INTERNATIONAL STANDARD ISO 48

INTERNATIONAL ORGANIZATION FOR STANDARDIZATION • МЕЖДУНАРОДНАЯ ОРГАНИЗАЦИЯ ПО СТАНДАРТИЗАЦИИ • ORGANISATION INTERNATIONALE DE NORMALISATION

Vulcanized rubbers — Determination of hardness (Hardness between 30 and 85 IRHD)

Élastomères vulcanisés — Détermination de la dureté (Dureté comprise entre 30 et 85 D.I.D.C.)

First edition — 1975-04-01

UDC 678.4/.7 : 539.3

Ref. No. ISO 48-1975 (E)

Descriptors : elastomers, synthetic elastomers, natural rubber, vulcanized elastomers, tests, physical tests, hardness tests, hardness testers.

Price based on 5 pages

FOREWORD

ISO (the International Organization for Standardization) is a worldwide federation of national standards institutes (ISO Member Bodies). The work of developing International Standards is carried out through ISO Technical Committees. Every Member Body interested in a subject for which a Technical Committee has been set up has the right to be represented on that Committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work.

Draft International Standards adopted by the Technical Committees are circulated to the Member Bodies for approval before their acceptance as International Standards by the ISO Council.

Prior to 1972, the results of the work of the Technical Committees were published as ISO Recommendations; these documents are now in the process of being transformed into International Standards. As part of this process, Technical Committee ISO/TC 45 has reviewed ISO Recommendation R 48 and found it technically suitable for transformation. International Standard ISO 48 therefore replaces ISO Recommendation R 48-1968 to which it is technically identical.

ISO Recommendation R 48 was approved by the Member Bodies of the following countries :

Australia	Hungary	Poland
Austria	India	South Africa, Rep. of
Canada	Iran	Spain
Czechoslovakia	Israel	Sweden
Chile	Italy	Switzerland
Egypt, Arab Rep. of	Japan	Turkey
France	Korea, Rep. of	United Kingdom
Germany	Netherlands	U.S.A.
Greece	New Zealand	U.S.S.R.

No Member Body expressed disapproval of the Recommendation.

No Member Body disapproved the transformation of ISO/R 48 into an International Standard.

Printed in Switzerland

Vulcanized rubbers – Determination of hardness (Hardness between 30 and 85 IRHD)

0 INTRODUCTION

The hardness test specified in this International Standard is based on a measurement of the indentation of a rigid ball into a rubber test piece under specified conditions. For the normal test the standard test piece is between 8 and 10 mm thick; test pieces less than 8 mm thick give smaller indentation than the standard test piece. For tests on thin pieces of rubber a scaled-down version (hereinafter referred to as the micro-test) of the normal test is therefore used, in which the apparatus dimensions are reduced to one-sixth. When used on a piece 1,6 to 2 mm in thickness, the result of the micro-test will be about the same as that obtained by the normal test.

It is considered unrealistic to fix a precise thickness above which the normal test should be used and below which the micro-test should be used, but in general the latter test should be used for thicknesses below about 4 mm. There will, however, be exceptions; for instance, the micro-test would be preferable even on thicknesses above 4 mm if the lateral dimensions of the test piece are much less than those specified for the normal test (see table 2), because the latter test would then be inaccurate. The micro-test would also be preferable for testing some small awkwardly-shaped rubber articles. The figure of 4 mm has been chosen for the following reasons :

a) at this thickness the normal test will give readings in international rubber hardness degrees (IRHD) higher than the "standard" reading (i.e. on 8 to 10 mm thickness), and the micro-test will give readings lower than this (because this test gives the "standard" reading on a thickness of about 1,6 to 2,0 mm). These two errors are about equal when the thickness tested is 4 mm;

b) 4 mm is the greatest thickness on which the micro-test could be made without increasing the lateral dimensions of the test piece above that now specified (i.e. 2 mm minimum between the indenter and the edge of the test piece).

In either the normal test or the micro-test, the measured indentation is converted into international rubber hardness degrees, the scale of degrees being so chosen that 0 represents the hardness of a material having an elasticity modulus of zero and 100 represents the hardness of a material of infinite elasticity modulus, and so that the following conditions are fulfilled over most of the normal range of hardness :

a) one international rubber hardness degree always represents approximately the same proportionate difference in Young's modulus;

b) for highly elastic rubbers, the scales of international rubber hardness degrees and the Shore A durometer are comparable.

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.

1 SCOPE AND FIELD OF APPLICATION

This International Standard specifies a method for the determination of the hardness of vulcanized rubbers preferably of a hardness range between 30 and 85 IRHD; however, the method may also be used for those rubbers with a hardness between 30 and 95 IRHD.

