



## Standard Test Method for Rubber Property – Durometer Hardness<sup>1</sup>

This standard is issued under the fixed designation D 2240; 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.

*This standard has been approved for use by agencies of the Department of Defense.*

### 1. Scope

1.1 This test method describes eight types of rubber hardness measurement devices known as durometers: types A, B, C, D, DO, O, OO and M. The procedure for determining indentation hardness of substances classified as thermoplastic elastomers, vulcanized (thermoset) rubber, elastomeric materials, cellular materials, and some plastics is also described.

1.2 This test method is not equivalent to other indentation hardness methods and instrument types, specifically those described in ASTM D 1415.

1.3 This test method is not applicable to the testing of coated fabrics.

1.4 The values stated in SI units are to be regarded as standard. The values given in parentheses are for information only. Many of the stated dimensions in SI are direct conversions from the U. S. Customary System to accommodate the instrumentation, practices and procedures that existed prior to the Metric Conversion Act of 1975.

1.5 All materials, instruments, or equipment used for the determination of mass, force or dimension shall have traceability to the National Institute for Standards and Technology, or other internationally recognized organization parallel in nature.

1.6 *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 374 Standard Test Method for Thickness of Solid Electrical Insulation<sup>2</sup>

D 618 Practice for Conditioning Plastics and Electrical Insulating Materials for Testing<sup>3</sup>

D 785 Test Method for Rockwell Hardness of Plastics and Electrical Insulating Materials<sup>2</sup>

D 1349 Practice for Rubber—Standard Temperatures For Testing<sup>4</sup>

D 1415 Standard Test Method for Rubber Property – International Hardness<sup>4</sup>

D 4483 Practice for Determining Precision for Test Method Standards in the Rubber and Carbon Black Industries<sup>4</sup>

E 691 Practice for Conducting an Interlaboratory Study to Determine the Precision of a Test Method<sup>5</sup>

### 3. Summary of Test Method

3.1 This test method permits hardness measurements based on either initial indentation or indentation after a specified period of time, or both. Durometers with maximum reading indicators used to determine maximum hardness values of a material may yield lower hardness when the maximum indicator is used.

3.2 The procedures for Type M, or micro hardness durometers, accommodate specimens that are, by their dimensions or configuration, ordinarily unable to have their durometer hardness determined by the other durometer types described. Type M durometers are intended for the testing of specimens having a thickness or cross sectional diameter of 1.25 mm (0.050 in) or greater, although specimens of lesser dimensions may be successfully accommodated under the conditions specified in Section 6, and have a Type M durometer hardness range of between 20 and 90. Those specimens which have a durometer hardness range other than specified shall use another suitable procedure for determining durometer hardness.

### 4. Significance and Use

4.1 This test method is based on the penetration of a specific type of indenter when forced into the material under specified conditions. The indentation hardness is inversely related to the penetration and is dependent on the elastic modulus and viscoelastic behavior of the material. *The geometry of the indenter and the applied force influence the measurements such that no simple relationship exists between the measurements obtained with one type of durometer and those obtained with another type of durometer or other instruments used for measuring hardness.* This test method is an empirical test intended primarily for control purposes. No simple relationship

<sup>1</sup> This test method is under the jurisdiction of ASTM Committee D11 on Rubber and is the direct responsibility of Subcommittee D11.10 on Physical Tests.

Current edition approved May 10, 2000. Published August 2000. Originally published as D 2240 – 64 T. Last previous edition D 2240 – 95.

<sup>2</sup> Annual Book of ASTM Standards, Vol 10.01.

<sup>3</sup> Annual Book of ASTM Standards, Vol 08.01.

<sup>4</sup> Annual Book of ASTM Standards, Vol 09.01.

<sup>5</sup> Annual Book of ASTM Standards, Vol 14.02.

exists between indentation hardness determined by this test method and any fundamental property of the material tested. For specification purposes it is recommended that ASTM Test Method D 785 be used for materials other than those described in 1.1.

5. Apparatus

5.1 Hardness measuring apparatus, or durometer, and an operating stand, Type 1, Type 2, or Type 3, refer to Section 5.1.2, consisting of the following components:

5.1.1 Durometer

5.1.1.1 Presser Foot, with an orifice (to allow for the protrusion of the indenter) having a diameter as specified in Fig. 1a, Fig. 1b, or Fig. 1c, with the center a minimum of 6.0 mm (0.24 in) from any edge of the foot.

5.1.1.2 Presser Foot, Type M, with an orifice (to allow for the protrusion of the indenter) having a diameter as specified in Fig. 1d, with the center a minimum of 1.60 mm (0.063 in) from any edge of the flat circular presser foot.

5.1.1.3 Indenter, formed from steel rod and hardened to 500 HV10 and shaped in accordance with Fig. 1a, Fig. 1b, or Fig. 1c, polished over the contact area so that no flaws are visible under 20X magnification, with an indenter extension of  $2.50 \pm 0.04$  mm ( $0.098 \pm 0.002$  in).

