



Designation: D 2084 – 95

Standard Test Method for Rubber Property—Vulcanization Using Oscillating Disk Cure Meter¹

This standard is issued under the fixed designation D 2084; 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 This test method describes the use of the oscillating disk cure meter for determining selected vulcanization characteristics of vulcanizable rubber compounds.

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 ISO 3417 is very similar to this test method. It has minor technical differences that are not considered to be significant.

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 and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 ASTM Standards:

D 1349 Practice for Rubber—Standard Temperatures for Testing²

D 3185 Test Methods for Rubber—Evaluation of SBR (Styrene-Butadiene Rubber) Including Mixtures With Oil²

D 3186 Test Methods for Rubber—Evaluation of SBR (Styrene-Butadiene Rubber) Mixed With Carbon Black or Carbon Black and Oil²

D 3187 Test Methods for Rubber—Evaluation of NBR (Acrylonitrile-Butadiene Rubber)²

D 3190 Test Methods for Rubber—Evaluation of Chloroprene Rubber (CR)²

D 4483 Practice for Determining Precision for Test Method Standards in the Rubber and Carbon Black Industries²

2.2 ISO Standard:

ISO 3417 Rubber—Measurement of Vulcanization Characteristics With the Oscillating Disk Rheometer³

¹ This test method is under the jurisdiction of ASTM Committee D-11 on Rubber and is the direct responsibility of Subcommittee D11.12 on Processability Tests.

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

³ Available from American National Standards Institute, 11 W. 42nd St., 13th Floor, New York, NY 10036.

3. Terminology

3.1 Definitions of Terms Specific to This Standard:

3.1.1 The following measurements may be taken from the curve of torque versus time (see Fig. 1).

3.1.2 *cure rate index*—measure of rate of vulcanization based on the difference between optimum vulcanization and incipient scorch time.

3.1.3 *maximum, plateau, or highest torque*—measure of stiffness or shear modulus of the fully vulcanized test specimen at the vulcanization temperature.

3.1.4 *minimum torque*—measure of the stiffness of the unvulcanized test specimen taken at the lowest point of the curve.

3.1.5 *time to incipient cure (scorch time)*—measure of the time at which vulcanization begins.

3.1.6 *time to a percentage of full cure*—measure of optimum cure based on the time to develop some percentage of the highest torque or difference in torque from the minimum.

3.1.7 *torque—for an oscillating shear cure meter*, the value measured by a torque transducer at the peak strain amplitude of the oscillating cycle.

4. Summary of Test Method

4.1 A test specimen of vulcanizable rubber compound is inserted into the cure meter test cavity and after a closure action is contained in a sealed cavity under positive pressure. The cavity is maintained at some elevated vulcanization temperature. The rubber totally surrounds a biconical disk after the dies are closed (see Fig. 2). The disk is oscillated through a small rotational amplitude (1° or 3°) and this action exerts a shear strain on the test specimen. The force required to oscillate or rotate the disk to maximum amplitude is continuously recorded as a function of time, with the force being proportional to the shear modulus (stiffness) of the test specimen at the test temperature. This stiffness first decreases as it warms up; then it increases due to vulcanization. The test is completed when the recorded torque either rises to an equilibrium or maximum value, or when a predetermined time has elapsed. The time required to obtain a cure curve is a function of the

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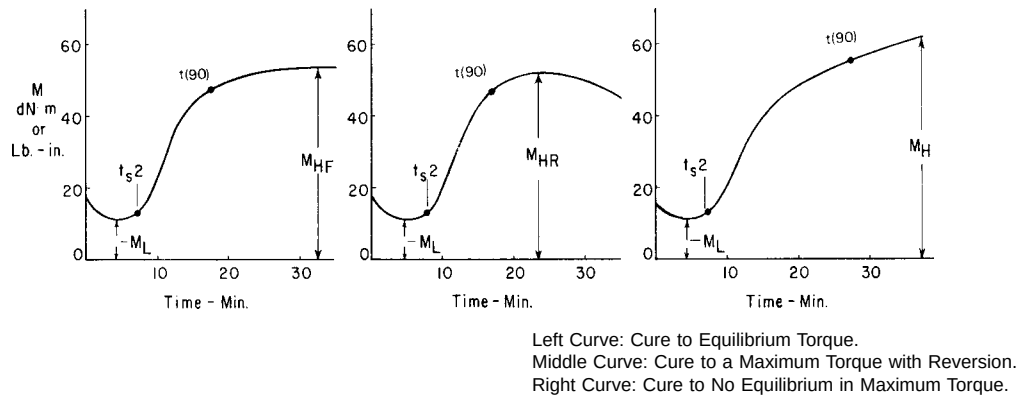


