

**CHANGE NOTICES ARE NOT
CUMULATIVE AND SHALL
BE RETAINED UNTIL SUCH
TIME AS THE ENTIRE
STANDARD IS REVISED.
RETAIN CHANGE NOTICES 1,
2, AND 3**

FED. TEST METHOD STD. NO. 601

April 12, 1955

CHANGE NOTICE 4

November 26, 1962

FEDERAL TEST METHOD STANDARD

RUBBER: SAMPLING AND TESTING

The following changes in Federal Test Method Standard No 601, dated April 12, 1955, have been approved by the Commissioner, Federal Supply Service, General Services Administration, for the the use of all Federal agencies

1. **New method.** The following new method is a part of this standard:

3061 Hardness, International, of Vulcanized, Natural and Synthetic Rubbers

RETAIN THIS COVER PAGE AND INSERT BEFORE THE TABLE OF
CONTENTS OF THIS STANDARD

FED. TEST METHOD STD. NO. 601

Method 3061
November 26, 1962

HARDNESS, INTERNATIONAL, OF VULCANIZED, NATURAL AND SYNTHETIC RUBBERS

1. SCOPE

1.1 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.

- (1) One International Rubber Hardness degree always represents approximately the same proportionate difference in Young's modulus, and
- (2) Readings in International Rubber Hardness degrees are approximately the same as those given by the durometer described in Method 3021

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. The relation between the difference of penetration and the hardness expressed in International Rubber Hardness degrees is based on the following.

- (1) The known relation* between penetration and Young's modulus for a perfectly elastic isotropic material, namely,

$$F/M = 0.00017 R^{0.67} P^{1.35}$$

where:

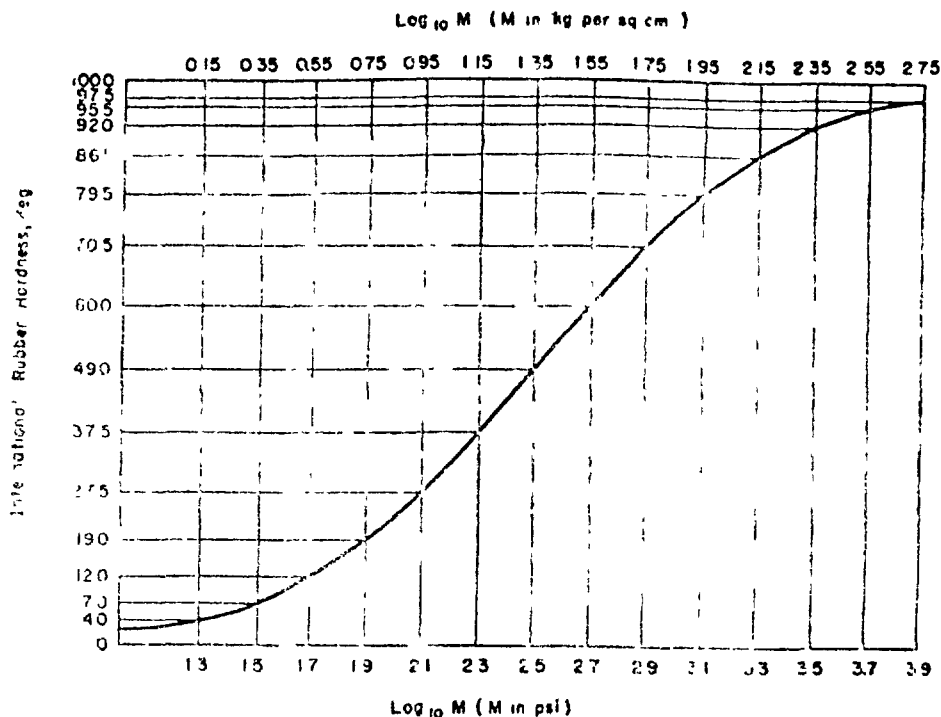
- F = indenting force in kilograms.
- M = Young's modulus in kilograms per square centimeter.
- P = penetration in hundredths of millimeters
- R = radius of ball in centimeters.

* This formula is approximate and is included as an indication.

- (2) Use of a probit (integrated normal error) curve to relate $\log_{10} M$ and the hardness in International Rubber Hardness degrees, as shown in figure 3061. The curve is defined as follows

Method 3061

November 26, 1962



The value of $\text{log}_{10} M$ corresponding to the midpoint of the curve is equal to 1.372, that is, $M = 23.55$ Kg per sq cm or 335 pounds per square inch.

The maximum slope is equal to 57 International Rubber Hardness degrees per unit increase in $\text{log}_{10} M$.