5.1.1.4 Indenter, Type M, formed from steel rod and hardened to 500 HV10 and shaped in accordance with Fig. 1d, polished over the contact area so that no flaws are visible under 50X magnification, with an indenter extension of  $1.25 \pm 0.02$  mm ( $0.049 \pm 0.001$  in).

5.1.1.5 Indenter Extension Indicator, (analog or digital electronic), having a display that is an inverse function of the indenter extension. The display shall indicate from 0 to 100 with equal divisions throughout the range at a rate of one hardness point for each 0.025 mm (0.001 in) of indenter movement, for Type M durometers, the display shall indicate from 0 to 100 with no less than 100 equal divisions at a rate of one hardness point for each 0.0125 mm (0.0005 in) of indenter movement.

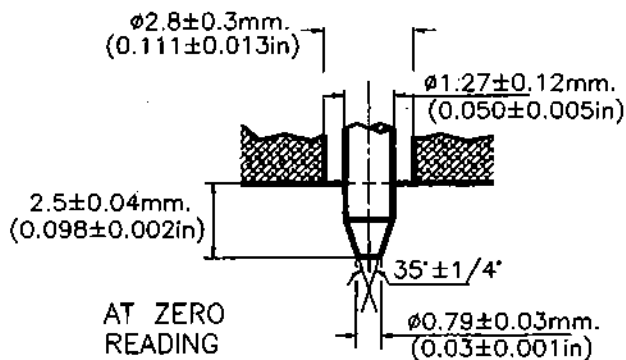


Figure 1a Type A and C Indenter

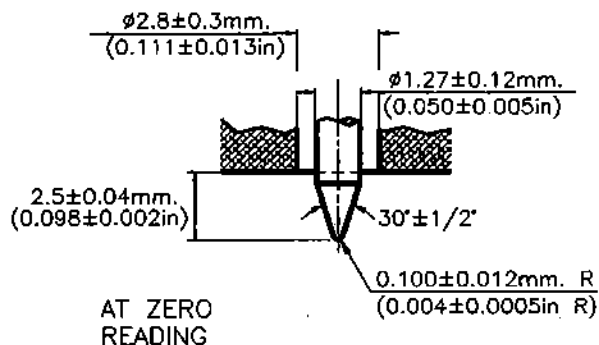


Figure 1b Type B and D Indenter

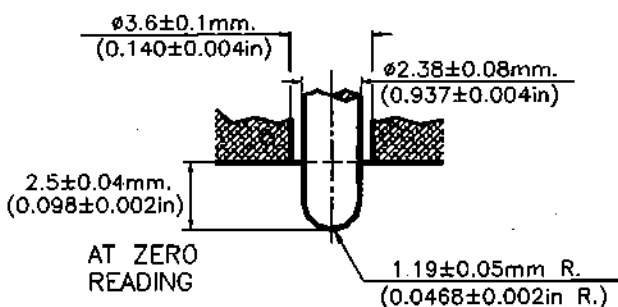


Figure 1c O, DO, and oo Indenter

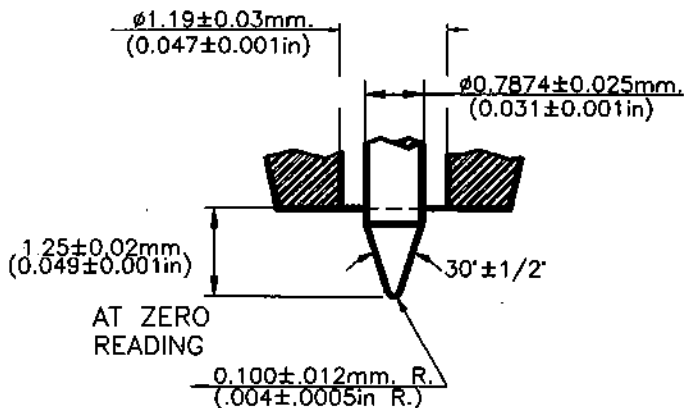


Figure 1d Type M Indenter

FIG. 1 Durometers

5.1.1.6 Timing Device (optional), capable of being set to a desired elapsed time, signaling the operator or holding the hardness reading when the desired elapsed time has been reached. The timer shall be automatically activated when the presser foot is in contact with the specimen being tested, e.g., the initial indenter travel has ceased. Digital electronic durometers may be equipped with electronic timing devices that shall not affect the indicated reading or determinations attained by more than one half the calibration tolerance stated in Table 1.

5.1.1.7 Maximum indicators (optional), maximum indicating pointers are auxiliary analog indicating hands designed to remain at the maximum hardness value attained until reset by the operator. Electronic maximum indicators are digital displays electronically indicating and maintaining the maximum value hardness value achieved, until reset by the operator.

5.1.1.8 Analog maximum indicating pointers have been shown to have a nominal affect on the values attained, however this affect is greater on durometers of lesser total mainspring loads, e.g., the affect of a maximum indicating pointer on Type D durometer determinations will be less than those determinations achieved using a Type A durometer. Analog style durometers may be equipped with maximum indicating pointers. The affect of a maximum indicating pointer shall be noted at the time of calibration in the calibration report, refer to Section 10.1.4, and when reporting hardness determinations, refer to Section 10.2.4. Analog Type M durometers shall not be equipped with maximum indicating pointers.