FIG. 1 Types of Cure Curve

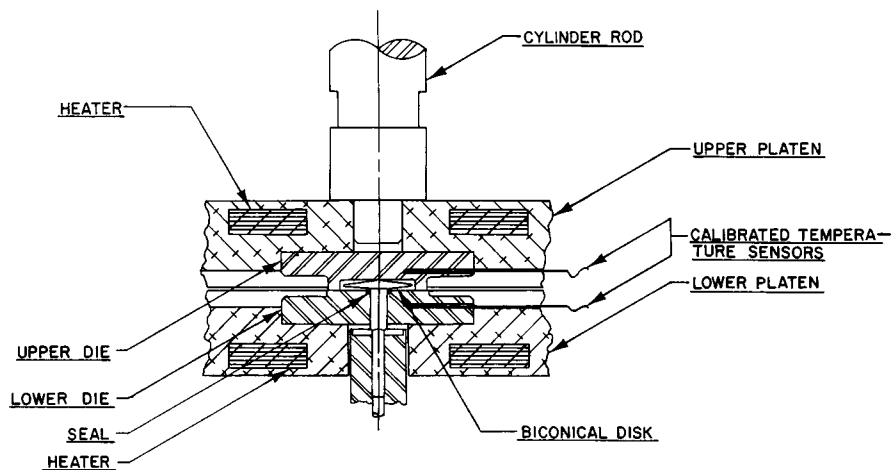


FIG. 2 Cure Meter Assembly

characteristics of the rubber compound and of the test temperature (see Fig. 1 for typical cure curves).

5. Significance and Use

5.1 This test method is used to determine the vulcanization characteristics of (vulcanizable) rubber compounds.

5.2 This test method may be used for quality control in rubber manufacturing processes, for research and development testing of raw-rubber compounded in an evaluation formulation, and for evaluating various raw materials used in preparing (vulcanizable) rubber compounds.

6. Apparatus

6.1 *Cure meter*, consists of the following major components: specimen chamber and closure mechanism, temperature control system, rotor drive and torque measuring system (see Fig. 2 for a detailed drawing of cure meter assembly).

6.2 *Specimen Chamber*—Consists of platens, dies, and a biconical disk.

6.2.1 *Platens*—Two platens made of aluminum alloy, each containing an electric heater, and each having in the center, a cavity to accommodate a die and from the side, a well for inserting a temperature sensor.

6.2.2 *Dies*—Two which form a cavity when closed and which shall be fabricated from tool steel having a minimum Rockwell Hardness HRC 50. The geometry of the standard

dies is shown in Fig. 3 and Fig. 4 with dimensions and tolerances (see Table 1). The top and bottom surfaces of the die cavity shall contain rectangularly shaped grooves arranged radially about the center and spaced at 20° intervals. Each die shall have a well or hole drilled from the side to accommodate a temperature sensor inserted through the platen. The lower dies shall have a hole in the center to allow for the insertion of the disk shaft. A suitable low-friction seal shall be provided in this hole to prevent material leaking from the cavity.

6.2.3 *Disk*—The biconical disk (see Fig. 5) shall be fabricated from tool steel having a minimum Rockwell Hardness of HRC 50. The disk shall be fitted with a stem that fits into the torque shaft. The disk is shown in Fig. 5 (see Table 2).

6.2.3.1 Disk wear will affect test results. A disk worn to such an extent that the disk diameter is less than the minimum diameter shown in this procedure shall not be used.

