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Rubber, vulcanized or thermoplastic — Determination of indentation hardness —

Part 1: Durometer method (Shore hardness)

*Caoutchouc vulcanisé ou thermoplastique — Détermination de la dureté
par pénétration —*

Partie 1: Méthode au duromètre (dureté Shore)



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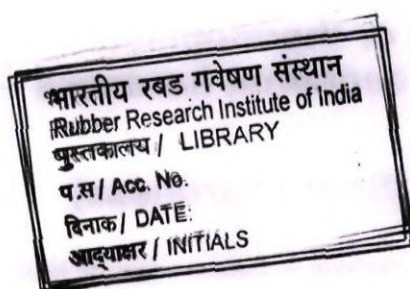
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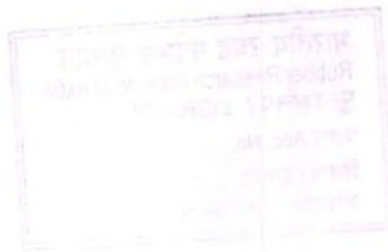
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Contents

Page

Foreword	iv
Introduction	v
1 Scope	1
2 Normative references	1
3 Principle and choice of durometer type	1
4 Apparatus	2
4.1 Durometer types A, D and AO	2
4.2 Durometer type AM	4
4.3 Stand	4
4.4 Durometer spring force calibration	5
5 Test pieces	5
5.1 General	5
5.2 Thickness	5
5.3 Surface	6
6 Conditioning and test temperature	6
7 Procedure	6
7.1 General	6
7.2 Test time	6
7.3 Measurements	6
8 Calibration and checking	6
8.1 Calibration	6
8.2 Checking using standard rubber blocks	7
9 Precision	7
10 Test report	7
Annex A (informative) Precision for the type AM durometer compared to that of Micro IRHD testing	8
Bibliography	10



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 7619-1 was prepared by Technical Committee ISO/TC 45, *Rubber and rubber products*, Subcommittee SC 2, *Testing and analysis*.

This second edition cancels and replaces the first edition (ISO 7619-1:2004), which has been technically revised to update the references to ISO 18898 for instrument calibration and ISO 23529 for the preparation of test pieces. It also incorporates the Amendment ISO 7619-1:2004/Amd.1:2008 which gives precision data (see Annex A).

ISO 7619 consists of the following parts, under the general title *Rubber, vulcanized or thermoplastic — Determination of indentation hardness*:

- *Part 1: Durometer method (Shore hardness)*
- *Part 2: IRHD pocket meter method*

Introduction

The hardness of rubber, as measured by a durometer (Shore hardness) or an IRHD pocket meter, is determined from the response of the rubber to an applied indentation. The response is a complex one and will depend upon:

- a) the elastic modulus of the rubber;
- b) the viscoelastic properties of the rubber;
- c) the thickness of the test piece;
- d) the geometry of the indenter;
- e) the pressure exerted;
- f) the rate of increase of pressure;
- g) the interval after which the hardness is recorded.

Because of these factors, it is inadvisable to relate results using a durometer (Shore hardness) directly to IRHD values, although correlations have been established for some individual rubbers and compounds.

Durometers were originally portable hand-held instruments that have proved to be particularly convenient for making measurements on products. Some laboratories now also use them on a stand with a weight applied to the pressure foot in order to improve precision.

NOTE ISO 48^[1] specifies hardness measurements for determination of hardness between 10 IRHD and 100 IRHD. Further information on the relationship between the durometer values and IRHD values is given in the literature^{[5][6][7]}.

Rubber, vulcanized or thermoplastic — Determination of indentation hardness —

Part 1: Durometer method (Shore hardness)

WARNING — Persons using this part of ISO 7619 should be familiar with normal laboratory practice. This part of ISO 7619 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 part of ISO 7619 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

This part of ISO 7619 specifies a method for determining the indentation hardness (Shore hardness) of vulcanized or thermoplastic rubber using durometers with the following scales:

- the A scale for rubbers in the normal-hardness range;
- the D scale for rubbers in the high-hardness range;
- the AO scale for rubbers in the low-hardness range and for cellular rubbers;
- the AM scale for thin rubber test pieces in the normal-hardness range.

