
**Rubber, vulcanized or thermoplastic —
Determination of hardness (hardness
between 10 IRHD and 100 IRHD)**

*Caoutchouc vulcanisé ou thermoplastique — Détermination de la dureté
(dureté comprise entre 10 DIDC et 100 DIDC)*



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ISO copyright office
Case postale 56 • CH-1211 Geneva 20
Tel. + 41 22 749 01 11
Fax + 41 22 749 09 47
E-mail copyright@iso.org
Web www.iso.org

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established 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. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 48 was prepared by Technical Committee ISO/TC 45, *Rubber and rubber products*, Subcommittee SC 2, *Testing and analysis*.

This fourth edition cancels and replaces the third edition (ISO 48:1994), which has been technically revised. It also incorporates the Amendment ISO 48:1994/Amd.1:1999.

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Introduction

The hardness test specified in this International Standard is intended to provide a rapid measurement of rubber stiffness, unlike hardness tests on other materials which measure resistance to permanent deformation.

Hardness is measured from the depth of indentation of a spherical indenter, under a specified force, into a rubber test piece. An empirical relationship between depth of indentation and Young's modulus for a perfectly elastic isotropic material has been used to derive a hardness scale which may conveniently be used for most rubbers.

When it is required to determine the value of Young's modulus itself, an appropriate test method should be used, for example that described in ISO 7743.

The guide to hardness testing, ISO 18517, may also be a useful reference.

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Rubber, vulcanized or thermoplastic — Determination of hardness (hardness between 10 IRHD and 100 IRHD)

WARNING — Persons using this International Standard should be familiar with normal laboratory practice. This standard does not purport to address all of the safety problems, if any, associated with its use. It is the responsibility of the user to establish appropriate safety and health practices and to ensure compliance with any national regulatory conditions.

CAUTION — Certain procedures specified in this International Standard may involve the use or generation of substances, or the generation of waste, that could constitute a local environmental hazard. Reference should be made to appropriate documentation on safe handling and disposal after use.

1 Scope

1.1 General

This International Standard specifies four methods for the determination of the hardness of vulcanized or thermoplastic rubbers on flat surfaces (standard-hardness methods) and four methods for the determination of the apparent hardness of curved surfaces (apparent-hardness methods). The hardness is expressed in international rubber hardness degrees (IRHD). The methods cover the hardness range from 10 IRHD to 100 IRHD.

The methods differ primarily in the diameter of the indenting ball and the magnitude of the indenting force, these being chosen to suit the particular application. The range of applicability of each method is indicated in Figure 1.

The determination of hardness by a pocket hardness meter is described in ISO 7619-2.

1.2 Standard-hardness methods

Method N: Normal test — This method is appropriate for rubbers with a hardness in the range 35 IRHD to 85 IRHD, but may also be used for hardnesses in the range 30 IRHD to 95 IRHD.

Method H: High-hardness test — This method is appropriate for rubbers with a hardness in the range 85 IRHD to 100 IRHD.

Method L: Low-hardness test — This method is appropriate for rubbers with a hardness in the range 10 IRHD to 35 IRHD.

Method M: Microtest — This method is essentially a scaled-down version of the normal test method N, permitting the testing of thinner and smaller test pieces. It is appropriate for rubbers with a hardness in the range 35 IRHD to 85 IRHD, but may also be used for hardnesses in the range 30 IRHD to 95 IRHD.

NOTE 1 The value of the hardness obtained by method N within the ranges from 85 IRHD to 95 IRHD and from 30 IRHD to 35 IRHD may not agree precisely with that obtained using method H or method L, respectively. The difference is not normally significant for technical purposes.

NOTE 2 Because of various surface effects in the rubber and the possibility of slight surface roughness (produced, for example, by buffing), the microtest may not always give results agreeing with those obtained by the normal test.