5.1.1.9 Digital electronic durometers may be equipped with electronic maximum indicators that shall not affect the indicated reading or determinations attained by more than one half of the spring calibration tolerance stated in Table 1.

5.1.1.10 Calibrated Spring, for applying force to the indenter, in accordance with Fig. 1a through Fig. 1d and capable of applying the forces as specified in Table 1.

5.1.2 Operating Stand

5.1.2.1 Type 1, Type 2, and Type 3, shall be capable of supporting the durometer presser foot surface parallel to the specimen support table (Fig. 2) throughout the travel of each. The durometer presser foot to specimen support table parallelism shall be verified each time the test specimen support table is adjusted to accommodate specimens of varying dimensions. This may be accomplished by applying the durometer presser foot to the point of contact with the specimen support table and

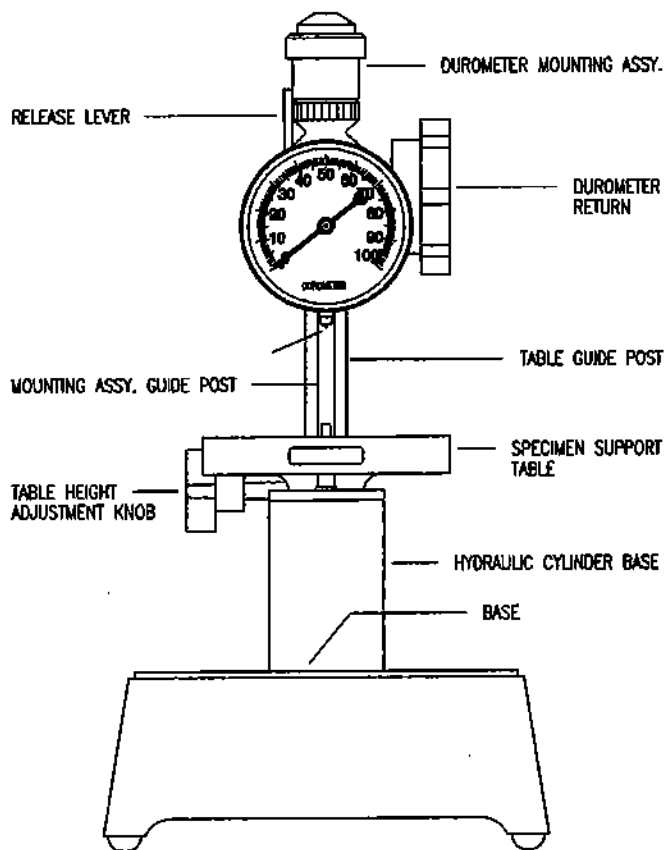


FIG. 2 Durometer Operating Stand

making adjustments by way of the durometer mounting assembly or as specified by the manufacturer.

5.1.2.2 Operating Stand, Type 1 (specimen to indenter type), shall be capable of applying the specimen to the indenter in a manner that minimizes shock.

5.1.2.3 Operating Stand, Type 2 (indenter to specimen type), shall be capable of controlling the rate of descent of the indenter to the specimen at a maximum of 3.20 mm/s (0.125 in/s) and applying a force sufficient to overcome the calibrated spring force as shown in Table 1.

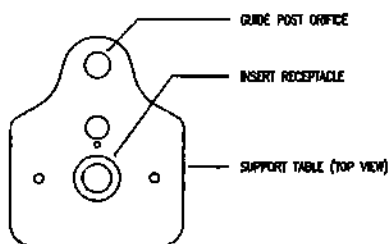
5.1.2.4 Operating Stand, Type 3 (indenter to specimen type), hydraulic dampening, pneumatic dampening or electro-mechanical (required for the operation of Type M durometers) shall be capable of controlling the rate of descent of the indenter to the specimen at a maximum of 3.2 mm/s (0.125 in/s) and applying a force sufficient to overcome the calibrated spring force as shown in Table 1. Manual application, Type 1 or Type 2 operating stands are not acceptable for Type M durometer operation.

5.1.2.5 The entire instrument should be plumb and level, and resting on a surface that will minimize vibration. Operating the instrument under adverse conditions will negatively affect the determinations attained.