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 Principle and choice of durometer type

The property measured is the depth of penetration of a specified indenter forced into the material under specified conditions.

When using durometers, the scale should be chosen as follows:

- for values less than 20 with a type D durometer: type A;
- for values less than 20 with a type A durometer: type AO;
- for values over 90 with a type A durometer: type D;
- for thin test pieces (less than 6 mm thick): type AM.

4 Apparatus

4.1 Durometer types A, D and AO

These durometers consist of the components specified in 4.1.1 to 4.1.5.

4.1.1 Pressure foot

The pressure foot for types A and D shall have a diameter of $18 \text{ mm} \pm 0,5 \text{ mm}$ and a central hole of diameter $3 \text{ mm} \pm 0,1 \text{ mm}$. For type AO, the pressure foot shall have a minimum area of 500 mm^2 with a central hole of diameter $5,4 \text{ mm} \pm 0,2 \text{ mm}$. The tolerances on the dimension of the central hole and the requirement for the size of the pressure foot only apply to instruments used on a stand.

4.1.2 Indentor

The indentor shall be formed from a hardened-steel rod of diameter $1,25 \text{ mm} \pm 0,15 \text{ mm}$ to the shape and dimensions shown in Figure 1 for type A durometers and Figure 2 for type D durometers. Type AO durometers shall have a round indentor with a radius of $2,5 \text{ mm} \pm 0,02 \text{ mm}$ in accordance with Figure 3.

4.1.3 Indicating device

This is a device for allowing the extent of protrusion of the point of the indentor beyond the face of the pressure foot to be read. It shall be calibrated directly in terms of units ranging from 0 for the maximum protrusion of $2,50 \text{ mm} \pm 0,02 \text{ mm}$ to 100 for zero protrusion obtained by placing the pressure foot and indentor in firm contact with a suitable flat, hard surface (e.g. glass).

4.1.4 Calibrated spring

This is used to apply a force, F , expressed in millinewtons, to the indentor in accordance with one of the following equations:

- For type A durometers:

$$F = 550 + 75H_A$$

where H_A is the hardness reading taken from the type A durometer.

- For type D durometers:

$$F = 445H_D$$

where H_D is the hardness reading taken from the type D durometer.

- For type AO durometers:

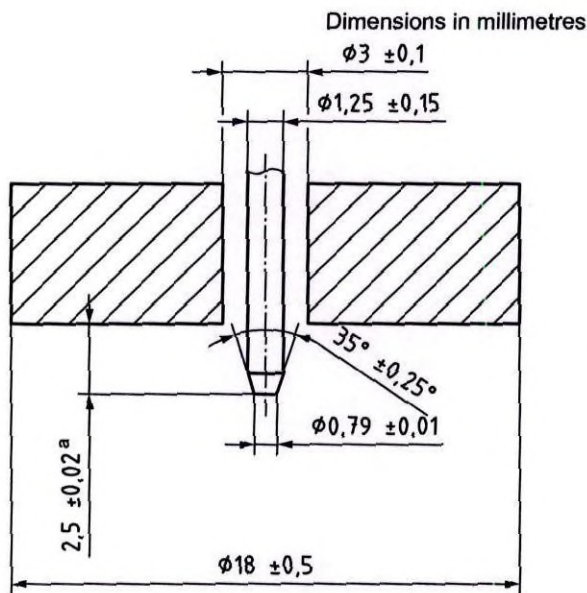
$$F = 550 + 75H_{AO}$$

where H_{AO} is the hardness reading taken from the type AO durometer.