1.3 Apparent-hardness methods

Also specified are four methods, CN, CH, CL and CM, for the determination of the apparent hardness of curved surfaces. These methods are modifications of methods N, H, L and M, respectively, for cases where the rubber surface tested is curved. Two cases exist, depending whether

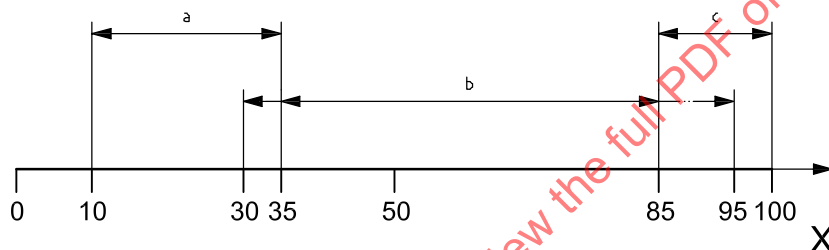
- a) the test piece or product tested is large enough for the hardness instrument to rest upon it;
- b) it is small enough for both the test piece and the instrument to rest upon a common support.

A variant of b) would be where the test piece rests on the specimen table of the instrument.

Apparent hardness can also be measured on non-standard flat test pieces using methods N, H, L and M.

The procedures described cannot provide for all possible shapes and dimensions of test piece, but cover some of the commonest types, such as O-rings.

Determination of the apparent hardness of rubber-covered rollers is dealt with separately in the various parts of ISO 7267.



Key

X hardness (IRHD)

a Method L and method CL.

b Methods N and M and methods CN and CM.

c Method H and method CH.

Figure 1 — Range of applicability

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 18898, *Rubber — Calibration and verification of hardness testers*

ISO 23529, *Rubber — General procedures for preparing and conditioning test pieces for physical test methods*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

3.1

international rubber hardness degree scale

IRHD scale

hardness scale chosen so that 0 represents the hardness of material having a Young's modulus of zero and 100 represents the hardness of a material of infinite Young's modulus, with the following applying over most of the normal range of hardnesses:

- a) one international rubber hardness degree always represents approximately the same proportional difference in Young's modulus;
- b) for highly elastic rubbers, the IRHD and Shore A scales are comparable

3.2

standard hardness

hardness, reported to the nearest whole number in international rubber hardness degrees, obtained using the procedures described in methods N, H, L and M on test pieces of the standard thickness and not less than the minimum lateral dimensions specified

3.3

apparent hardness

hardness, reported to the nearest whole number in international rubber hardness degrees, obtained using the procedures described in methods N, H, L and M on test pieces of non-standard dimensions, as well as hardness values obtained using methods CN, CH, CL and CM

NOTE Values obtained by methods CN, CH, CL and CM are always given as apparent hardnesses since tests are commonly made on the complete article where the thickness of the rubber may vary and, in many cases, the lateral dimensions may not provide the minimum distance between the indenter and the edge necessary to eliminate edge effects. Thus the readings obtained do not in general coincide with readings obtained on standard test pieces as defined in methods N, H, L and M or on a flat parallel-faced slab of the same thickness as the article. Moreover, the readings may depend appreciably on the method of support of the article and whether or not a presser foot is used. It should, therefore, be recognized that results obtained on curved surfaces are arbitrary values applicable only to test pieces or articles of one particular shape and of particular dimensions, and supported in one particular way, and in extreme cases such values may differ from the standard hardness by as much as 10 IRHD. Furthermore, surfaces that have been buffed or otherwise prepared to remove cloth markings, etc., may give slightly different hardness values from those with a smooth, moulded finish.

4 Principle

The hardness test consists in measuring the difference between the depths of indentation of a ball into the rubber under a small contact force and a large (indenting) force. From this difference, multiplied when using the microtest by the scale factor 6, the hardness in international rubber hardness degrees (IRHD) is obtained from Tables 3 to 5 or from graphs based on these tables or from a scale, reading directly in international rubber hardness degrees, calculated from the tables and fitted to the indentation-measuring instrument. These tables and curves are derived from the empirical relationship between indentation depth and hardness given in Annex A.

5 Apparatus

5.1 General

Calibration and verification of the apparatus shall be performed in accordance with ISO 18898.

5.2 Methods N, H, L and M

The essential parts of the apparatus are as specified in 5.2.1 to 5.2.6, the appropriate dimensions and forces being shown in Table 1.

5.2.1 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.

5.2.2 Means for applying a contact force and an additional indenting force to the plunger, making allowance for the mass 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 are as specified.