Methods for very hard and very soft rubbers are the subject of ISO 1400 and ISO 1818 respectively; the range of applicability of each is indicated in the following figure :

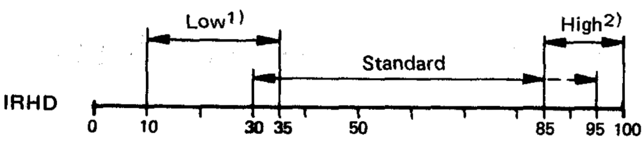

FIGURE 1 – **Range of applicability of hardness tests**

2 PRINCIPLE

The hardness test consists in measuring the difference between the depths of indentation of the ball into the rubber under a small contact force and a large total force. From this difference, multiplied when using the micro-test by the scale factor 6, the hardness in international rubber hardness degrees (IRHD) is derived by using either table 3 or a graph based on this table, or a scale reading directly in international rubber hardness degrees and derived from the table, fitted to the indentation-measuring instrument.

The relation between the difference of indentation and the hardness expressed in international rubber hardness degrees is based on :

a) the known relation, for a perfectly elastic isotropic material, between indentation P, expressed in hundredths of a millimetre, and Young's modulus M, expressed in meganewtons per square metre, namely :

$$\frac{F}{M} = 0{,}003\,8\, R^{0{,}65} P^{1{,}35} \,*$$

where

F is the indenting force, expressed in newtons;

R is the radius of the ball, expressed in millimetres;

b) the use of a probit (integrated normal error) curve to relate $\log_{10} M$ to the hardness in international rubber hardness degrees, as shown in figure 2. This curve is defined as

1) *the value of* $\log_{10} M$ *corresponding to the midpoint of the curve*
= 0,364 (M being expressed in meganewtons per square metre);

2) *the maximum slope*
= 57 international rubber hardness degrees per unit increase in $\log_{10} M$.

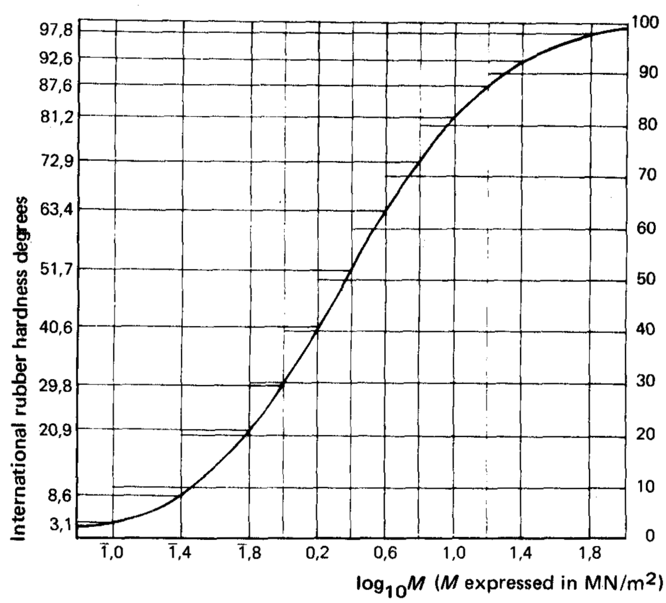

FIGURE 2 – **Relation of $\log_{10} M$ to hardness in international rubber hardness degrees**

3 APPARATUS

The essential parts of the apparatus are as follows, the appropriate dimensions and forces being shown in table 1 :

3.1 Vertical plunger having a rigid ball or spherical surface on the lower end, and means for supporting the plunger so that the spherical tip is kept slightly above the surface of the annular foot prior to applying the contact force.

3.2 Means for applying a contact force, and an additional indenting force to the plunger, making allowance for the weight of the plunger including any fittings attached to it and for the force of any spring acting on it, so that the forces actually transmitted through the spherical end of the plunger shall be as specified.

3.3 Means for measuring the increase in depth of indentation of the plunger caused by the indenting force, either in metric units or reading directly in IRHD. The means employed may be mechanical, optical or electrical.

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1) See ISO 1818.

2) See ISO 1400.