5.1.2.6 Specimen Support Table, (Fig. 2) integral to the operating stand, and having a solid flat surface. The specimen support platform may have orifices designed to accept various inserts or support fixtures (Fig. 3) to provide for the support of irregularly configured specimens. When inserts are used to

TABLE 1 Durometer Spring Force Calibration  
All Values are In N

Indicated Value	Type M	Type A, B, O	Type C, D, DO	Type OO
0	0.324	0.55		0.203
10	0.368	1.3	4.445	0.294
20	0.412	2.05	8.89	0.385
30	0.456	2.8	13.335	0.476
40	0.5	3.55	17.78	0.566
50	0.544	4.3	22.225	0.657
60	0.589	5.05	26.67	0.748
70	0.633	5.8	31.115	0.839
80	0.677	6.55	35.56	0.93
90	0.721	7.3	40.005	1.02
100	0.765	8.05	44.45	1.111
N/durometer unit	0.0044	0.075	0.4445	0.00908
Spring Calibration Tolerance	± 0.0176 N	± 0.075 N	± 0.4445 N	± 0.0182 N



TYPICAL TABLE INSERTS USED FOR POSITIONING TUBING, O-RINGS AND SMALL SPECIMENS

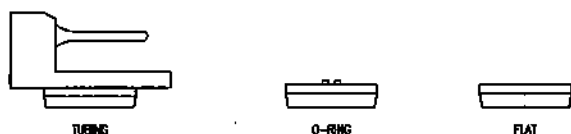


FIG. 3 Small Specimen Support Table

support test specimens, care must be taken to align the indenter to the center of the insert, or the point at which the indenter is to contact the specimen. Care should be exercised to assure that the indenter does not abruptly contact the specimen support table as damage to the indenter may result.

### 6. Test Specimen

6.1 The test specimen, herein referred to as 'specimen' or 'test specimen' interchangeably, shall be at least 6.0 mm (0.24 in) in thickness unless it is known that results equivalent to the 6.0 mm (0.24 in) values are obtained with a thinner specimen.

6.1.1 A specimen may be composed of plied pieces to obtain the necessary thickness, but determinations made on such specimens may not agree with those made on solid specimens as the surfaces of the plied specimens may not be in complete contact. The lateral dimensions of the specimen shall be sufficient to permit measurements at least 12.0 mm (0.48 in) from any edge unless it is known that identical results are obtained when measurements are made at a lesser distance from an edge.

6.1.2 The surfaces of the specimen shall be flat and parallel over an area to permit the presser foot to contact the specimen over an area having a radius of at least 6.0 mm (0.24 in) from the indenter point. The specimen shall be suitably supported to provide for positioning and stability. *A suitable hardness determination cannot be made on an uneven or rough point of contact with the indenter.*

6.2 Type M test specimens should be at least 1.25 mm (0.05 in) in thickness unless it is known that results equivalent to the 1.25 mm (0.05 in) values are obtained with a thinner specimen.

6.2.1 A Type M specimen, that is not of a configuration described in Section 6.2.2, may be composed of plied pieces to obtain the necessary thickness, but determinations made on such specimens may not agree with those made on solid specimens because the surfaces of the plied specimens may not be in complete contact. The lateral dimensions of the specimen should be sufficient to permit measurements at least 2.50 mm

(0.10 in) from any edge unless it is known that identical results are obtained when measurements are made at lesser distance from an edge. *A suitable hardness determination cannot be made on an uneven or rough point of contact with the indenter.*

6.2.2 The Type M specimen, when configured as an o-ring, circular band, or other irregular shape shall be at least 1.25 mm (0.05 in) in cross sectional diameter, unless it is known that results equivalent to the 1.25 mm (0.05 in) values are obtained with a thinner specimen. The specimen shall be suitably supported in a fixture (Fig. 3) to provide for positioning and stability.

6.3 The minimum requirement for the thickness of the specimen is dependent on the extent of penetration of the indenter into the specimen; e.g., thinner specimens may be used for materials having higher hardness values. The minimum distance from the edge at which measurements may be made likewise decreases as the hardness increases.

### 7. Calibration

7.1 Indenter extension adjustment procedure. Place precision ground dimensional blocks (Grade B or better) on the support table and beneath the durometer presser foot and indenter. Arrange the blocks so that the durometer presser foot contacts the larger block(s) and the indenter tip just contacts the smaller block (Fig. 4). It is necessary to observe the arrangement of the blocks and the presser foot/indenter under a minimum of 20 × magnification to assure proper alignment.

7.1.1 Indenter extension and shape must be in accordance with Section 5.1.1.3 or Section 5.1.1.4 respective to durometer type (Fig. 1a through Fig. 1d). Examination of the indenter under 20× magnification, 50× for Type M indentors, is required to examine the indenter condition. Misshapen or damaged indentors shall be replaced.

7.1.2 A combination of dimensional gage blocks shall be used to achieve a difference of 2.54 mm +0.00 -0.0254 mm (0.100 in +0.00 -0.001 in) between them. For Type M durometers the gage block dimensions are 1.27 mm +0.0 -0.0127 mm (0.050 in +0.00 -0.0005 in) between them (Fig. 4).

7.1.3 Carefully lower the durometer presser foot until it contacts the largest dimensional block(s), the indenter tip should just contact the smaller block, verifying full indenter extension.