5.2.3 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 gauge employed may be mechanical, optical or electrical.

5.2.4 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 $30 \text{ kPa} \pm 5 \text{ kPa}$ provided that 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.

Table 1 — Forces and dimensions of apparatus

Test	Diameters mm	Force on ball			Force on foot N
		Contact N	Indenting N	Total N	
Method N (normal test)	Ball $2,50 \pm 0,01$ Foot 20 ± 1 Hole 6 ± 1	$0,30 \pm 0,02$	$5,40 \pm 0,01$	$5,70 \pm 0,03$	$8,3 \pm 1,5$
Method H (high hardness)	Ball $1,00 \pm 0,01$ Foot 20 ± 1 Hole 6 ± 1	$0,30 \pm 0,02$	$5,40 \pm 0,01$	$5,70 \pm 0,03$	$8,3 \pm 1,5$
Method L (low hardness)	Ball $5,00 \pm 0,01$ Foot 22 ± 1 Hole 10 ± 1	$0,30 \pm 0,02$	$5,40 \pm 0,01$	$5,70 \pm 0,03$	$8,3 \pm 1,5$
Method M (microtest)	mm	mN	mN	mN	mN
	Ball $0,395 \pm 0,005$ Foot $3,35 \pm 0,15$ Hole $1,00 \pm 0,15$	$8,3 \pm 0,5$	$145 \pm 0,5$	$153,3 \pm 1,0$	235 ± 30

NOTE 1 In the microtest, when using instruments in which the test piece table is pressed upwards by a spring, the values of the foot pressure and the force on the 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 $380 \text{ mN} \pm 30 \text{ mN}$.

NOTE 2 Not all possible combinations of dimensions and forces given in this table will meet the pressure requirements of 5.2.4.

5.2.5 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 effectively eliminated.)

5.2.6 Chamber for the test piece, when tests are made at temperatures other than a standard laboratory temperature. This chamber shall be equipped with a means of maintaining the temperature within 2 °C of the desired value. The foot and vertical plunger shall 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 (see ISO 23529).

5.3 Methods CN, CH, CL and CM

5.3.1 General

The apparatus used shall be essentially that described in 5.2 but differing in the following respects.

5.3.2 Cylindrical surfaces of radius greater than 50 mm

The base of the instrument shall have a hole below the plunger, allowing free passage of the annular foot such that measurement may be made above or below the base.

The lower surface of the base shall be in the form of two cylinders parallel to each other and the plane of the base. The diameter of the cylinders and their distance apart shall be such as to locate and support the instrument on the curved surface to be tested. Alternatively, the modified base may be fitted with feet movable in universal joints so that they adapt themselves to the curved surface.

5.3.3 Surfaces with double curvature of large radius greater than 50 mm

The instrument with adjustable feet described in 5.3.2 shall be used.

5.3.4 Cylindrical surfaces of radius 4 mm to 50 mm or small test pieces with double curvature

On surfaces too small to support the instrument, the test piece or article shall be supported by means of special jigs or V-blocks so that the indenter is vertically above the test surface. Wax may be used to fix small items to the test piece table.

In general, an instrument as described for method M should be used only where the thickness of the rubber tested is less than 4 mm.

NOTE Instruments for method M in which the test piece table is pressed upwards by a spring are not suitable for use on large test pieces or articles with a large radius of curvature.

5.3.5 Small O-rings and articles of radius of curvature less than 4 mm

These shall be held in suitable jigs or blocks or secured by wax to the instrument table. Measurements shall be made using the instrument for method M.

No test shall be made if the smallest radius is less than 0,8 mm.

6 Test pieces

6.1 General

Test pieces shall be prepared in accordance with ISO 23529.

6.2 Methods N, H, L and M

6.2.1 General

The test pieces shall have their 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.

6.2.2 Thickness

6.2.2.1 Methods N and H

The standard test piece shall be 8 mm to 10 mm thick and shall be made up of layers of rubber, the thinnest of which shall not be less than 2 mm thick. All surfaces shall be flat and parallel.

Non-standard test pieces may be either thicker or thinner, but not less than 4 mm thick.

