBWA, March, 1958; *Rubber Age*, RUAGA, March, 1958; *Rubber Chemistry and Technology*, RCTEA, July-Sept. 1958.

TABLE 1 Recommended Load on Specimen

NOTE 1—For calculation of masses, the long arm is 288.3 mm (11.35 in.) and the shorter arm 127.0 mm (5.0 in.).

Load on Beam		Load on Specimen		Unit Load on Specimen	
N	lbf	N	lbf	kPa	psi
70.5 ± 0.2	15.86 ± 0.03	160	36	644	93.54
108.0 ± 0.2	24.23 ± 0.03	245	55	990	142.91
216.0 ± 0.2	48.46 ± 0.03	489	110	1970	285.83

12. Procedure

12.1 Check the machine for proper adjustment and the required test conditions. Place the necessary weights on the rear hanger to give the desired load.

12.2 If a stroke other than 4.45 mm (0.175 in.) used in adjusting the machine (8.2) is desired, then a new zero setting will be required on the micrometer after adjusting the eccentric to the new stroke. Proceed as outlined in 8.2 to obtain the zero setting.

12.3 For elevated temperatures requiring the use of the oven, allow a minimum of 2 h for preheating and equilibrium prior to start of the test. Maintain the lower anvil at the zero setting, that is, 67 mm (2 ⅝ in.) above the loading lever (8.1) during the conditioning period.

12.4 Measure and record the height of the specimen. Measure and record the indentation hardness. When the oven is to be used, place the specimen in the oven on the platform, with the small end of the cut specimen down. Condition for a minimum of 20 min before the start of the test.

12.5 Before starting the test, equilibrium of the lower platen temperature with the ambient should be assured. With the upper anvil or cross bar in its highest position, lower the bottom anvil and quickly position the specimen thereon, inverting its position from that used during the warm-up period.

12.6 Raise the lower anvil by means of the micrometer until a firm contact is established with the upper anvil or hammer. Remove the locking pin and apply the load. Then advance the micrometer until the beam is again restored to its original level condition as determined by the indicator.

12.7 If the specimen had an original height of exactly 25.4 mm (1.000 in.), then the micrometer reading may be used without correction for the compression height.

12.8 When the original height of the specimen is less than 25.4 mm (1.000 in.), then the difference shall be subtracted from the micrometer reading. For a specimen greater than 25.4 mm (1.000 in.) in height, the difference shall be added to the micrometer reading.

12.9 For a smooth start, restore the pin to the locked position of the loading lever, and back off the micrometer three to four turns. Then loosen the pin, start the machine, and remove the pin completely. Immediately restore the beam to the level position by means of the micrometer and record the reading. Subject this reading to the same corrections as used for the static measurements. **Caution**—If the initial running deflection is less than one half of the impressed stroke or does not exceed this value within 1 or 2 min of the start, an unreliable and misleading heat rise will be obtained. The loading lever must be maintained in a level position throughout the test.

12.10 The ambient air temperature and the temperature of the lower anvil shall be at the steady state before starting the test.

NOTE 5—The thermocouple in the lower anvil will stabilize at a temperature approximately 5.6°C (10°F) lower in an oven ambient of 100°C (212°F). This is the base temperature above which the heat rise or ΔT is measured. Any momentary drop in the base temperature at the start of the test is to be disregarded.

12.11 If a recorder is not used to obtain a continuous heat rise curve, then obtain a series of measurements using a suitable potentiometer. Plot the readings and draw the heat rise curve.

12.12 The test is usually terminated after 25 min at which time the ΔT or temperature rise is determined.

12.13 Remove the specimen from the machine and allow to cool at room temperature for 1 h. Measure the height and calculate the permanent set in accordance with Method A of Test Methods D 395.

13. Report

13.1 The report shall include the following:
13.1.1 Condition of test,
13.1.2 Ambient temperature,
13.1.3 Thermocouple base temperature,
13.1.4 Length of stroke,
13.1.5 Static load, kPa (psi),
13.1.6 Conditioning time,
13.1.7 Date of test,
13.1.8 Indentation hardness,
13.1.9 Initial height of specimen,
13.1.10 Static compression percent,
13.1.11 Flexing compression at start and end of test,
13.1.12 Running time,
13.1.13 Temperature rise, ΔT,
13.1.14 Recovered height, and
13.1.15 Compression set.

TEST METHOD B—FIRESTONE FLEXOMETER[5]

14. Nature of Test

14.1 In this test method, which uses the Firestone Flexometer, a rotary motion is applied to one end of a test specimen held under a constant compression load, and the time required for a definite change in height of the test specimen is determined.

15. Apparatus

15.1 The apparatus is illustrated in Fig. 2. The speed of oscillation of the oscillating plate shall be constant at 13.3 Hz (800 cycles per minute), but the compression load and the magnitude of the oscillation may be varied over a wide range. The oscillating and loading plates are equipped with center inserts of wood, 76.2 mm (3 in.) in diameter and 12.7 mm (0.50 in.) in thickness.