6.2.3.2 The standard frequency of the rotary oscillation of the disk shall be constant at 1.7 Hz (100 cpm). Other frequencies may be used, if required.

6.2.3.3 A rotary drive system shall be provided for oscillatory rotation of the disk. The amplitude of oscillation of the unloaded disk shall be constant at $\pm 1.00^\circ$ with a tolerance of $\pm 0.03^\circ$ about the center position, that is, a total amplitude of 2° . Other amplitudes may be used, if specified.

NOTE 1—Where the effect of surface contamination on the disk is not

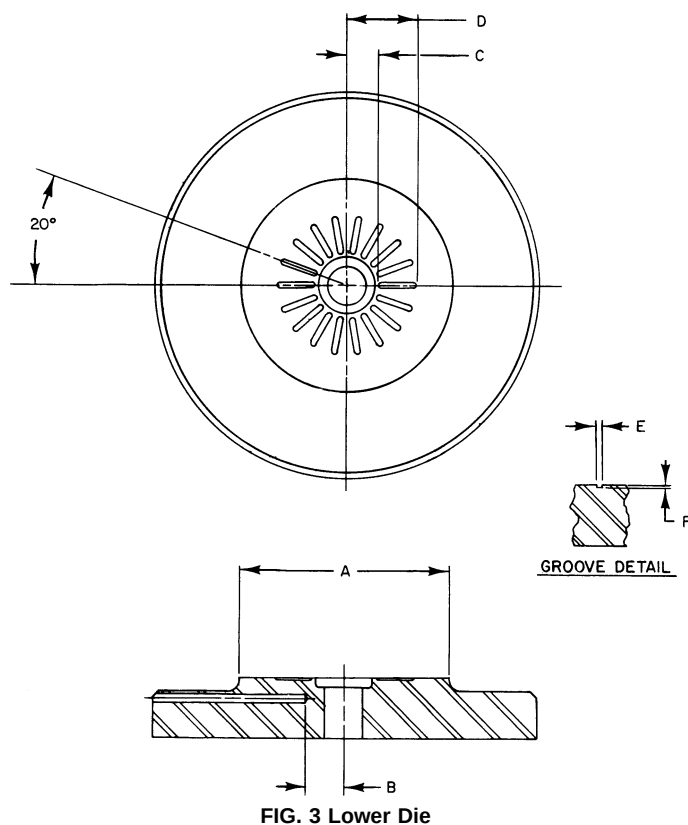


FIG. 3 Lower Die

a problem, greater sensitivity in determining curing characteristics may be obtained using $\pm 3^\circ$ angle of oscillation.

6.2.4 Die Closing Mechanism—A pneumatic cylinder or other device shall close the dies and hold them closed during the test with a force of 11.0 ± 0.5 kN (2500 ± 100 lbf).

NOTE 2—The manufacturer recommends the source air pressure be adjusted to 345 kPa (50 psi). Provisions are made for this adjustment in the instrument. Therefore, 345 kPa acting on the instrument's 203-mm (8-in.) diameter air cylinder will produce a force of 11 kN (2500 lbf) on the die per the following equation:

$$F = P \left(\frac{\pi D^2}{4} \right) \quad (1)$$

where:

F = closure force on die,

P = source air pressure, and

D = diameter of piston in pneumatic cylinder.

To calculate maximum cavity pressure, the effect of this force acting on the surface area of the upper die may be calculated per the following equation:

$$P_c = \frac{4F}{\pi d^2} \quad (2)$$

where:

P_c = pressure on sample in upper die cavity, and

d = diameter of upper die cavity (55.9 mm (2.2 in.)).

$$\begin{aligned} \text{(For example, } P_c &= \left(P_c \right. \\ &= \frac{(4)(2500)}{(3.14)(2.2)^2} \\ &= \frac{10\,000}{(3.14)(4.84)} \end{aligned}$$