7.1.4 Adjust the indenter extension to 2.50 ± 0.04 mm (0.098 ± 0.002 in). For Type M durometers, adjust the indenter

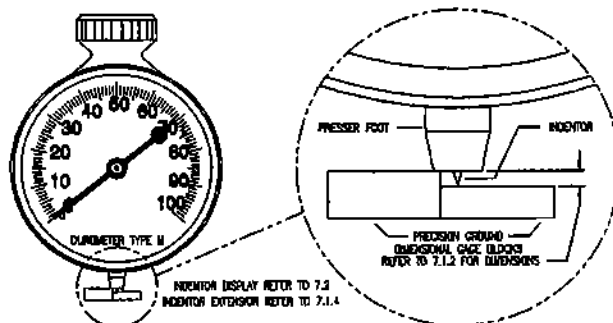


FIG. 4 Detail of Indenter Extension & Display Adjustment

extension to  $1.25 \pm 0.02$  mm ( $0.049 \pm 0.001$ ), following the manufacturer's recommended procedure.

7.1.4.1 When performing the procedures in Section 7.1, care should be used so as not to cause damage to the indenter tip. Fig. 4 depicts a suitable arrangement for gauging indenter extension.

7.1.5 Parallelism of the durometer presser foot to the support surface, and hence the dimensional gage blocks, at the time of instrument calibration shall be in accordance with ASTM D 374, Machinist's Micrometers. The application of this parallel tolerance is not practical during routine use as described in Section 5.1.2.1.

7.2 Indentor Display adjustment. After adjusting the indentor extension as indicated in Section 7.1, use a similar arrangement of dimensional gage blocks to verify the linear relationship between indentor travel and indicated display at two points: 0 and 100. Following the manufacturer's recommendations, make adjustments so that:

7.2.1 The indicator displays a value equal to the indentor travel measured to within:

- 0.0 +1.0 durometer units measured at '0';
- $\pm 0.50$  durometer units measured at 100;
- $\pm 1$  durometer units at all other points delineated in 7.4.

7.2.2 Each durometer point indicated is equal to 0.025 mm (0.001 in) of indentor travel, for Type M Durometers each indicated point is equal to 0.0125 mm (0.0005 in).

7.2.3 The indicator shall not display a value greater than 100 or less than 0 at the time of calibration.

7.2.4 Other means of determining indentor extension or indentor travel, such as optical or laser measurement methods, are acceptable. The instrumentation used shall have traceability as described in Section 1.5.

7.2.5 The durometer shall be supported in a suitable fashion when performing the procedures described in Sections 7.1 and 7.2.

7.3 Calibration device. The durometer spring shall be calibrated by supporting the durometer in a calibrating device, refer to Fig. 5, in a vertical position and applying a measurable force to the indenter tip. The force may be measured by means of a balance as depicted in Fig. 5, or an electronic force cell. The calibrating device shall be capable of measuring applied force to within 0.5 % of the maximum spring force necessary

to achieve 100 durometer units.

7.3.1 Care should be taken to ensure that the force is applied vertically to the indenter tip, as lateral force will cause errors in calibration. Refer to Sections 7.1.4.1 and 7.1.5.

7.4 Spring Calibration. The durometer spring shall be calibrated at displayed readings of 10, 20, 30, 40, 50, 60, 70, 80, and 90. The measured force ( $9.8 \times$  mass in kilograms) shall be within the spring calibration tolerance specified in Table 1. Table 1 identifies the measured force applied to the indentor for the entire range of the instrument, although it is necessary only to verify the spring calibration at points listed herein.

7.5 Spring Calibration Procedure. Assure that the indentor extension has been adjusted in accordance with Section 7.1 and the linear relationship between indentor travel and display is as specified in Section 7.2.

7.5.1 Place the durometer in the calibration device as depicted in Fig. 5. Apply the forces indicated in Table 1 so that forces applied are aligned with the centerline of the indentor in a fashion that eliminates shock or vibration and adjust the durometer according to manufacturers' recommendations so that:

7.5.2 At the points enumerated in Section 7.4, the display shall indicate a value equal to 0.025 mm (0.001 in) of indentor travel, for Type M Durometers the display shall indicate a value equal to 0.0125 mm (0.0005 in) of indentor travel within the spring calibration tolerances specified in Section 7.6.

7.6 Spring Calibration tolerances are  $\pm 1.0$  durometer units for Types A, B, C, D, O and DO,  $\pm 2.0$  durometer units for Type OO and  $\pm 4.0$  durometer units for Type M, while not indicating below 0 or above 100 at the time of calibration, refer to Table 1.

7.7 Spring Force combinations:

For Type M Durometers:

$$\text{Force, } N = 0.324 + 0.0044 \text{ HM}$$

Where HM = hardness reading on Type M durometers

For Type A, B, and O Durometers:

$$\text{Force, } N = 0.55 + 0.075 \text{ HA}$$

Where HA = hardness reading on Type A, B, and O durometers

For Type C, D, and DO Durometers:

$$\text{Force, } N = 0.4445 \text{ HD}$$

Where HD = hardness reading on Type C, D, and DO durometers

For Type OO Durometers:

$$\text{Force, } N = 0.203 + 0.00908 \text{ HOO}$$

Where HOO = hardness reading on Type OO durometers

7.8 The rubber, or metal, reference block(s) provided for checking durometer operation and state of calibration are not to be relied upon as calibration standards. The calibration procedures outlined in Section 7 are the only valid calibration procedures.