1.2 The hardness test consists of measuring the difference between the depths of penetration of the ball into the rubber under a small initial load and a large final load. Two types of apparatus are described to accommodate specimens of different dimensions. The standard tester for testing specimens greater than 4 mm in thickness, preferably 8 to 10 mm, and the microtester for testing specimens less than 4 mm in thickness. Specimens thicker than 4 mm having lateral dimensions less than those specified for the standard test, and rubber articles that do not have flat surfaces suitable for

use in the standard tester. In both procedures, the hardness in International Hardness degrees (IRHD) is derived from the difference in penetrations and a table or graph constructed from the table. Curved specimens, e.g., O-rings, may be tested with the microtester but the values obtained may not be identical with those obtained with flat specimens. The value obtained on the microtester for difference in penetration must first be multiplied by the scale factor 6. Alternatively, the penetration measuring instrument may be calibrated directly in International Rubber Hardness degrees.

2. SPECIMEN

2.1 Tests intended to be comparable shall 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 di-

Method 3061
November 26, 1962

mensions of the specimens depend on the tester used to measure the hardness

2.1.1 Standard tester Unless otherwise specified in the detail specification, the specimen shall be a portion of the test unit not less than 8 mm and not more than 10 mm thick. When specified in the detail specification, specimens thicker or thinner may be tested, but in no case shall they be less than 3 mm thick. The lateral dimensions of the specimen 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 I.

TABLE I—Size of specimen defined by location of test

| Total thickness of specimen | | Minimum distance from edge | |
|-----------------------------|------|----------------------------|------|
| mm | in | mm | in |
| 4 | 0.16 | 7.0 | 0.28 |
| 6 | .25 | 8.0 | .31 |
| 8 | .3 | 9.0 | .35 |
| 10 | .4 | 10.0 | .40 |
| 15 | .6 | 11.5 | .45 |
| 25 | 1.0 | 12.5 | .50 |

2.1.2 Microtester Unless otherwise specified in the detail specification, the specimen shall be a portion of the test unit not less than 2 mm and not more than 25 mm in thickness and its lateral dimensions shall be such that no test is made at a distance less than 2 mm from the edge. Specimens 2 to 25 mm. in thickness give hardness values practically identical to those obtained with the standard tester on specimens 8 to 10 mm. in thickness. When specified in the detail specification, thicker or thinner specimens may be tested but in no case shall they be less than 1 mm thick. 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. When specified in the detail specification, curved specimens, e.g., O-rings may be used.

3. APPARATUS

3.1 The essential parts of the apparatus shall be as follows; the appropriate dimensions and loads being given in table II:

3.1.1 A vertical plunger terminating in a rigid ball

3.1.2 Means for applying a minor load and a major load to the ball, the weight of the plunger and of any fittings attached to it and the force of any spring acting on it being included in the minor and major loads in order that the loads actually applied to the ball shall be as specified

3.1.3 A mechanical, optical, or electrical device graduated either in standard units of length or in International Rubber Hardness for measuring the increase in depth of penetration of the plunger caused by the major load

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

3.1.5 Means, e.g., an electrically operated buzzer, for gently vibrating the apparatus to overcome any slight friction which should not exceed 5 percent of the minor load. This part may be omitted on apparatus without any friction

Method 3061
November 26, 1962

TABLE II — Apparatus requirements

| | Standard testers | | Microtester |
|--|------------------|-------------|---------------------|
| | | | |
| Diameter of ball, mm | 2.38 ± 0.01 | 2.50 ± 0.01 | 0.395 ± 0.005 |
| Minor load on ball, grams ^a | 30 ± 2 | 30 ± 2 | 0.85 ± 0.05 |
| Major load on ball, grams | 531 ± 1 | 550 ± 1 | 14.85 ± 0.05 |
| Total load on ball, grams | 564 ± 3 | 580 ± 3 | 15.70 ± 0.10 |
| Outside diameter of foot, mm | 20 ± 1 | 20 ± 1 | 3.35 ± 0.15 |
| Inside diameter of foot, mm | 6 ± 1 | 6 ± 1 | 1.00 ± 0.15 |
| Load on foot, grams ^b | 850 ± 150 | 850 ± 150 | 24 ± 3 ^c |

a Includes frictional forces in apparatus

b The load should be adjusted within these limits to the actual area of the foot so that the pressure on the specimen is about 300 ± 5 grams per square centimeter

c Load on foot during application of total load on ball,

Load on foot during application of minor load on ball
21 gram minimum, 42 gram maximum

PROCEDURE

1.1 Unless otherwise specified in the detail specification, specimens shall be conditioned for 3 hours prior to testing, at a standard temperature of 23° ± 1°C (73.4° ± 1.8°F.) and a relative humidity of 50 ± 2 percent, and shall be tested in the same atmosphere. When higher or lower temperatures are specified, the specimens shall be maintained at the conditions of test for a time sufficient to reach equilibrium with the testing chamber.

1.2 If the material is too thick or has an uneven surface that may interfere with the test, the material shall be cut or buffed as described in method 1111.

1.3 The specimen shall be free from mechanical damage. The upper and lower surfaces of the specimen shall be slightly dusted with talc. The specimen shall be supported on a horizontal rigid surface and the foot lowered to rest on the surface of the specimen for 5 seconds. The plunger, with the minor load on the indenting ball, shall be

pressed vertically on to the specimen for 5 seconds.