6.2.2.2 Method L

The standard test piece shall be 10 mm to 15 mm thick and shall be made up of layers of rubber, the thinnest of which shall not be less than 2 mm thick. All surfaces shall be flat and parallel.

Non-standard test pieces may be either thicker or thinner, but not less than 6 mm thick.

6.2.2.3 Method M

The standard test piece shall have a thickness of $2 \text{ mm} \pm 0,5 \text{ mm}$. Thicker or thinner test pieces may be used, but in no case less than 1 mm thick. Readings made on such test pieces do not in general agree with those obtained on the standard test piece.

6.2.3 Lateral dimensions

6.2.3.1 Methods N, H and L

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 point of contact from test piece edge

Dimensions in millimetres

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

6.2.3.2 Method M

The lateral dimensions shall be such that no test is made at a distance from the edge of less than 2 mm.

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

6.3 Methods CN, CH, CL and CM

The test piece shall be either a complete article or a piece cut therefrom. The underside of a cut piece shall be such that it can be properly supported during the hardness test. If the surface on which the test is to be made is cloth-marked, it shall be buffed prior to testing. Test pieces shall be allowed to recover at a standard laboratory temperature (see ISO 23529) for at least 16 h after buffing and shall be conditioned in accordance with Clause 8. The conditioning period may form part of the recovery period.

7 Time-interval between vulcanization and testing

Unless otherwise specified for technical reasons, the following requirements shall be observed (see ISO 23529):

- For all normal test purposes, the minimum time between vulcanization and testing shall be 16 h. In cases of arbitration, the minimum time shall be 72 h.
- For non-product tests, the maximum time between vulcanization and testing shall be 4 weeks and, for evaluations intended to be comparable, the tests, as far as possible, shall be carried out after the same time-interval.
- For product tests, whenever possible, the time between vulcanization and testing shall not exceed 3 months. In other cases, tests shall be made within 2 months of the date of receipt by the purchaser of the product.

8 Conditioning of test pieces

8.1 When a test is made at a standard laboratory temperature (see ISO 23529), the test pieces shall be maintained at the conditions of test for at least 3 h immediately before testing.

8.2 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, and then immediately tested.

9 Temperature of test

The test shall normally be carried out at standard laboratory temperature (see ISO 23529). When other temperatures are used, these shall be selected from the list of preferred temperatures specified in ISO 23529.

10 Procedure

Condition the test piece as specified in Clause 8.

Lightly dust the upper and lower surfaces of the test piece with dusting powder. Place the test piece on a horizontal rigid surface. Bring the foot into contact with the surface of the test piece. Press the plunger and indenting ball for 5 s on to the rubber, the force on the ball being the contact force.

NOTE Talc has been found to be a suitable dusting powder.

If the gauge is graduated in international rubber hardness degrees (IRHD), adjust it to read 100 at the end of the 5 s period; then apply the additional indenting force and maintain it for 30 s, when a direct reading of the hardness in international rubber hardness degrees is obtained.

If the gauge is graduated in metric units, note the differential indentation D (in hundredths of a millimetre) of the plunger caused by the additional indenting force, applied for 30 s. Convert this (after multiplying by the scale factor of 6 when using the apparatus for the microtest) into international rubber hardness degrees, using Tables 3 to 5 or a graph constructed therefrom.

During the loading periods, vibrate the apparatus gently unless it is essentially free of friction.

11 Number of readings

Make one measurement at each of a minimum of three different points distributed over the test piece and separated from each other by a minimum of 6 mm, and take the median of the results when these are arranged in increasing order.

12 Expression of results

Express the hardness, to the nearest whole number, as the median of the individual measurements in international rubber hardness degrees, indicated by the degree sign (°) followed by:

- a) either the letter S indicating that the test piece was of the standard thickness or, for tests on non-standard test pieces, the actual test piece thickness and the smaller lateral dimension (in millimetres) (the result then being an apparent hardness);
- b) the code-letter for the method, i.e. N for the normal test, H for the high-hardness test, L for the low-hardness test and M for the microtest;
- c) for tests on curved surfaces, the prefix letter C.