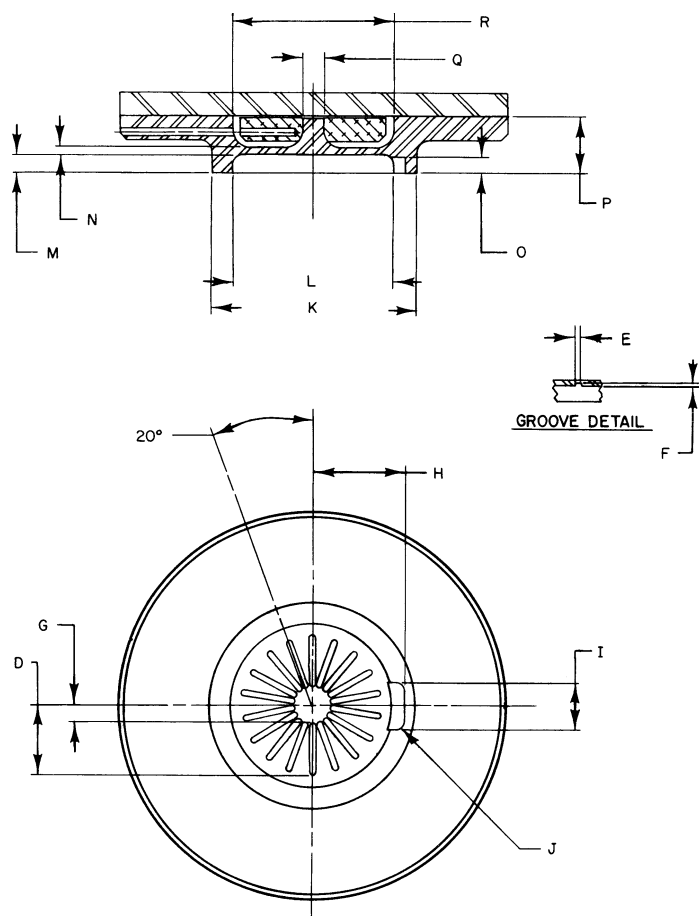


FIG. 4 Upper Die

TABLE 1 Die Dimensions

Code	Dimension, mm	Tolerance, mm
A	55.88	± 0.13
B	10.64	± 0.25
C	7.94	± 0.13
D	18.26	± 0.13
E	1.57	± 0.13
F	0.8	± 0.1
G	4.76	± 0.13
H	24.07	± 0.06
I	12.70	± 0.40
J	2.38	± 0.40
K	54.61	± 0.05
L	41.91	± 0.03
M	5.35	± 0.01
N	1.65	± 0.03
O	4.57	± 0.13
P	15.38	± 0.03
Q	5.08	± 0.05
R	41.91	± 0.03

$$\begin{aligned} &= \frac{10\,000}{12.06} \\ &= 829 \text{ psi.} \end{aligned} \quad (3)$$

6.3 Temperature Controlling System—A temperature controller shall be provided for maintaining the dies within $\pm 0.5^\circ\text{C}$ ($\pm 1^\circ\text{F}$) of the specified test temperature.