16. Precautions

16.1 Take care that only well-molded blocks are used and that the machine is correctly set each time. If these two precautions are taken, consistent results will be obtained. The machine is not intricate in design or movement, yet it can readily be used for a wide variety of tests.

17. Test Specimen

17.1 The laboratory test specimen shall be in the shape of a frustum of a rectangular pyramid and shall have the following

[5] Cooper, L. V., *Industrial and Engineering Chemistry,* IENAA, Analytical Edition, Vol 5, 1933, pp. 350–351.

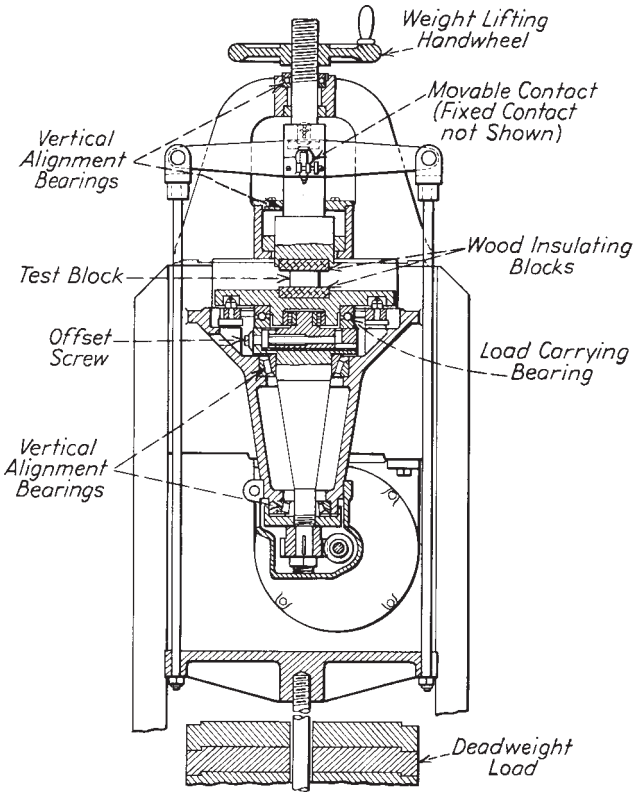


FIG. 2 Firestone Flexometer

dimensions: base, 54 by 28.6 mm (2.125 by 1.125 in.); top, 50.8 by 25.4 mm (2 by 1 in.); and altitude, 38.1 mm (1.50 in.). This tapered shape permits the preparation of perfect specimens from any type of stock. Test specimens of cured articles may be cut into any suitable size and shape, provided a similar specimen of a known control may be prepared.

18. Procedure

18.1 Set the oscillating plate on dead center and bring to a definite starting temperature. See Practice D 1349.

18.2 Place the test specimen on the oscillating plate, directly under the loading plate and between the wood inserts in the plates. The wood inserts act as heat insulators, and tend to hold all generated heat in the test specimen.

18.3 Apply the load to the test specimen by turning the hand wheel on top until the load is carried by the block and not by the thrust bearing on the wheel.

18.4 Measure the height of the block after applying the load and calculate the deflection.

18.5 Set the oscillating plate the desired amount off center, distorting the test specimen so that it resembles the frustum of a sloping rectangular pyramid. The diameter of the circle described by the lower plate while in motion is designated as the "throw."

18.6 Adjust the electrical bell-ringing contacts so that they are a definite distance apart.

NOTE 6—This initial contact opening is called "signal distance." As the block is deflected under the testing conditions, the upper contact is carried downward toward the lower contact, because the load, which is a dead weight, continues to rest on the yielding block. This downward movement has been found by many tests to be a definite criterion of the condition of the center of the block. In other words the signal distance, at the time porosity began, was the same for all blocks of similar composition. Should the test be continued sufficiently long, the block will actually blow out, or shatter to pieces, and it is to prevent this actual destruction that the yield distance of slight porosity is used.

18.7 Start the test and measure its duration from the time the circular motion is started until the bell rings. The bell does not ring until the test block has been deformed sufficiently to allow the electrical contact to close.

19. Report

19.1 The report of the results of test by either Test Method A or B shall include the following:

19.1.1 The value of all variables in the test method such as speed of testing, vertical and horizontal loads, and air or oven temperatures.

19.1.2 All measured results such as changes in temperature of the test specimen, changes in static or dynamic compression, and time to end point, and all other pertinent observations.

20. Precision and Bias [6]

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

20.2 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 below. 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.

20.3 Two Type 1 precision programs were conducted; one in 1988 and one in 1989. Both repeatability and reproducibility are short term; a period of a few days separates replicate test results. A test result is the single value, as specified by this method, obtained on one determination or measurement of the property or parameter in question.