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

TABLE 1 – **Forces and dimensions of apparatus**

Test	Diameters	Force on ball			Force on foot
		Contact	Indenting	Total	
Normal	mm	N	N	N	N
	either ball 2,38 ± 0,01 foot 20 ± 1 hole 6 ± 1	0,30 ± 0,02	5,23 ± 0,01	5,53 ± 0,03	8,3 ± 1,5
	or ball 2,50 ± 0,01 foot 20 ± 1 hole 6 ± 1	0,30 ± 0,02	5,40 ± 0,01	5,70 ± 0,03	8,3 ± 1,5
Micro	mm	mN	mN	mN	mN[1)]
	ball 0,395 ± 0,005 foot 3,35 ± 0,15 hole 1,00 ± 0,15	8,3 ± 0,5	145 ± 0,5	153 ± 1	235 ± 30

1) In the micro-test using instruments in which the test piece table is pressed upwards by a spring (see Scott and Soden, *Trans. I.R.I.* 1960,3b, 1, Fig. 8), the values of foot pressure and force on foot are those acting during the period of application of the total force. Before the indenting force of 145 mN is applied, the force on the foot is greater by this amount, and hence equals 380 ± 30 mN.

3.4 Flat annular foot normal to the axis of the plunger and having a central hole for the passage of the plunger. The foot rests on the test piece and exerts a pressure on it of 30 ± 5 kN/m^2, provided the total load on the foot does not fall outside the values given in table 1. The foot shall be rigidly connected to the indentation measuring device, so that a measurement is made of the movement of the plunger relative to the foot (i.e. the top surface of the test piece), not relative to the surface supporting the test piece.

NOTE – All possible combinations of dimensions and forces in table 1 will not meet the pressure requirements of 3.4.

3.5 Means for gently vibrating the apparatus, for example an electrically operated buzzer, to overcome any slight friction (this may be omitted in instruments where friction is completely eliminated).

3.6 Chamber for the test piece when tests are made at temperatures other than a standard laboratory temperature. This chamber should be equipped with means of maintaining the temperature within 2 °C of the desired value. The foot and vertical plunger should extend through the top of the chamber, and the portion passing through the top shall be constructed from a material having a low thermal conductivity. A sensing device shall be located within the chamber, near or at the location of the test piece, for measuring the temperature.

4 TEST PIECE

4.1 Dimensions

The test piece shall have its upper and lower surfaces flat, smooth and parallel to one another.

Tests intended to be comparable shall be made on test pieces of the same thickness.

To obtain the necessary thickness, it is permissible to superimpose two pieces of rubber (but not more than two), provided these have flat parallel surfaces.

4.1.1 *Normal test*

The standard test piece shall be 8 to 10 mm thick. Non-standard test pieces may be either thicker or thinner, but usually the thickness should not be less than 4 mm. The lateral dimensions of both standard and non-standard test pieces shall be such that no test is made at a distance from the edge of the test piece less than the appropriate distance shown in table 2.

TABLE 2 – **Minimum distance of impact from test piece edge**

Total thickness of test piece	Minimum distance from point of impact to edge of test piece
mm	mm
4	7,0
6	8,0
8	9,0
10	10,0
15	11,5
25	13,0

4.1.2 *Micro-test*

The standard test piece shall have a thickness of 2 ± 0,5 mm. Because of the variable effects of surface hardening of the rubber and of any slight surface roughness (produced, for example, by buffing), no standard thickness of test piece will always give results agreeing with those of the normal test using its standard test piece. A thickness in the range 1,6 to 2 mm will most often give such agreement, but this will not always be exact. Thicker or thinner test pieces may be used, but in no case less than 1 mm thick. On such test pieces the readings will not in general agree with those given by the normal test. The lateral dimensions shall be such that no test is made at a distance from the edge less than 2 mm.

When test pieces thicker than 4 mm are tested on the micro-test instrument because lateral dimensions or area of flatness do not permit testing on a normal instrument, the test shall be made at a distance from the edge as great as possible.

Curved test pieces, O-rings for example, may be tested with the micro-instrument but the values may not be comparable with those obtained on flat test pieces.

4.2 Conditioning

Tests shall not be carried out less than 16 h after vulcanization and, for arbitration, not less than 72 h after vulcanization.

When a test is made at a standard laboratory temperature, the test pieces shall be maintained at the conditions of test for at least 3 h immediately before testing.

When tests are made at higher or lower temperatures, the test pieces shall be maintained at the conditions of test for a period of time sufficient to reach temperature equilibrium with the testing environment, or for the period of time required by the specification covering the material or product being tested.

5 TEMPERATURE OF TEST

The test should normally be carried out at a standard laboratory temperature (20 ± 2 °C, 23 ± 2 °C or 27 ± 2 °C); the same temperature shall be used throughout any one test or series of tests intended to be comparable.