## 8. Laboratory Atmosphere and Test Specimen Conditioning

8.1 Tests shall be conducted in the standard laboratory atmosphere, as defined in D 618, Section 4.2.

8.2 The instrument shall be maintained in the standard laboratory atmosphere, as defined in D 618, Section 4.1, for 12 h prior to performing a test.

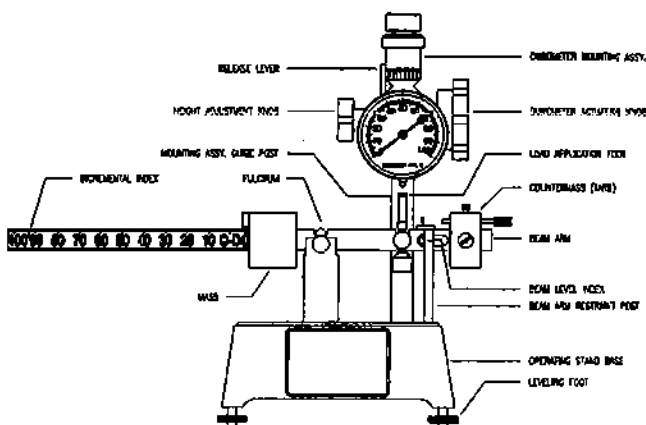


FIG. 6 Example of Durometer Calibration Apparatus

8.3 The specimen shall be conditioned in accordance with condition 40/23 exclusive of humidity control, as described in D 618, Section 8.1, Procedure A and tested under the same conditions, exclusive of humidity control.

8.4 These procedures may be modified if agreed upon between laboratories or between supplier and user and are in accordance with alternative procedures identified in D 618.

8.5 No conclusive evaluation has been made on durometers at temperatures other than  $23.0 \pm 2.0$  degrees C ( $73.4 \pm 3.6$  degrees F). Conditioning at temperatures other than the above may show changes in calibration. Durometer use at temperatures other than the above should be decided locally (see Practice D 1349).

## 9. Procedure

9.1 Operating Stand Operation (Type 3 operating stand required for Type M)

9.1.1 Care shall be exercised to minimize the exposure of the instrument to environmental conditions that are adverse to the performance of the instrument, or adversely affect test results.

9.1.2 Adjust the presser foot to support table parallelism as described in Section 5.1.2.1. It is necessary to make this adjustment each time the support table is moved to accommodate specimens of varying dimensions.

9.1.3 Prior to conducting a test, adjust the vertical distance from the presser foot to the contact surface of the test specimen to  $25.4 \pm 2.5$  mm ( $01.00 \pm 0.100$  in), unless it is known that identical results are obtained with presser foot at a greater or lesser vertical distance from the test specimen contact surface, or if otherwise stipulated by the manufacturer.

9.1.4 Place the specimen on the specimen support table, in a manner that the contact point of the indenter is in accordance with Section 6, unless it is known that identical results are obtained when measurements are made with the indenter at a lesser distance from the edge of the test specimen.

9.1.5 Actuate the release lever (Fig. 2) of the operating stand or activate the electromechanical device, allowing the durometer to descend at a controlled rate and apply the presser foot to the specimen in accordance with Section 5.1.2. In the case of 'specimen to indenter' type operating stands, operate the lever or other mechanism to apply the specimen to the indenter in a manner that assures parallel contact of the specimen to the durometer presser foot without shock and with just sufficient force to overcome the calibrated spring force as shown in Table 1.

9.1.6 An operating stand that applies the mass at a controlled rate of descent, without shock is mandatory for Type M durometers. Hand held application or the use of a Type 1 or Type 2 operating stands for the Type M durometer is not an acceptable practice, refer to Section 5.1.2.4.

9.1.7 For any material covered in 1.1, once the presser foot is in contact with the specimen, e.g. the initial indenter travel has ceased, the indicated reading shall be recorded within  $1s \pm 0.1s$ , or after any period of time agreed upon among laboratories or between supplier and user. If the durometer is equipped with a maximum indicator, the maximum indicated reading shall be recorded within  $1s \pm 0.1s$  of the cessation of indenter travel. The indicated hardness reading may change with time.

9.1.8 Make five determinations of hardness at different positions on the specimen at least 6.0 mm (0.24 in) apart, 0.80 mm (0.030 in) apart for Type M; and calculate the arithmetic mean, or alternatively calculate the median. The means of calculating the determinations shall be reported according to Section 10.2.8

9.2 Manual (hand held) Operation of Durometer

9.2.1 Care shall be exercised to minimize the exposure of the instrument to environmental conditions that are adverse to the performance of the instrument, or adversely affect test results.

9.2.2 Place the specimen on a flat, hard, horizontal surface. Hold the durometer in a vertical position with the indenter tip at a distance from any edge of the specimen as described in Section 6, unless it is known that identical results are obtained when measurements are made with the indenter at a lesser distance.