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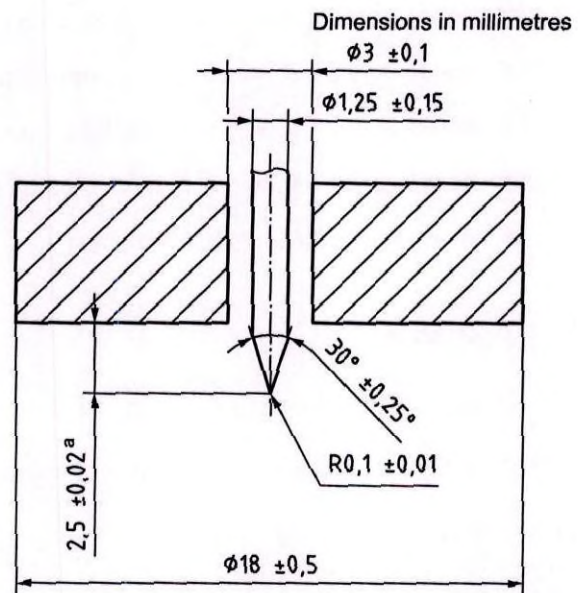
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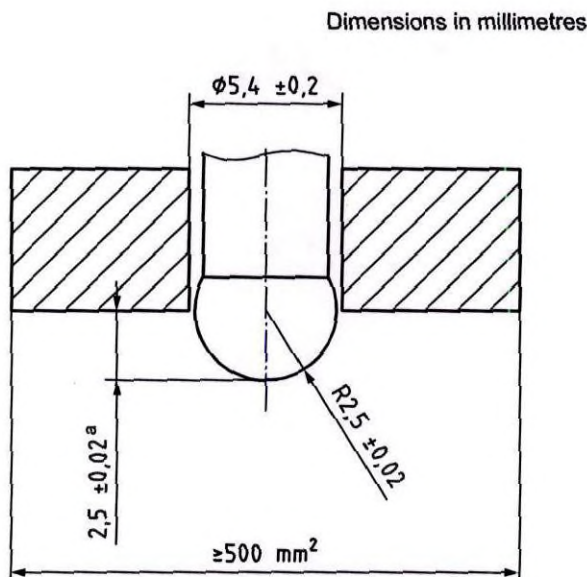
^a The protrusion shown is valid for a reading of 0.

Figure 1 — Indentor for type A durometer



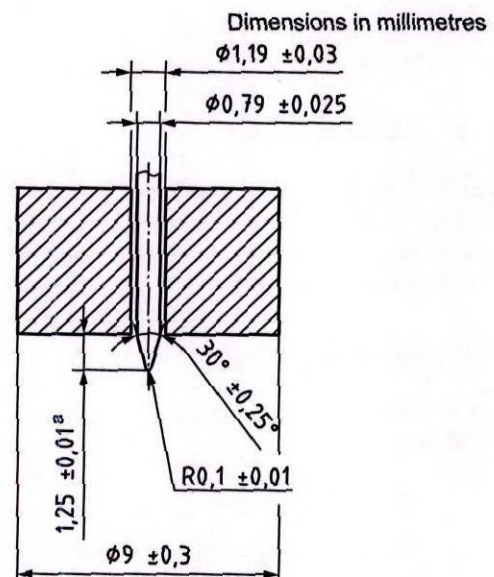
^a The protrusion shown is valid for a reading of 0.

Figure 2 — Indentor for type D durometer



^a The protrusion shown is valid for a reading of 0.

Figure 3 — Indentor for type AO durometer



^a The protrusion shown is valid for a reading of 0.

Figure 4 — Indentor for type AM durometer

4.1.5 Automatic timing device (optional)

The timer shall be automatically activated when the pressure foot is in contact with the test piece and shall indicate the end of the test time or lock the test value at its completion. Use of a timing device for the test time improves precision. When the instrument is used on a stand, the time tolerance shall be $\pm 0,3$ s.

4.2 Durometer type AM

This durometer consists of the components specified in 4.2.1 to 4.2.5.

4.2.1 Pressure foot

The pressure foot shall have a diameter of $9 \text{ mm} \pm 0,3 \text{ mm}$ and a central hole of diameter $1,19 \text{ mm} \pm 0,03 \text{ mm}$.

4.2.2 Indentor

The indentor shall be formed from a hardened-steel rod of diameter $0,79 \text{ mm} \pm 0,025 \text{ mm}$ to the shape and dimensions shown in Figure 4.

4.2.3 Indicating device

This is a device for allowing the extent of protrusion of the point of the indentor beyond the face of the pressure foot to be read. It shall be calibrated directly in terms of units ranging from 0 for the maximum protrusion of $1,25 \text{ mm} \pm 0,01 \text{ mm}$ to 100 for zero protrusion obtained by placing the pressure foot and indentor in firm contact with a suitable flat, hard surface (e.g. glass).