20.4 In the 1988 program, three different materials were used in the interlaboratory program; these were tested in six laboratories on two different days.

20.5 In the 1989 program, five materials were used; these were tested in seven laboratories on two different days.

20.5.1 The results of the precision calculations for repeatability and reproducibility are given in Table 2 and Table 3, in ascending order of material average or level, for each of the materials evaluated.

20.6 Since two programs were conducted, two sets of precision results are given. A review of Table 2 and Table 3, for the 1988 and 1989 programs respectively, will show that the precision was different for both programs. The statements given below for repeatability and reproducibility should be considered to apply to "pooled" precision values, that is, to the results of both the 1988 and 1989 programs. Both sets of

[6] The full details and test results of the interlaboratory test program used for this precision section are contained in a research report available from ASTM headquarters. Request RR:D11-1059.

TABLE 2 Type 1 Precision Evaluation Results—1988 D623 Interlaboratory Test Program (ITP) (delta–*T*, °C)[A]

	Within Laboratories				Between Laboratories		
Material	Average	*Sr*	*r*	(*r*)	*SR*	*R*	(*R*)
CPD-A	15.8	1.23	3.49	22.1	3.80	10.8	68.1
CPD-C	28.9	1.09	3.09	10.7	7.90	22.4	77.5
CPD-B	39.3	0.86	2.44	6.21	9.42	26.7	67.9
Pooled or Average Values	28.0	1.07	3.04	10.9	7.43	21.0	75.2
			% Per. Set				
Material	Average	*Sr*	*r*	(*r*)	*SR*	*R*	(*R*)
CPD-C	2.6	0.15	0.43	16.6	0.69	1.97	76.0
CPD-A	5.9	0.62	1.75	29.5	2.61	7.39	124.0
CPD-B	11.0	0.48	1.36	12.4	4.01	11.3	103.0
Pooled or Average Values	6.51	0.46	1.30	20.0	2.79	7.90	121.0

[A] *Sr* = repeatability standard deviation,
r = repeatability = 2.83 × *SR*,
(r) = repeatability as percentage of material average,
SR = reproducibility standard deviation,
R = reproducibility = 2.83 × *SR*, and
(R) = reproducibility as percentage of material average.

TABLE 3 Type 1 Precision Evaluation Results for 1989 D623 Interlaboratory Test Program (ITP) (delta–*T*, °C)[A]

	Within Laboratories				Between Laboratories		
Material	Average	*Sr*	*r*	(*r*)	*SR*	*R*	(*R*)
CPD-B	5.6	0.94	2.66	47.2	6.28	17.8	316.0
CPD-C	17.5	1.76	4.98	28.4	6.38	18.0	103.0
CPD-A	26.0	1.12	3.17	12.2	7.32	20.7	79.8
CPD-E	26.8	1.02	2.89	10.8	7.81	22.1	82.4
CPD-D	30.2	1.57	4.44	14.7	8.61	24.4	80.7
Pooled or Average Values	21.1	1.33	3.77	17.7	7.26	20.5	96.9
			% Per. Set				
Material	Average	*Sr*	*r*	(*r*)	*SR*	*R*	(*R*)
CPD-A	3.7	0.48	1.34	36.0	0.96	2.73	73.0
CPD-E	4.4	0.16	0.46	10.5	1.20	3.39	77.4
CPD-B	4.9	1.13	3.20	65.7	2.10	5.93	121.0
CPD-D	5.3	0.63	1.79	33.5	1.29	3.65	68.5
CPD-C	8.7	0.53	1.50	17.3	1.12	3.18	36.7
Pooled or Average Values	5.3	0.684	1.94	36.5	1.35	3.82	72.0

[A] See Table 2, Footnote A.

precision results are given so the user of the standard may be aware of the differences encountered. Three laboratories were common to both the 1988 and 1989 programs. The materials for the two programs were different however.

20.7 Table 4 gives details on the five compounds used in the 1989 program.

20.8 The precision of this test method may be expressed in the format of the following statements which 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.

TABLE 4 Compounds For 1989 D623 Interlaboratory Test Program (ITP)

CPD	Rubber	Black	Accel/Sulfur Levels
1 or A	SBR1500	45 N330	2.0 TMTD
2 or B	NR	35 N330	0.7 TBBS, 2.25 Sulfur
3 or C	SBR1712	69 N330	1.38 TBBS, 1.75 Sulfur
4 or D	CPD-A + 5 phr	N330	
5 or E	CPD-A + 5 phr	Oil	

20.9 *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.

20.10 *Reproducibilty*— The reproducibility, *R*, of this test method has been established as the appropriate value tabulated in the 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.

20.11 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 differences in the two single test results is expressed as a percentage of the arithmetic mean of the two test results.

20.12 *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

method since the value (of the test property) is exclusively defined by the test method. Bias, therefore, cannot be determined.

21. Keywords

21.1 rubber test; flexing; heat; compression; fatigue