9.2.3 Apply the presser foot to the specimen, maintaining it in a vertical position keeping the presser foot parallel to the specimen, with a firm smooth downward action that will avoid shock, rolling of the presser foot over the specimen, or the application of lateral force. Apply sufficient pressure to assure firm contact between the presser foot and the specimen.

9.2.4 For any material covered in Section 1.1, after the presser foot is in contact with the specimen, the indicated reading shall be recorded within  $1s \pm 0.1s$ , or after any period of time agreed upon among laboratories or between supplier and user. If the durometer is equipped with a maximum indicator, the maximum indicated reading shall be recorded within  $1s \pm 0.1s$  of the cessation of initial indenter travel. The indicated hardness reading may change with time.

9.2.5 Make five determinations of hardness at different positions on the specimen at least 6.0 mm (0.24 in) apart and calculate the arithmetic mean, or alternatively calculate the median. The means of calculating the determinations shall be reported according to Section 10.2.8.

9.3 It is acknowledged that durometer readings below 20 or above 90 are not considered reliable. It is suggested that readings in these ranges not be recorded.

9.4 Manual operation (hand held) of a durometer will cause variations in the results attained. Improved repeatability may be obtained by using a mass, securely affixed to the durometer and centered on the axis of the indenter. Recommended masses are 1 kg for Type A, B and O durometers, 5 kg for Type C, D and DO durometers, and 400 g for Type OO durometers. Further improvement may be achieved by the use of a durometer operating stand which controls the rate of descent of the durometer presser foot to the test specimen and incorporates the masses described above.

## 10. Report

10.1 Instrument Calibration Report (durometer or operating stand):

10.1.1 Date of calibration

10.1.2 Date of last calibration

10.1.3 Manufacturer, type, model, and serial number of the instrument, and a notation when a maximum indicator or timing device is present

10.1.4 Values obtained (pre- and post calibration results),

including a notation of the affect of a maximum indicator, if present. The method of reporting the calibrated value shall be by attaining the arithmetic mean of the determinations.

10.1.5 Ambient Temperature

10.1.6 Relative humidity

10.1.7 Technician identification

10.1.8 Applicable standards to which the instrument is calibrated

10.1.9 Calibrating instrument information to include type, serial number, manufacturer, date of last calibration and a statement of traceability of standards used to NIST or other acceptable organization. Refer to Section 1.5.

10.2 Hardness Measurement Report

10.2.1 Date of test

10.2.2 Relative humidity

10.2.3 Ambient Temperature

10.2.4 Manufacturer, type and serial number of the durometer and/or operating stand, including a notation when a maximum indicator or timing device is present, and date of last calibration

10.2.5 Means of testing, whether manual (hand held), Type 1 operating stand (specimen to indenter), Type 2 operating stand (indenter to specimen type) or Type 3 operating stand (electromechanical or hydraulically dampened)

10.2.6 Description of test specimen, including thickness, number of pieces plied if less than the thickness indicated in Section 6, including the vulcanization date

10.2.7 Complete identification of material tested

10.2.8 Hardness value obtained and method of calculation, either arithmetic mean or alternatively, the median.

10.2.9 Indentation hardness time interval at which determination was made, Readings may be reported in the form: M/60/1 where M is the type of durometer, 60 the reading, and 1 the time in seconds that the presser foot is in contact with the specimen or from an electronic timing device.

## 11. Precision and Bias

11.1 These precision and bias statements have been prepared in accordance with Practice D 4483. Refer to this Practice for terminology and other testing and statistical concepts.

11.2 The Type 1 precision for the Type M method was determined from an interlaboratory program with 21 materials of varying hardness, with six participating laboratories. Tests were conducted on two separate days in each laboratory for the Type M testing program. All materials were supplied from a single source, being those commonly supplied as reference materials with the instruments from the manufacturer.

11.3 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 above. The precision parameters should not be used for acceptance or rejection testing, or both, 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.

11.4 The Type 1 precision for both Type A and D methods was determined from an interlaboratory program with 3 materials of varying hardness, with six participating laboratories. Tests were conducted on two separate days in each laboratory for both A and D testing programs. All materials were supplied from a single source.

11.5 A test result for hardness, for Types A, D, and M, was the median of five individual hardness readings on each day in each laboratory.

11.6 Table 2 shows the precision results for Type M method<sup>6</sup>, Table 3 shows the precision results for Type A method<sup>7</sup>, and Table 4 gives the precision results for Type D method<sup>7</sup>.

11.7 Precision. The precision of this test method may be expressed in the format of the following statements which use as appropriate value  $r$ ,  $R$ ,  $(r)$ , 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 a mean level in Table 1 closest to the mean level under consideration (at any given time, for any given material) in routine testing operations.

11.7.1 Repeatability. The repeatability,  $r$ , of these test methods has been established as the appropriate value tabulated in Tables 2-4. 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.

11.7.2 Reproducibility. The reproducibility,  $R$ , of these test methods has been established as the appropriate value tabulated in Tables 2-4. 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.

11.7.3 Repeatability and reproducibility are 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 test results.

11.8 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.