6 PROCEDURE

The test piece shall first be conditioned as specified in 4.2. The upper and lower surfaces of the test piece shall be lightly dusted with talcum powder, and the test piece supported on a horizontal rigid surface. The foot shall first be brought into contact with the surface of the test piece. The plunger and indenting ball shall be pressed for 5 s onto the rubber, the force on the ball being the contact force.

a) If the gauge is graduated in international rubber hardness degrees, it shall be adjusted to read 100 at the end of the 5 s period. The additional indenting force shall then be applied and maintained for 30 s, when a direct reading of the hardness in international rubber hardness degrees is obtained.

b) If the gauge is graduated in metric units, the difference in indentations *D* (expressed in hundredths of a millimetre) of the plunger caused by the additional indenting force, applied for 30 s, shall be noted. This (after multiplying by the scale factor of 6 when using the apparatus for the micro-test), shall be converted into international rubber hardness degrees by using table 3 or a graph constructed therefrom.

During the loading periods, the apparatus may be gently vibrated to overcome any friction.

7 NUMBER OF READINGS

One measurement shall be made at either three or five different points distributed over the test piece and the median of the results shall be taken, i.e. the middle value when these are arranged in increasing order.

8 EXPRESSION OF RESULTS

Hardness shall be reported to the nearest whole number as the median of the three or five measurements in international rubber hardness degrees.

9 TEST REPORT

The test report shall include the following particulars :

a) hardness expressed in IRHD;

b) dimensions of test piece, and whether made up of one or two pieces;

c) temperature of test;

d) type of surface tested (moulded, buffed or otherwise);

e) type of apparatus used (normal or micro).

For instruments calibrated in international rubber hardness degrees, the following amounts shall be subtracted in case of readings lower than 34,4 IRHD.

Reading	Correction IRHD
33,3 to 34,3	0,1
32,3 to 33,2	0,2
31,7 to 32,2	0,3
31,1 to 31,6	0,4
30,7 to 31,0	0,5
30,2 to 30,6	0,6
30,0 to 30,1	0,7

TABLE 3 – **Conversion of values of *D* to international rubber hardness degrees (IRHD)**

D 0,01 mm	International rubber hardness degrees	*D* 0,01 mm	International rubber hardness degrees	*D* 0,01 mm	International rubber hardness degrees	*D* 0,01 mm	International rubber hardness degrees
0	100	45	73,9	90	52,3	135	38,9
1	100	46	73,3	91	52,0	136	38,7
2	99,9	47	72,7	92	51,6	137	38,4
3	99,8	48	72,2	93	51,2	138	38,2
4	99,6	49	71,6	94	50,9	139	38,0
5	99,3	50	71,0	95	50,5	140	37,8
6	99,0	51	70,4	96	50,2	141	37,5
7	98,6	52	69,8	97	49,8	142	37,3
8	98,1	53	69,3	98	49,5	143	37,1
9	97,7	54	68,7	99	49,1	144	36,9
10	97,1	55	68,2	100	48,8	145	36,7
11	96,5	56	67,6	101	48,5	146	36,5
12	95,9	57	67,1	102	48,1	147	36,2
13	95,3	58	66,6	103	47,8	148	36,0
14	94,7	59	66,0	104	47,5	149	35,8
15	94,0	60	65,5	105	47,1	150	35,6
16	93,4	61	65,0	106	46,8	151	35,4
17	92,7	62	64,5	107	46,5	152	35,2
18	92,0	63	64,0	108	46,2	153	35,0
19	91,3	64	63,5	109	45,9	154	34,8
20	90,6	65	63,0	110	45,6	155	34,6
21	89,8	66	62,5	111	45,3	156	34,4
22	89,2	67	62,0	112	45,0	157	34,2
23	88,5	68	61,5	113	44,7	158	34,0
24	87,8	69	61,1	114	44,4	159	33,8
25	87,1	70	60,6	115	44,1	160	33,6
26	86,4	71	60,1	116	43,8	161	33,4
27	85,7	72	59,7	117	43,5	162	33,2
28	85,0	73	59,2	118	43,3	163	33,0
29	84,3	74	58,8	119	43,0	164	32,8
30	83,6	75	58,3	120	42,7	165	32,6
31	82,9	76	57,9	121	42,5	166	32,4
32	82,2	77	57,5	122	42,2	167	32,3
33	81,5	78	57,0	123	41,9	168	32,1
34	80,9	79	56,6	124	41,7	169	31,9
35	80,2	80	56,2	125	41,4	170	31,7
36	79,5	81	55,8	126	41,1	171	31,6
37	78,9	82	55,4	127	40,9	172	31,4
38	78,2	83	55,0	128	40,6	173	31,2
39	77,6	84	54,6	129	40,4	174	31,1
40	77,0	85	54,2	130	40,1	175	30,9
41	76,4	86	53,8	131	39,9	176	30,7
42	75,8	87	53,4	132	39,6	177	30,5
43	75,2	88	53,0	133	39,4	178	30,4
44	74,5	89	52,7	134	39,1	179	30,2
						180	30,0