4.2.4 Calibrated spring

This is used to apply a force, F , expressed in millinewtons, to the indentor in accordance with the equation:

$$F = 324 + 4,4H_{AM}$$

where H_{AM} is the hardness reading taken from the type AM durometer.

4.2.5 Automatic timing device (optional)

The timer shall be automatically activated when the pressure foot is in contact with the test piece and shall indicate the end of the test time or lock the test value at its completion. Use of a timing device for the test time improves precision. The time tolerance shall be $\pm 0,3 \text{ s}$.

4.3 Stand

4.3.1 Better precision is obtained by using a stand with a weight centred on the axis of the indentor to apply the pressure foot to the test piece. Durometer types A, D and AO may be used either as pocket meters by hand or mounted on a stand. Type AM durometers shall always be mounted on a stand.

4.3.2 The operating stand shall be capable of supporting the pressure-foot surface of the durometer parallel to the test piece support table.

4.3.3 The stand shall be capable of applying the test piece to the indentor, or *vice versa*, without shock.

NOTE A maximum speed of $3,2 \text{ mm/s}$ has been found to be suitable.

4.3.4 The total mass of the durometer and extra mass to overcome the spring force shall be:

$1^{+0,1}_0 \text{ kg}$ for types A and AO;

$5^{+0,5}_0 \text{ kg}$ for type D;

$0,25^{+0,05}_0 \text{ kg}$ for type AM.

4.4 Durometer spring force calibration

The force values shall be in accordance with Table 1.

Table 1 — Durometer spring forces

Indicated durometer value	Spring force mN		
	Type AM	Type A and AO	Type D
0	324	550	—
10	368	1 300	4 450
20	412	2 050	8 900
30	456	2 800	13 350
40	500	3 550	17 800
50	544	4 300	22 250
60	588	5 050	26 700
70	632	5 800	31 150
80	676	6 550	35 600
90	720	7 300	40 050
100	764	8 050	44 500
Millinewtons (mN) per unit	4,4	75	445
Spring force tolerance	±8,8	±37,5	±222,5

NOTE For hand-held durometers, the tolerances may be increased; in particular, the spring force tolerance can be doubled.

5 Test pieces

5.1 General

Test pieces shall be prepared in accordance with ISO 23529.

5.2 Thickness

For the determination of hardness using type A, D and AO durometers, the thickness of the test piece shall be at least 6 mm.

For the determination of hardness using type AM durometers, the thickness of the test piece shall be at least 1,5 mm.

For sheets thinner than 6 mm and 1,5 mm (see above), the test piece may be composed of not more than three layers, in order to obtain the necessary thickness. However, determinations made on such test pieces might not agree with those made on single-layer test pieces.

For comparative-test purposes, the test pieces shall be similar.

NOTE Measurements made on thin test pieces of soft rubber will be influenced by the support table and will give a result which is too high.

5.3 Surface

The other dimensions of the test piece shall be sufficient to permit measurements at least 12 mm away from any edge for types A and D, and 15 mm and 4,5 mm away from any edge for type AO and type AM, respectively.

The surface of the test piece shall be flat and parallel over an area sufficient to permit the pressure foot to come into contact with the test piece over an area having a radius of at least 6 mm from the indenter point for types A and D, 9 mm for type AO and 2,5 mm for type AM.

Satisfactory hardness determinations cannot be made on rounded, uneven or rough surfaces using durometers. However, their use in certain specialized applications is recognized, e.g. ISO 7267-2^[3] for the determination of the hardness of rubber-covered rolls. In such applications, the limitations to their use shall be clearly identified.

6 Conditioning and test temperature

Where practical, test pieces shall be conditioned immediately before testing for a minimum period of 1 h at one of the standard laboratory temperatures specified in ISO 23529. The same temperature shall be used throughout any single test or series of tests intended to be comparable.

7 Procedure

7.1 General

Place the test piece on a flat, hard, rigid surface (e.g. glass). Apply the pressure foot to the test piece, or *vice versa*, as rapidly as possible but without shock, keeping the foot parallel to the surface of the test piece and ensuring that the indenter is normal to the rubber surface.

7.2 Test time

Apply a force in accordance with 4.3.3 sufficient only to obtain firm contact between the pressure foot and the test piece and take the reading at the specified time after the pressure foot is in firm contact with the test piece. The standard test time is 3 s for vulcanized rubber and 15 s for thermoplastic rubber. Other test times may be used, provided they are stated in the test report. Rubbers of unknown types should be treated as vulcanized.

