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Plastics — Determination of hardness —

Part 1:
Ball indentation method

Plastiques — Détermination de la dureté —

Partie 1: Méthode de pénétration à la bille

Reference number
ISO 2039-1:2001(E)

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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 3.

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 part of ISO 2039 may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 2039-1 was prepared by Technical Committee ISO/TC 61, *Plastics*, Subcommittee SC 2, *Mechanical properties*.

This third edition cancels and replaces the second edition (ISO 2039-1:1993), subclause 8.3 and annex A of which have been technically revised.

ISO 2039 consists of the following parts, under the general title *Plastics — Determination of hardness*:

— *Part 1: Ball indentation method*

— *Part 2: Rockwell hardness*

Annex A of this part of ISO 2039 is for information only.

Plastics — Determination of hardness —

Part 1:
Ball indentation method

1 Scope

This part of ISO 2039 specifies a method for determining the hardness of plastics and ebonite by means of a loaded ball indenter.

The ball indentation hardness determined by this method may provide data for research and development, quality control and acceptance or rejection under specifications.

2 Normative reference

The following normative document contains provisions which, through reference in this text, constitute provisions of this part of ISO 2039. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. However, parties to agreements based on this part of ISO 2039 are encouraged to investigate the possibility of applying the most recent edition of the normative document indicated below. For undated references, the latest edition of the normative document referred to applies. Members of ISO and IEC maintain registers of currently valid International Standards.

ISO 291:1997, *Plastics — Standard atmospheres for conditioning and testing*

3 Term and definition

For the purposes of this part of ISO 2039, the following term and definition apply.

3.1
ball indentation hardness
HB
the quotient of the load on the ball indenter by the surface area of the impression caused by the ball indenter after a specified time of load application

NOTE It is expressed in newtons per square millimetre.

4 Principle

The method consists of forcing a ball under a specified load into the surface of the test specimen. The depth of impression is measured under load. The surface area of the impression is computed from its depth. The ball indentation hardness is then calculated from the following relationship:

Ball indentation hardness = Applied load/Surface area of impression

5 Apparatus

5.1 Hardness tester, consisting essentially of a frame with an adjustable platform fitted with a plate to support the test specimen, an indenter with its associated fittings and a device for applying the load without impact.

The tester shall also be equipped with a device to measure the depth of penetration of the indenter over a range of 0,4 mm with an accuracy of ± 0,005 mm.

The frame shall not be deformed under the maximum load by more than 0,05 mm, the deformation being measured along the main axis of the applied force.

The indenter shall be a hardened and polished steel ball. The ball shall not show any deformation or damage after the test.

The diameter of the ball shall be (5,0 ± 0,05) mm.

5.2 Timing device, accurate to ± 0,1 s

6 Test specimens

Each test specimen shall be a smooth flat sheet or block of sufficient size to minimize edge effects on the test result; for example 20 mm × 20 mm. The surfaces of the test specimen shall be parallel. A thickness of 4 mm is recommended.

The supported surface of the test specimen shall not show any deformation after testing.

NOTE 1 If test specimens with thicknesses less than 4 mm are to be tested, it is possible to stack several test specimens on top of each other. However, hardness values obtained on stacked test specimens and on single test specimens of the same thickness may be different.

NOTE 2 Although every effort should be made to ensure the parallelism of the specimen, there are some cases, especially specimens injection-moulded from semi-crystalline thermoplastics, where it is difficult to obtain test specimens that are exactly flat. If such slightly warped test specimens are used, part of the measured “depth of impression” will in fact correspond to the distance travelled by the indenter in pressing the test specimen down on to the supporting plate. This difficulty can be overcome by using a circular supporting plate of diameter (10 ± 1) mm. This diameter is also sufficiently large for perfectly flat test specimens. Also recommended is that the test specimen be placed with the flatter side towards the support plate.

7 Conditioning

Condition the test specimens, prior to testing, in one of the standard atmospheres specified in ISO 291.

8 Procedure

8.1 Unless otherwise specified, carry out the tests in the same atmosphere as was used for conditioning.

8.2 Place the test specimen on the supporting plate so that the test specimen is fully supported and its surfaces are perpendicular to the direction of the applied load.