EXAMPLE 1 58°, SN

EXAMPLE 2 16°, 8 × 25 mm, L

EXAMPLE 3 90°, CH

13 Precision

See Annex B.

**Table 3 — Conversion of values of D to international rubber hardness degrees (IRHD)
for use in method N**

D = differential indentation, in hundredths of a millimetre, with 2,5 mm indenter

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

Table 4 — Conversion of values of D into international rubber hardness degrees (IRHD) for use in method H D = differential indentation, in hundredths of a millimetre, with 1 mm indenter

D	IRHD	D	IRHD	D	IRHD	D	IRHD	D	IRHD	D	IRHD
0	100,0	8	99,3	16	97,0	24	93,8	32	90,2	40	86,6
1	100,0	9	99,1	17	96,6	25	93,4	33	89,7	41	86,1
2	100,0	10	98,8	18	96,2	26	92,9	34	89,3	42	85,7
3	99,9	11	98,6	19	95,8	27	92,5	35	88,8	43	85,3
4	99,9	12	98,3	20	95,4	28	92,0	36	88,4	44	84,8
5	99,8	13	98,0	21	95,0	29	91,6	37	87,9		
6	99,6	14	97,6	22	94,6	30	91,1	38	87,5		
7	99,5	15	97,3	23	94,2	31	90,7	39	87,0		

Table 5 — Conversion of values of D into international rubber hardness degrees (IRHD) for use in method L D = differential indentation, in hundredths of a millimetre, with 5 mm indenter

D	IRHD	D	IRHD	D	IRHD	D	IRHD	D	IRHD	D	IRHD
110	34,9	146	26,8	182	21,1	218	17,0	254	13,8	290	11,5
112	34,4	148	26,4	184	20,8	220	16,8	256	13,7	292	11,4
114	33,9	150	26,1	186	20,6	222	16,6	258	13,5	294	11,3
116	33,4	152	25,7	188	20,3	224	16,4	260	13,4	296	11,2
118	32,9	154	25,4	190	20,1	226	16,2	262	13,3	298	11,1
120	32,4	156	25,0	192	19,8	228	16,0	264	13,1	300	11,0
122	31,9	158	24,7	194	19,6	230	15,8	266	13,0	302	10,9
124	31,4	160	24,4	196	19,4	232	15,6	268	12,8	304	10,8
126	30,9	162	24,1	198	19,2	234	15,4	270	12,7	306	10,6
128	30,4	164	23,8	200	18,9	236	15,3	272	12,6	308	10,5
130	30,0	166	23,5	202	18,7	238	15,1	274	12,5	310	10,4
132	29,6	168	23,1	204	18,5	240	14,9	276	12,3	312	10,3
134	29,2	170	22,8	206	18,3	242	14,8	278	12,2	314	10,2
136	28,8	172	22,5	208	18,0	244	14,6	280	12,1	316	10,1
138	28,4	174	22,2	210	17,8	246	14,4	282	12,0	318	9,9
140	28,0	176	21,9	212	17,6	248	14,3	284	11,8		
142	27,6	178	21,6	214	17,4	250	14,1	286	11,7		
144	27,2	180	21,3	216	17,2	252	14,0	288	11,6		

14 Test report

The test report shall include the following particulars:

- a) a reference to this International Standard;
- b) test piece details:
 - 1) the dimensions of the test piece,
 - 2) the number of layers and the thickness of the thinnest layer,
 - 3) in the case of curved or irregularly shaped test pieces, a description of the test piece,
 - 4) the method of preparation of the test piece from the sample, for example moulded, buffed, cut out,
 - 5) details of the compound and the cure, where appropriate;
- c) test method:
 - 1) the method used,
 - 2) for curved test pieces, the way in which the test piece was mounted and the way the test force was applied;
- d) test details:
 - 1) the time and temperature of conditioning prior to testing,
 - 2) the temperature of test, and the relative humidity, if necessary,
 - 3) any deviation from the procedure specified;
- e) test results:
 - 1) the number of test pieces,
 - 2) the individual test results,
 - 3) the median of the individual results, expressed as in Clause 12;
- f) the date of the test.