## 12. Keywords

12.1 Durometer; Durometer Hardness; Hardness; Indentation Hardness; Micro Durometer Hardness

<sup>6</sup> Supporting data are available from ASTM Headquarters. Request RR: D11-1091.

<sup>7</sup> Supporting data are available from ASTM Headquarters. Request RR: D11-1029.

**TABLE 2 Type 1 Precision—Type M Durometer Method**

Material	Within Laboratories				Between Laboratories		
	MEAN	$S_r^A$	$r^B$	$(r)^C$	$S_R^D$	$R^E$	$(R)^F$
1	31.8	1.26	3.58	11.24	3.76	10.63	33.41
2	40.8	1.14	3.23	7.90	2.47	7.00	17.13
3	54.0	0.975	2.76	5.11	2.38	6.73	12.46
4	62.8	0.782	2.21	3.52	2.24	6.34	10.10
5	70.9	0.709	2.01	2.89	0.974	2.76	3.89
6	80.6	1.686	4.77	5.92	1.61	4.56	5.65
7	87.7	1.15	3.25	3.71	2.63	7.45	8.60
8	92.4	0.947	2.68	8.26	3.64	10.29	31.73
9	41.8	0.797	2.26	5.40	2.23	6.31	15.11
10	53.3	0.669	1.89	3.55	2.29	6.49	12.17
11	63.2	0.485	1.37	2.17	2.19	6.20	9.80
12	69.6	0.737	2.09	3.00	0.99	2.80	4.02
13	78.3	0.784	2.22	2.84	1.04	2.94	3.75
14	87.6	1.121	3.17	3.62	2.65	7.49	8.55
15	34.1	0.85	2.40	7.05	1.84	5.20	15.25
16	42.3	0.635	1.80	4.25	1.20	3.39	8.01
17	54.6	0.56	1.59	2.90	2.15	6.09	11.15
18	62.9	1.12	3.17	5.04	1.47	4.16	6.61
19	70.3	0.689	1.95	2.77	0.944	2.67	3.80
20	81.7	0.483	1.37	1.67	1.10	3.10	3.80
21	87.9	0.879	2.49	2.83	2.07	5.86	6.67
AVERAGE	61.4						
POOLED VALUES		0.924	2.62	4.26	2.146	6.07	9.89

<sup>A</sup> $S_r$  = repeatability standard deviation, measurement units.  
<sup>B</sup> $r$  = repeatability =  $2.83 \times S_r$ , measurement units.  
<sup>C</sup> $(r)$  = repeatability, relative, (that is, in percent).  
<sup>D</sup> $S_R$  = reproducibility standard deviation, measurement units.  
<sup>E</sup> $R$  = reproducibility =  $2.83 \times S_R$ , measurement units.  
<sup>F</sup> $(R)$  = reproducibility, relative, (that is, in percent).

**TABLE 3 Type 1 Precision—Type A Durometer Method**

Material	Average Level	Within Laboratories			Between Laboratories		
		$S_r^A$	$r^B$	$(r)^C$	$S_R^D$	$R^E$	$(R)^F$
1	51.4	0.646	1.83	3.56	1.56	4.41	8.59
2	65.3	0.878	2.48	3.81	2.21	6.06	9.27
3	68.0	0.433	1.23	1.80	2.28	6.45	9.49
Pooled	61.6	0.677	1.92	3.11	2.018	5.72	9.28

<sup>A</sup> $S_r$  = repeatability standard deviation, measurement units.  
<sup>B</sup> $r$  = repeatability =  $2.83 \times S_r$ , measurement units.  
<sup>C</sup> $(r)$  = repeatability, relative, (that is, in percent).  
<sup>D</sup> $S_R$  = reproducibility standard deviation, measurement units.  
<sup>E</sup> $R$  = reproducibility =  $2.83 \times S_R$ , measurement units.  
<sup>F</sup> $(R)$  = reproducibility, relative, (that is, in percent).

**TABLE 4 Type 1 Precision—Type D Durometer Method**

Material	Average Level	Within Laboratories			Between Laboratories		
		$S_r^A$	$r^B$	$(r)^C$	$S_R^D$	$R^E$	$(R)^F$
1	42.8	0.316	0.894	2.10	2.82	7.88	18.7
2	54.5	0.791	2.24	4.11	3.54	10.0	18.4
3	62.3	1.01	2.86	3.47	3.54	10.0	12.2
Pooled	59.8	0.762	2.16	3.61	3.32	9.40	15.7

<sup>A</sup> $S_r$  = repeatability standard deviation, measurement units.  
<sup>B</sup> $r$  = repeatability =  $2.83 \times S_r$ , measurement units.  
<sup>C</sup> $(r)$  = repeatability, relative, (that is, in percent).  
<sup>D</sup> $S_R$  = reproducibility standard deviation, measurement units.  
<sup>E</sup> $R$  = reproducibility =  $2.83 \times S_R$ , measurement units.  
<sup>F</sup> $(R)$  = reproducibility, relative, (that is, in percent).

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