Designation: D1415 – 06 (Reapproved 2012)

Standard Test Method for Rubber Property—International Hardness[1]

This standard is issued under the fixed designation D1415; 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 U.S. Department of Defense.

1. Scope

1.1 This test method covers a procedure for measuring the hardness of vulcanized or thermoplastic rubber. The hardness is obtained by the difference in penetration depth of a specified dimension ball under two conditions of contact with the rubber: (*1*) with a small initial force and (*2*) with a much larger final force. The differential penetration is taken at a specified time and converted to a hardness scale value.

1.2 This test method is technically similar to ISO 48.

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:*[2]

D1349 Practice for Rubber—Standard Conditions for Testing

D2240 Test Method for Rubber Property—Durometer Hardness

D4483 Practice for Evaluating Precision for Test Method Standards in the Rubber and Carbon Black Manufacturing Industries

2.2 *International Standard:*[3]

ISO 48 Rubber, Vulcanized or Thermoplastic—Determination of Hardness (Hardness between 10 and 100 IRHD)

3. Summary of Test Methods

3.1 Four procedures are given to accommodate specimens of different dimensions hardness of vulcanized or thermoplastic rubbers on flat surfaces:

Type S1 and S2, Standard hardness tests;
Type M, Micro-hardness tests;
Type L, Low hardness test;
Type H, High hardness test.

3.1.1 *Types S1 and S2 (refer to* Table 1*)*—The standard test for hardness is the appropriate method for specimens having a thickness described in Section 6, and is appropriate for those having a hardness of 35 IRHD to 85 IRHD. It may be used for those in the range of 30 IRHD to 95 IRHD.

NOTE 1—The hardness values obtained by Types S and S1, within the ranges of 85 IRHD to 95 IRHD and 30 IRHD to 35 IRHD may not agree with those obtained using Types H or L. The differences are not generally considered significant.

3.1.2 *Type M (refer to* Table 1*)*—The micro-hardness test is a scaled-down version of Type S1 and S2, which permit testing of thinner and smaller specimens. It is applicable for specimens having a thickness described in Section 6, and a hardness of 35 IRHD to 85 IRHD. It may be used for those in the range of 30 IRHD to 95 IRHD.

NOTE 2—The hardness values obtained by Type M may not agree with those obtained using Types S1 or S2 due to the effects of surface variations or specimen configuration.

3.1.3 *Type L*—The appropriate method for specimens having a thickness described in Section 6, and a hardness of 10 IRHD to 35 IRHD.

3.1.4 *Type H*—The appropriate method for specimens having a thickness described in Section 6, and a hardness of 85 IRHD to 100 IRHD.

3.2 In all procedures, the hardness in International Rubber Hardness Degrees (IRHD) is derived from the difference in penetrations and a table or graph constructed from the table. In the micro-tester procedure, the difference in penetration must first be multiplied by scale factor 6. Alternatively, the penetration measuring instrument may be calibrated directly in IRHD.

[1] This test method is under the jurisdiction of ASTM Committee D11 on Rubber and is the direct responsibility of Subcommittee D11.10 on Physical Testing.

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[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

[3] Available from American National Standards Institute (ANSI), 25 W. 43rd St., 4th Floor, New York, NY 10036.

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TABLE 1 Apparatus Requirements

NOTE 1—In Type M micro-hardness testing using instruments in which the test piece table is pressed upwards by a spring, the value of the force on foot is that acting during the period of application of the total indenting force. Before the indenting force increment of 0.145 *N* is applied, the force on the foot is greater by this amount, and hence is 0.38 ± 0.03 *N*.

	Type S1	Type S2	Type M	Type L	Type H
Diameter of ball, mm	2.38 ± 0.01	2.50 ± 0.01	0.395 ± 0.005	5.0 ± 0.01	1.0 ± 0.01
Minor force on ball, N[A]	0.30 ± 0.02	0.29 ± 0.02	0.0083± 0.0005	0.3 ± 0.02	0.3 ± 0.02
Major force on ball, N[A]	5.23 ± 0.01	5.4 ± 0.01	0.1455 ± 0.0005	5.4 ± 0.01	5.4 ± 0.01
Total force on ball, N[A]	5.53 ± 0.03	5.7 ± 0.03	0.153 ± 0.001	5.7 ± 0.03	5.7 ± 0.03
Outside diameter of foot, mm	20 ± 1	20 ± 1	3.35± 0.15	22 ± 1.0	20 ± 1.0
Inside diameter of foot, mm	6 ± 1	6 ± 1	1.00± 0.15	10 ± 1.0	6 ± 1.0
Force on foot, N[B]	8.3 ± 1.5	8.3 ± 1.5	0.235± 0.03[C]	8.3 ± 1.5	8.3 ± 1.5

[A] Includes frictional forces in apparatus.
[B] The force should be adjusted within these limits to the actual area of the foot so that the pressure in the specimen is 30 ± 0.5 kPa.
[C] Force on foot during application of total force on ball; force on foot during application of minor force on ball, 0.2 N minimum, 0.4 N maximum.