1.4 If the gage is graduated directly in International Rubber Hardness degrees, the gage shall be adjusted to indicate 100. Care shall be exercised to avoid exerting any vertical pressure on the gage. The major load shall be added to the specimen and the total load on the ball maintained for 30 seconds. During the loading periods, the apparatus shall be gently vibrated if there is any friction. The reading on the gage shall be recorded as the hardness in International Rubber Hardness degrees. No measurement shall be made at a distance from the edge of the specimen less than either the appropriate distance shown in table I when the standard tester is used or 2 mm when the microtester is used.

1.5 If the gage is graduated in metric or inch units, the movement of the plunger caused by application of the major load for 30 seconds shall be recorded. If the microtester is used, multiply this movement by the scale factor 6. The value shall be converted into International Rubber Hardness degrees by using table III or a graph constructed from this table.

Method 3061
November 26, 1962

TABLE III—RELATION BETWEEN INTERNATIONAL RUBBER HARDNESS DEGREES (IRHD) AND PENETRATIONS DIFFERENCES

| IRHD | Movement of Plunger | | IRHD | Movement of Plunger | | IRHD | Movement of Plunger | | IRHD | Movement of Plunger | |
|------|---------------------|------|------|---------------------|------|------|---------------------|------|------|---------------------|------|
| | mm | mils | | mm | mils | | mm | mils | | mm | mils |
| 28 | 1 934 | 76 1 | 47 | 1 055 | 41 5 | 66 | 0 589 | 23 2 | 85 | 0 280 | 11 0 |
| 29 | 1 867 | 73 5 | 48 | 1 024 | 40 3 | 67 | 0 570 | 22 5 | 86 | 0 260 | 10 5 |
| 30 | 1 803 | 71 0 | 49 | 0 994 | 39 1 | 68 | 0 552 | 21 7 | 87 | 0 251 | 9 9 |
| 31 | 1 743 | 68 6 | 50 | 0 964 | 38 0 | 69 | 0 534 | 21 0 | 88 | 0 237 | 9 3 |
| 32 | 1 685 | 66 4 | 51 | 0 936 | 36 8 | 70 | 0 516 | 20 3 | 89 | 0 223 | 8 8 |
| 33 | 1 630 | 64 2 | 52 | 0 908 | 35 8 | 71 | 0 498 | 19 6 | 90 | 0 209 | 8 2 |
| 34 | 1 574 | 62 1 | 53 | 0 881 | 34 7 | 72 | 0 481 | 18 9 | 91 | 0 195 | 7 7 |
| 35 | 1 524 | 60 1 | 54 | 0 855 | 33 7 | 73 | 0 464 | 18 3 | 92 | 0 180 | 7 1 |
| 36 | 1 479 | 58 2 | 55 | 0 830 | 32 7 | 74 | 0 447 | 17 6 | 93 | 0 166 | 6 5 |
| 37 | 1 433 | 56 4 | 56 | 0 806 | 31 7 | 75 | 0 431 | 17 0 | 94 | 0 151 | 6 0 |
| 38 | 1 389 | 54 7 | 57 | 0 781 | 30 8 | 76 | 0 415 | 16 3 | 95 | 0 135 | 5 3 |
| 39 | 1 346 | 53 0 | 58 | 0 758 | 29 8 | 77 | 0 399 | 15 7 | 96 | 0 119 | 4 7 |
| 40 | 1 305 | 51 4 | 59 | 0 735 | 28 9 | 78 | 0 384 | 15 1 | 97 | 0 102 | 4 0 |
| 41 | 1 265 | 49 8 | 60 | 0 713 | 28 1 | 79 | 0 368 | 14 5 | 98 | 0 083 | 3 3 |
| 42 | 1 227 | 48 2 | 61 | 0 691 | 27 2 | 80 | 0 353 | 13 9 | 99 | 0 060 | 2 4 |
| 43 | 1 190 | 46 9 | 62 | 0 670 | 26 4 | 81 | 0 338 | 13 3 | 100 | 0 000 | 0 0 |
| 44 | 1 155 | 45 5 | 63 | 0 649 | 25 5 | 82 | 0 323 | 12 7 | | | |
| 45 | 1 120 | 44 1 | 64 | 0 629 | 24 7 | 83 | 0 309 | 12 2 | | | |
| 46 | 1 087 | 42 8 | 65 | 0 609 | 24 0 | 84 | 0 294 | 11 6 | | | |

5. RESULTS

5.1 Unless otherwise specified in the detail specification, five specimens shall be tested from each test unit.

5.2 The hardness of the test unit shall be the median of the values obtained from the specimens tested.

5.3 The hardness of the test unit shall be recorded to the nearest whole scale read-

ing and shall be expressed in International Rubber Hardness degrees (IRHD).

5.4 The dimensions of the specimen and the number of pieces, i.e., one or two, shall be recorded.

5.5 The type of surface tested, i.e., molded, buffed, or otherwise shall be recorded.

5.6 The type of tester used, i.e., standard or micro, shall be recorded.

5.7 The temperature of test shall be recorded.

FED. TEST METHOD STD. NO. 601