Annex A (normative)

Empirical relationship between indentation and hardness

The relationship between the differential indentation and the hardness expressed in international rubber hardness degrees is based on the following:

- a) The known relationship ^[10], for a perfectly elastic isotropic material, between indentation D , expressed in hundredths of a millimetre, and Young's modulus E , expressed in megapascals, viz:

$$D = 61,5R^{-0,48} \left[\left(\frac{F}{E} \right)^{0,74} - \left(\frac{f}{E} \right)^{0,74} \right]$$

where

F is the total indenting force, in newtons;

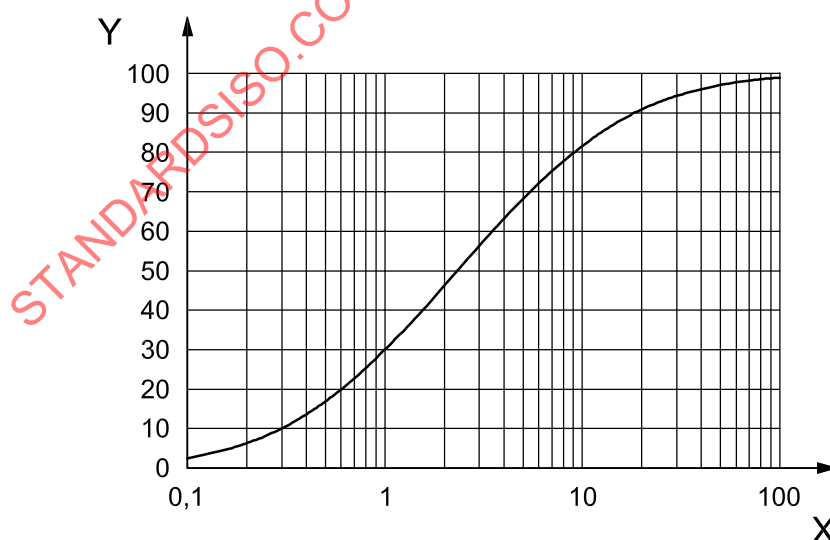
f is the contact force, in newtons;

R is the radius of the ball, in millimetres.

- b) The use of a probit (integrated normal error) curve to relate $\log_{10} E$ to the hardness in international rubber hardness degrees. This curve is defined in terms of

- 1) the value of $\log_{10} E$ corresponding to the midpoint of the curve: 0,364 (E being expressed in megapascals);
- 2) the maximum slope: 57 IRHD per unit increase in $\log_{10} E$.

Figures A.1, A.2 and A.3 show the relationship between E , in MPa, and IRHD as defined in 1) and 2).