NOTE A test time of 15 s has been introduced for thermoplastic rubber because the hardness value continues to decrease over a longer period of time than for vulcanized rubber, this test time being the same as that specified for plastics in ISO 868^[2].

7.3 Measurements

Make five measurements of hardness at different positions on the test piece at least 6 mm apart for types A, D and AO and at least 0,8 mm apart for type AM, and determine the median value.

If the time interval after which each reading was taken is different from 3 s, record the individual values of the indentation hardness together with the time interval after which each reading was taken, and determine the median value and the maximum and minimum values obtained.

8 Calibration and checking

8.1 Calibration

The instrument shall be adjusted and calibrated in accordance with ISO 18898.

8.2 Checking using standard rubber blocks¹⁾

Press the instrument against a suitable flat, hard surface (e.g. glass) and adjust the reading on the scale to give a value of 100. Continue the instrument check using a set of standard rubber blocks covering the measurement range. All adjustments shall be made in accordance with the manufacturer's instructions. The set of standard rubber blocks used shall consist of at least six test pieces kept lightly dusted with talc in a suitable covered container away from light, heat, oil and grease. The standard rubbers shall themselves be calibrated against the dead-load gauge at intervals not exceeding 1 year or when a drift in excess of 1 unit is observed. Instruments in regular use shall be checked at least each week against standard rubber blocks.

9 Precision

See Annex A.

10 Test report

The test report shall include the following information:

- a) sample details:
 - 1) a full description of the sample and its origin,
 - 2) a description of the test piece, including its thickness and, in the case of a composite test piece, the number of layers;
- b) the test method used, i.e. the reference number of this part of ISO 7619;
- c) test details:
 - 1) the temperature of test, and the relative humidity when the hardness of the material is dependent on the humidity,
 - 2) the type of instrument used,
 - 3) the time which elapsed between the preparation of the test piece and the measurement of its hardness,
 - 4) details of any deviation from the standard procedure,
 - 5) details of any operations not specified in this part of ISO 7619 and any incidents likely to have had an influence on the result;
- d) the test result, expressed as a whole number, together with the scale used, e.g. 75 Shore A;
- e) the date of the test.

1) Standard rubber hardness blocks are available from a number of instrument manufacturers and accredited test laboratories.

Annex A (informative)

Precision for the type AM durometer compared to that of Micro IRHD testing

A.1 An interlaboratory test programme (ITP) for precision evaluation for micro-hardness tests was conducted in 2004 using the precision procedures and guidelines described in the subsequently published ISO/TR 9272:2005^[4].

The precision was determined for a type AM durometer. The results are given in Tables A.1 and A.2. Although Micro IRHD testing is not specified in this test method, the precision for Micro International Rubber Hardness Degrees (Micro IRHD) was also evaluated for the purposes of comparison. ISO 48 includes the additional set of precision results for IRHD.²⁾

The *repeatability*, or local domain precision, for each of the hardness test methods was established for each material as the values found in Table A.1. Two individual test results (obtained by the proper use of this part of ISO 7619) that differ by more than the tabulated values of r (in measurement units) and (r) (in percent) should be considered as suspect, i.e. as having come from different populations, and should suggest that some appropriate investigative action be taken.

The *reproducibility*, or global domain precision, for the type AM durometer hardness test method was established for each material as the values found in Table A.1. Two individual test results obtained in different laboratories (by the proper use of this part of ISO 7619) that differ by more than the tabulated values of R (in measurement units) and (R) (in percent) should be considered as suspect, i.e. as having come from different populations, and should suggest that some appropriate investigative action be taken.

A.2 A type 1 precision was evaluated (for both tests) using cured test pieces prepared from four different rubber compounds, A, B, C and D (with a range of hardness values), supplied to each of the six laboratories participating in the ITP. On each of two test days, two weeks apart, the following test sequence was carried out. Three test pieces were furnished for each compound, and the median value of five hardness measurements on each of the three test pieces was obtained for each of two operators. For each operator, the median value was selected for all three test pieces. The two median values were then averaged to obtain a single value designated as the test result for that test day. Shore AM measurements were made on one side of the test piece and IRHD measurements were made on the reverse side. The precision analysis was based on test result data, i.e. two test result values per laboratory.

