



Designation: D 1415 – 88 (Reapproved 1999)

Standard Test Method for Rubber Property—International Hardness¹

This standard is issued under the fixed designation D 1415; 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 a procedure for measuring the hardness of 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 identical in substance with 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:*

D 1349 Practice for Rubber—Standard Temperatures for Testing²

D 2240 Test Method for Rubber Property—Durometer Hardness²

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

2.2 *ISO Standard:*

ISO/48 Vulcanized Rubbers—Determination of Hardness (Hardness between 30 and 85 IRHD)³

3. Summary of Test Methods

3.1 Two procedures are given to accommodate specimens of different dimensions. The standard test is intended to be used on specimens greater than 4 mm in thickness, preferably 8 to 10 mm. The micro-tester is used on specimens less than 4 mm in thickness, on specimens thicker than 4 mm having lateral dimensions less than those specified for the standard test, or on rubber articles that do not have flat surfaces suitable for making the standard test. In both procedures, the hardness in Interna-

tional 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.

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 International Rubber Hardness Degrees, 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. The scale chosen also fulfills the following conditions over most of the normal range of hardness: one International Rubber Hardness Degree range represents approximately the same proportionate difference in Young's modulus, and for rubber vulcanizates in the usual range of resilience, readings in International Rubber Hardness Degrees are comparable with those given by a Type A durometer (Test Method D 2240D 2240) when testing standard specimens. 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 result in differences in hardness values. Readings may not be comparable when testing curved or irregularly shaped test pieces.

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

4.1.2 The relation between the difference of penetration and the hardness expressed in International Rubber Hardness Degrees is based on the following:

4.1.2.1 The relation⁴ between penetration and Young's modulus for a perfectly elastic isotropic material:

$$F/M = 1.9 R^2(P/R)^{1.35} \quad (1)$$

¹ This test method is under the jurisdiction of ASTM Committee D-11 on Rubber and is the direct responsibility of Subcommittee D11.10 on Physical Testing.

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

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

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

where:

F = indenting force,
 M = Young's modulus, MPa,
 R = radius of ball, mm, and
 P = penetration, mm.

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

4.1.2.3 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.

4.1.2.4 The maximum slope is equal to 57 International Rubber Hardness Degrees 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 International Rubber Hardness Degrees 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 parallel upper and lower surfaces. Two pieces of rubber, but not more than two, may be superimposed to obtain the required thickness. The dimensions of the specimen depend on the tester used to measure the hardness.

6.2 *Standard Tester*—The standard specimen shall be between 8 and 10 mm in thickness; nonstandard specimens may be either thicker or thinner but in no case less than 4 mm thick. The lateral dimensions of both standard and nonstandard specimens shall be not less than 20 mm, and no test shall be made at a distance from the edge of the specimen less than the appropriate distance shown in Table 2.

6.3 *Micro Tester*—The standard specimen for the micro test procedure shall be between 2 and 2.5 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 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.

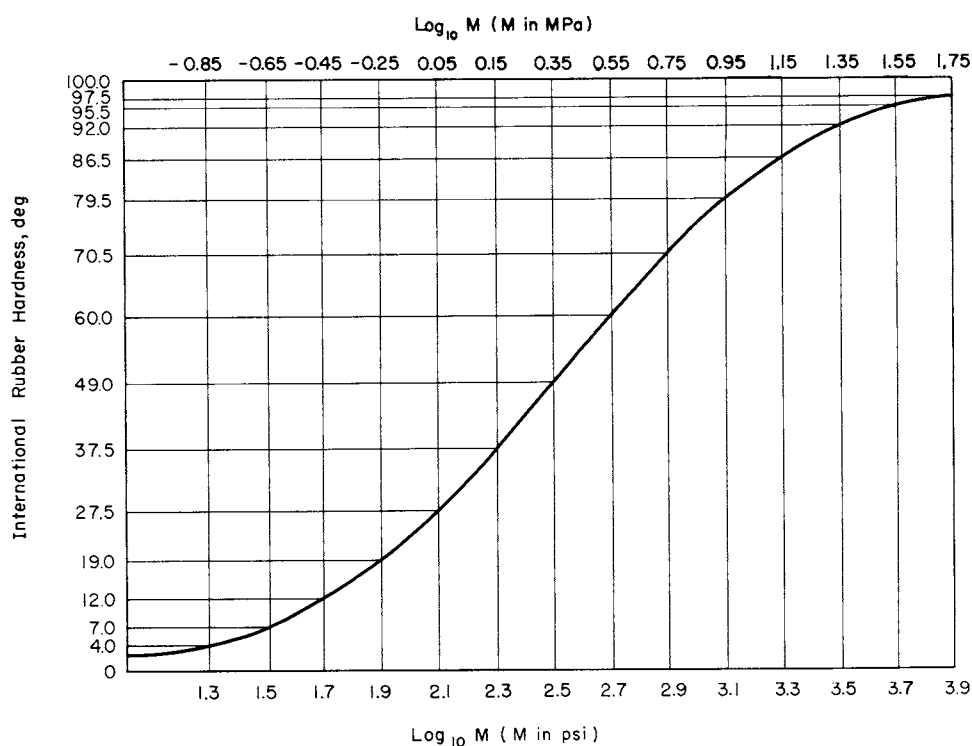


FIG. 1 Point Curve to Relate $\log_{10} M$ and the Hardness in International Rubber Hardness Degrees