4. Significance and Use

4.1 The International Hardness test is based on measurement of the penetration of a rigid ball into the rubber specimen under specified conditions. The measured penetration is converted into IRHD, the scale of degrees being so chosen that 0 represents a material having an elastic modulus of zero, and 100 represents a material of infinite elastic modulus.

4.1.1 The scale also fulfills the following conditions over most of the normal range of hardness: one IRHD range represents approximately the same proportionate difference in Young's modulus, and for rubber vulcanizates in the usual range of resilience, readings in IRHD are comparable with those given by a Type A durometer (Test Method D2240) when testing standard specimens.

4.1.1.1 The term "usual range of resilience" is used to exclude those compounds that have unusually high rates of stress relaxation or deformational hysteresis. For such compounds, differences in the dwell time in the two hardness tests (Test Methods D2240 and D1415) result in differences in hardness values. Readings may not be comparable when testing curved or irregularly shaped test specimens.

4.1.2 For substantially elastic isotropic materials like well-vulcanized natural rubbers, the hardness in IRHD bears a known relation to Young's modulus, although for markedly plastic or anisotropic rubbers the relationship will be less precisely known.

4.1.3 The relation between the difference of penetration and the hardness expressed in IRHD is based on the following:

4.1.3.1 The relation[4] between penetration and Young's modulus for a perfectly elastic isotropic material:

$$D = 61.5\, R^{-0.48}\left([F/E]^{0.74} - [f/E]^{0.74}\right) \quad (1)$$

where:

D = known relationship for a perfectly elastic isotropic material, between indentation,
R = radium of the ball, mm,
F = total indenting force,
E = Young's modulus expressed in megapascals, and
f = contact force

4.1.3.2 Use of a probit (integrated normal error) curve to relate $\log_{10} M$ and hardness in IRHD, as shown in Fig. 1. This curve is defined as follows:

4.1.3.3 The value of $\log_{10} M$ corresponding to the midpoint of the curve is equal to 0.364, that is, M = 2.31 MPa or 335 psi.

4.1.3.4 The maximum slope is equal to 57 IRHD per unit increase in $\log_{10} M$.

5. Apparatus

5.1 The essential parts of the apparatus are as follows, the appropriate dimensions and loads being given in Table 1:

5.1.1 *Vertical Plunger,* terminating in a rigid ball.

5.1.2 *Force Applicator,* for applying a minor force and a major force to the ball, the mass of the plunger, and of any fittings attached to it, and the force of any spring acting on it shall be included in determining the minor and major forces. This is in order that the forces actually applied to the ball shall be as specified.

5.1.3 *Measuring Device*—A mechanical, optical, or electrical device graduated either in standard units of length or in IRHD for measuring the increase in depth of penetration of the plunger caused by the major load.

5.1.4 *Foot*—A flat annular-shaped foot that is rigidly fastened to the penetration-measuring device and normal to the axis of the plunger, and which during the test is forced against the specimen in order to determine accurately the position of the upper surface.

5.1.5 *Vibrating Device*—For example, an electrically operated buzzer, for gently vibrating the apparatus to overcome any slight friction; this should not exceed 5 % of the minor load. This device may be omitted on apparatus without any friction.

6. Test Specimen

6.1 Tests intended to be comparable must be made on specimens of the same thickness that have smooth, flat and

[4] This relation is approximate and is included as an indication.