The ISO/TR 9272:2005 option 2 outlier treatment procedure, outlier replacement, was adopted since the ITP had the minimum number of six participating laboratories. This option 2 procedure replaces each outlier declared as significant with a value that is consistent with the data value distribution for the non-outlier data for that material. See ISO/TR 9272:2005 for the rationale behind this concept and for other details.

The precision results as determined by this ITP may not be applied to acceptance or rejection testing for any group of materials or products without documentation that the results of this precision evaluation actually apply to the materials or products tested.

A.3 The precision results for type AM durometer measurements are given in Table A.1, with the materials listed in order of increasing hardness. The results are given in terms of both absolute precision, r and R , and relative precision (r) and (R). General statements for the use of the precision results are given above.

2) This is to ensure that optimum use is made of the results on IRHD from the ITP for ISO 7619-1, given that these results might otherwise be discarded. Having precision in both documents (ISO 7619-1 and ISO 48) for IRHD expands the precision knowledge base for IRHD and provides more precision information on this method.

A.4 The precision results for Micro IRHD testing are given in Table A.2, with the materials listed in order of increasing hardness. The results are given in terms of both absolute precision, r and R , and relative precision (r) and (R). General statements for the use of the precision results are given above.

A.5 The results of the precision analyses in Tables A.1 and A.2 indicate that there is no pronounced trend for r or R versus hardness level over the 46 to 74 range. The repeatability parameters for the type AM durometer [$r = 0,88$, (r) = 1,47] and for Micro IRHD [$r = 1,14$, (r) = 2,04] are reasonably similar. However, the reproducibility of the two hardness measurement methods is substantially different: for Shore AM, $R = 5,08$ and (R) = 8,98, and for IRHD, $R = 2,20$ and (R) = 3,85. The reproducibility parameters R and (R) for IRHD are 43 % of the value(s) for Shore AM, indicating much better between-laboratory agreement for the IRHD measurements.

Table A.1 — Precision for ISO 7619-1 hardness — Type AM durometer

Material	Mean level	Within-laboratory			Between laboratories			Number of laboratories ^d
		Standard deviation	Repeatability (absolute)	Repeatability (relative)	Standard deviation	Reproducibility (absolute)	Reproducibility (relative)	
		s_r^a	r^a	(r) ^b	s_R^c	R^a	(R) ^b	
B (2)	47,9	0,276	0,772	1,61	2,32	6,5	13,57	6
C (3)	55,2	0,223	0,623	1,13	1,85	5,17	9,35	6 (1)
A (1)	62,8	0,404	1,13	1,8	1,95	5,45	8,68	6
D (4)	73,9	0,357	1	1,35	1,14	3,2	4,33	6 (1)
Average		—	0,881 25	1,472 5	—	5,08	8,982 5	—
NOTE See Clause A.5 for a discussion of the precision results in this table.								
^a In measurement units.								
^b In percent of mean level.								
^c For total between-laboratory variation, in measurement units.								
^d Number of option 2 outlier laboratory replacement values given in parentheses.								

Table A.2 — Precision for ISO 48 hardness — Micro IRHD

Material	Mean level	Within-laboratory			Between laboratories			Number of laboratories ^d
		Standard deviation	Repeatability (absolute)	Repeatability (relative)	Standard deviation	Reproducibility (absolute)	Reproducibility (relative)	
		s_r^a	r^a	(r) ^b	s_R^c	R^a	(R) ^b	
B (2)	45,6	0,404	1,13	2,48	0,954	2,67	5,85	6
C (3)	53,9	0,469	1,31	2,43	0,583	1,63	3,03	6 (1)
A (1)	63,7	0,605	1,7	2,66	0,728	2,04	3,2	6
D (4)	74	0,149	0,416	0,57	0,875	2,45	3,31	6 (1)
Average		—	1,139	2,035	—	2,197 5	3,847 5	—
NOTE See Clause A.5 for a discussion of the precision results in this table.								
^a In measurement units.								
^b In percent of mean level.								
^c For total between-laboratory variation, in measurement units.								
^d Number of option 2 outlier laboratory replacement values given in parentheses.								

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