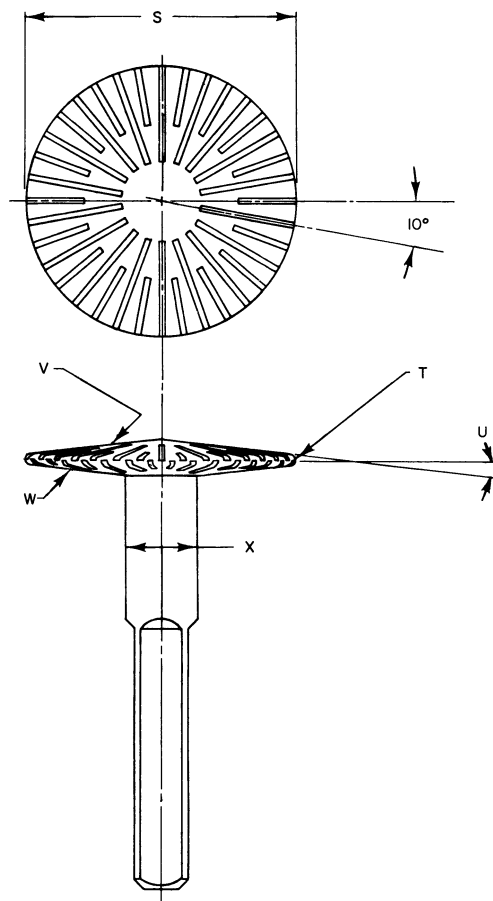


FIG. 5 Biconical Disk

TABLE 2 Disk Dimensions

	Code	Dimension, mm	Tolerance, mm
S	Diameter	35.55	± 0.01
T	Radius	0.80	± 0.03
U		6.28°	$\pm 0.08^\circ$
V ^A	Groove width	0.80	± 0.05
	Groove depth	0.8	± 0.1
	Groove lengths, min	7.5	
		12.5	
W ^A	Groove width	0.80	± 0.05
	Groove depth	0.8	± 0.1
	Groove lengths, min	7.5	
		9.5	
X	Diameter	9.50	± 0.02
			-0.00

^AGrooves on top and bottom surfaces should be displaced 5°.

6.4 Torque Measuring System—The torque measuring system shall consist of a device, such as a torque transducer, producing a signal that is directly proportional to the torque required to oscillate the disk. A recorder to record the maximum amplitude signal from the torque transducer shall be provided. The recorder shall have a full-scale deflection response on the torque scale of 1 s or less and be capable of recording the torque with accuracy of $\pm 0.5\%$ of the torque range. Four torque ranges shall be provided; 0 to 25, 0 to 50, 0 to 100, and 0 to 200 dN·m (or 0 to 25, 0 to 50, 0 to 100, and 0 to 200 lbf·in.)

NOTE 3—The term “recorder” as used in this test method implies the

use of any suitable data collection device, including printers, plotters, and computers.

NOTE 4—Direct proportionality between torque and stiffness cannot be expected under all test conditions, particularly in higher torque ranges, because elastic deformation of the disk shaft and driving device must be taken into account. However, for routine quality control test purposes corrections are not necessary.

7. Sampling

7.1 The sample shall be taken from a vulcanizable rubber compound as required by the mixing method or other sampling instructions.

7.2 The sample shall be in sheeted form, at room temperature, and as free of air as possible.

8. Test Specimen

8.1 A circular test specimen taken from a sample shall be 30 ± 2 mm (1.2 ± 0.1 in.) in diameter and 11.5 ± 1.5 mm (0.45 ± 0.05 in.) in thickness or equivalent to a volume of 9 cm^3 (0.5 in.^3).

8.2 The test specimen is considered to be of proper size when a small bead of compound is extruded uniformly around the periphery of the die as it is closed. This is achieved when the specimen volume is between 8 and 11 cm^3 (9 to 13 g of rubber compound with a specific gravity of 1.15). Undersized specimens can cause low cavity pressure and low torque readings. Oversized specimens cool the dies excessively during the early part of the test cycle affecting the vulcanization characteristics.

9. Test Temperatures

9.1 The standard test temperature shall be 160°C (320°F).

9.2 The test temperature tolerance shall be $\pm 0.5^\circ\text{C}$ ($\pm 1.0^\circ\text{F}$).

9.3 Tests may be carried out at other temperatures, if required. They should be selected in accordance with Practice D 1349.

10. Calibration

10.1 The cure meter shall be calibrated mechanically in accordance with the manufacturer's instructions.

10.2 Provisions shall be made for electronic verification of the recorder and for torque transducer calibration by means of a resistor incorporated in the torque measuring circuit that simulates an applied torque of specified value.

10.3 The cure meter shall be calibrated with the torque standard supplied by the manufacturer any time the results are suspected of being inaccurate, after any repairs, any change in arc, or frequently enough to ensure the maintenance of proper calibration. The cure meter shall read zero when running empty and read the certified value with the torque standard inserted.

11. Procedure

11.1 Preparation for Test:

11.1.1 Bring the temperature of both dies to the temperature of test with the disk in place and the dies in the closed position. Set recorder range to zero and adjust the recorder pen to zero torque and zero time position on the chart. Select the correct running time and choose the torque range to give maximum torque in the upper half of the recorder chart.