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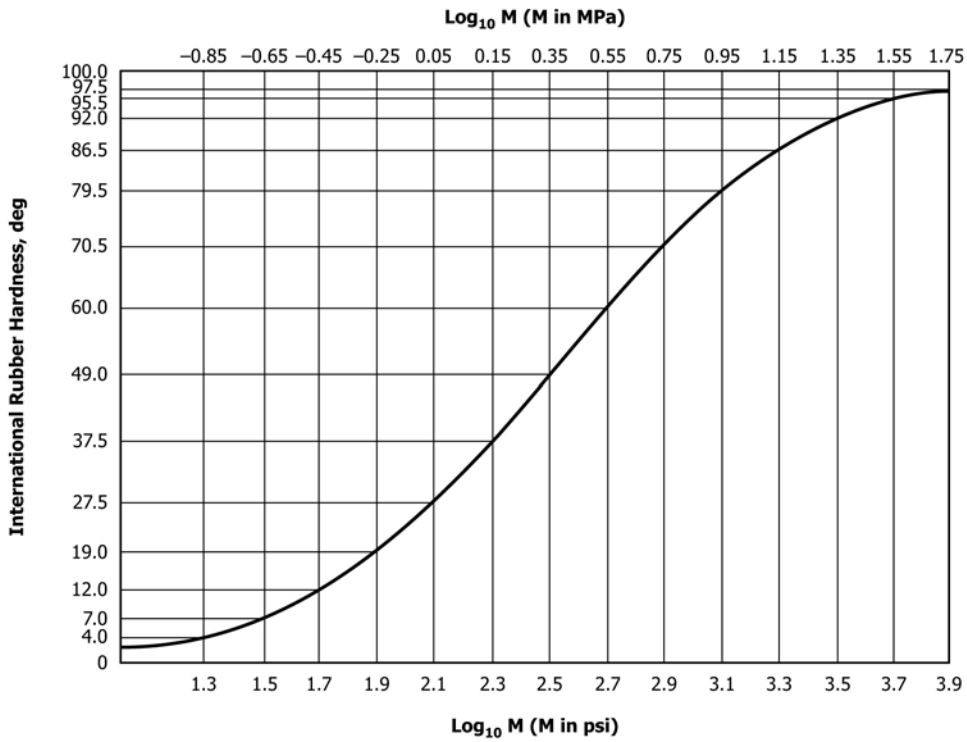

FIG. 1 Point Curve to Relate Log_{10} M and the Hardness in IRHD

parallel upper and lower surfaces. Up to three specimens may be plied to obtain the required thickness. The dimensions of the specimen depend on the test type being used to measure the hardness.

6.2 *Types S1 and S2*—The Types S1 and S2 specimens shall be between 8 and 10 mm in thickness. Nonstandard specimens may be either thicker or thinner but in no case less than 2 mm thick. The lateral dimensions of both standard and nonstandard specimens shall be such that no test is made at a distance from the edge of the specimen less than the appropriate distance shown in Table 2.

6.3 *Type M*—The Type M specimen micro-hardness tests shall be 2 ± 0.5 mm in thickness. Nonstandard specimens may be either thicker or thinner but in no case less than 1 mm thick. The lateral dimensions of both standard and nonstandard specimens shall be such that no test is made at a distance from the edge of less than 2 mm. When specimens thicker than 4 mm are tested on the micro tester because lateral dimensions or area of flatness do not permit testing on a standard tester, the test shall be made at a distance from the edge as great as possible. Curved specimens, for example, O-rings, may be tested with the micro-hardness tester if the specimens are mounted in such a manner as to prevent movement during the test, but the values obtained may not be comparable to those obtained with flat specimens.

TABLE 2 Minimum Distance from Edge of Specimen at Which Test is Made (All types except M)

Total Thickness of Specimen		Minimum Distance from Edge	
mm	in.	mm	in.
4	0.16	7.0	0.28
6	0.25	8.0	0.31
8	0.3	9.0	0.35
10	0.4	10.0	0.40
15	0.6	11.5	0.45
25	1.0	13.0	0.50

6.4 *Type L*—The Type L specimens shall be 10 to 15 mm in thickness. Standard specimens may be either thicker or thinner but in no case less than 2 mm. Nonstandard specimens may be either thicker or thinner but in no case less than 6 mm. The lateral dimensions of both standard and nonstandard specimens shall be such that no test is made at a distance from the edge of the specimen less than the appropriate distance shown in Table 2.

6.5 *Type H*—Refer to 6.2 (Types S1 and S2).

7. Test Temperature

7.1 The test shall be normally carried out at 23 ± 2°C (73.4 ± 3.6°F). The specimens shall be maintained at the test temperature for at least 3 h immediately prior to testing. Specimens that are sensitive to atmospheric moisture shall be conditioned in an atmosphere controlled to 50 ± 5 % relative humidity (RH%) for at least 24 h. When tests are made at higher or lower temperatures, the specimens shall be maintained at the conditions of test for a period of time sufficient to reach temperature equilibrium with the testing chamber, and the temperatures shall be chosen from those specified in Practice D1349, or as otherwise agreed upon between customer and supplier.

8. Procedure

8.1 Condition the specimen in accordance with 7.1. Slightly dust the upper and lower surfaces of the test specimen with

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