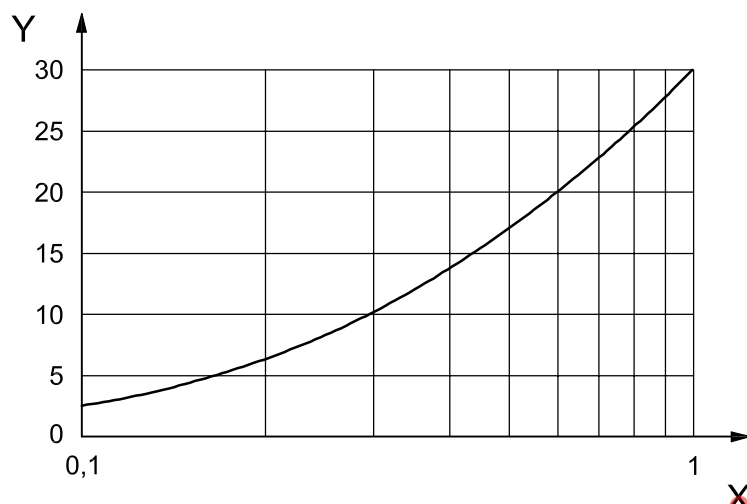


Key

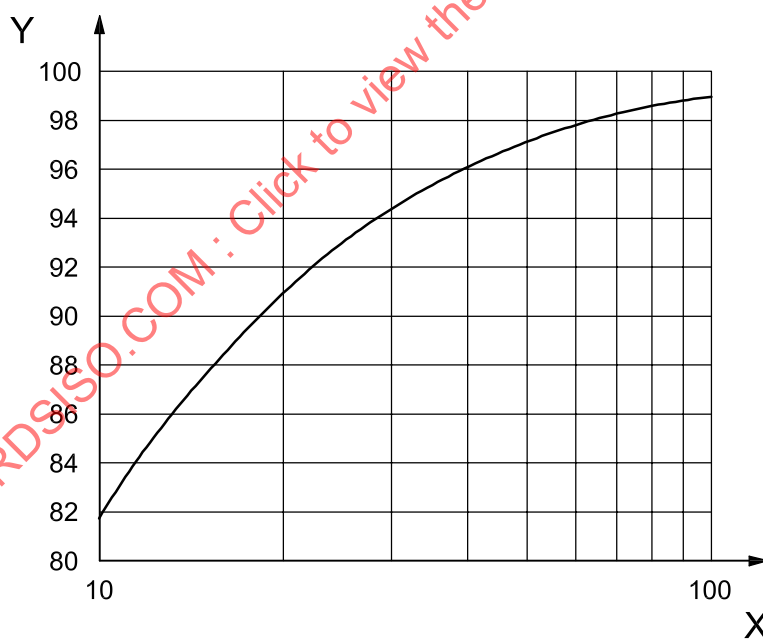
X E , in MPa

Y IRHD

Figure A.1 — Relationship between E and hardness in IRHD from 3 to 100

**Key**X E , in MPa

Y IRHD

Figure A.2 — Relationship between E and hardness in IRHD from 3 to 30**Key**X E , in MPa

Y IRHD

Figure A.3 — Relationship between E and hardness in IRHD from 80 to 100

Annex B (informative)

Precision

B.1 General

Interlaboratory test programmes (ITPs) were initially carried out between 1985 and 1989 (see B.2). A further ITP was carried out specifically for method M (the microtest method) in 2004 (see B.3). The precision calculations to provide repeatability and reproducibility values were performed in accordance with ISO/TR 9272. Consult this for precision concepts and nomenclature. Annex C gives guidance on the use of repeatability and reproducibility values.

NOTE The 1986 edition of ISO/TR 9272 was used for the interlaboratory test programmes carried out between 1985 and 1989, but the 2005 edition was used for the 2004 programme.

B.2 Precision results from the ITPs carried out between 1985 and 1989

B.2.1 Programme details

B.2.1.1 Five interlaboratory test programmes (ITPs) were organized and conducted by Statens Provningsanstalt (Sweden) between 1985 and 1989. Cured test pieces were prepared in one laboratory and sent to all the participants. The details of the five ITPs are as follows:

Medium-hardness rubbers, method N: Four rubber compounds, nominal hardness range 30 IRHD to 85 IRHD, 26 laboratories. Three determinations (measurements) of hardness on each compound on each of two days, one week apart, using method N. The median of the three was used as the “test result” for the precision analysis.

Medium-hardness rubbers, method M: Four rubber compounds, nominal hardness range 30 IRHD to 85 IRHD, 26 laboratories. Three determinations (measurements) of hardness on each of two days, one week apart, using method M. The median of the three was used as the “test result” for the precision analysis.

High-hardness rubbers, method N: Three rubber compounds, nominal hardness range 85 IRHD to 100 IRHD, 12 laboratories. Five determinations (measurements) of hardness on each of two days, one week apart, using method N. The median of the five was used as the “test result” for the precision analysis.

High-hardness rubbers, method H: Three rubber compounds, nominal hardness range 85 IRHD to 100 IRHD, 12 laboratories. Three determinations (measurements) of hardness on each of two days, one week apart, using method H. The median of the three was used as the “test result” for the precision analysis.

Low-hardness rubber, method L: One rubber compound of nominally low hardness, five laboratories. Three determinations (measurements) of hardness on each of two days, one week apart, using method L. The median of the three was used as the “test result” for the precision analysis.

B.2.1.2 The precision assessments are type 1 (cured, prepared test pieces circulated) and the time for repeatability and reproducibility is on a scale of days. For the low-hardness rubber, method L, due to the small number of laboratories in the precision evaluation programme the tabulated precision results should be used with caution.