Apply an initial load F_0 of (9,8 ± 0,1) N at a point not less than 10 mm from the edge of the test specimen. Set the depth-indicating device to zero and then smoothly apply the test load F_m (see 8.3) over a period of 2 to 3 s.

8.3 Choose the test load F_m from the values

49,0 N; 132 N; 358 N; 961 N (tolerance ± 1 %)

such that the depth of impression h after correction for deformation of the frame (see 8.7) is between 0,15 mm and 0,35 mm.

If values of the depth of impression after 30 s are outside this range (either in the case of a series of test specimens or in the case of an individual test specimen), change the test load to obtain a depth of impression *within the range specified above*. The number of test measurements which do not give correct depths of impression shall be reported.

If in a series of tests the test load has to be changed, the difference of hardness values occurring in the transition region between different test loads may lead to difficulties in the interpretation of the test results, e.g. when assessing the influence of heat ageing on hardness. In such cases, it is acceptable, by agreement between the interested parties, to extend the range of depths of impression beyond the limits given above, but not by more than 20 % of the range. Use that test load for which the majority of depths of impression of the test series in question lie between 0,15 mm and 0,35 mm.

8.4 Carry out the test in such a manner that any bubbles or cracks in the test specimen do not influence the results. If several determinations are carried out on the same test specimen, ensure that the points of application of the indenter are not less than 10 mm apart from each other and from the edge of the test specimen.

8.5 After 30 s of application of the test load F_m, measure the depth of impression under load, h_1, with the accuracy specified in 5.1.

8.6 Make ten valid tests on one or more test specimens.

8.7 Determine the deformation of the frame of the apparatus, h_2, in millimetres, as follows: Place a soft copper block (at least 6 mm thick) on the supporting plate and apply the initial load F_0. Set the depth-indicating device to zero and apply the test load F_m. Maintain the test load until the depth indicator is stationary. Note the reading, remove the test load and reset the depth indicator to zero.

Repeat this sequence of operations until the reading of the depth indicator is constant after each application of the test load. This represents the point at which no further penetration of the copper block takes place and therefore the constant depth reading is the movement of the depth-indicating device due to the deformation of the frame of the apparatus. Note this constant reading as h_2. The corrected depth of impression h is given by $h = h_1 - h_2$.

9 Expression of results

9.1 Calculate the reduced test load F_r, in newtons, as follows:

$$F_r = F_m \times \frac{\alpha}{(h - h_r) + \alpha} = F_m \times \frac{0{,}21}{h - 0{,}25 + 0{,}21}$$

where

F_m is the load, in newtons, on the indenter;

h_r is the reduced depth of impression (= 0,25 mm);

h_1 is the depth of impression, in millimetres, under the test load on the indenter;

h_2 is the deformation, in millimetres of the test apparatus under the test load;

h (= $h_1 - h_2$) is the depth of impression, in millimetres, after correcting for the deformation of the frame;

α (= 0,21) is a constant.

NOTE The values of h_r and α are taken from a paper by H.H. Racké and Th. Fett in *Materialprüfung*, **10** (1968), No. 7, p. 226.

9.2 Calculate the ball indentation hardness from the equation

$$\text{HB} = \frac{F_r}{\pi d h_r}$$

where

HB is the ball indentation hardness, in newtons per square millimetre;

F_r is the reduced test load, in newtons (see 9.1);

h_r is the reduced depth of impression, in millimetres (= 0,25 mm);

d is the diameter of the ball indenter (= 5 mm).

9.3 For values of HB lower than 250 N/mm^2, round to the nearest 1 N/mm^2.

For values of HB greater than 250 N/mm^2, round to the nearest multiple of 10 N/mm^2.

10 Test report

The test report shall include the following particulars:

a) a reference to this part of ISO 2039;

b) all details necessary for complete identification of the material tested;

c) the conditioning and the conditions under which the tests were carried out;

d) a description, the dimensions and the manner of preparation of the test specimens;

e) the number of tests averaged;

f) the number of tests which resulted in incorrect depths of impression;

g) the ball indentation hardness, average value and standard deviation;

h) the date of testing.

Annex A
(informative)

Value of the ball indentation hardness as a function of the depth of penetration and the test load

The values of HB in Table A.1 were calculated using the equations given in 9.1 and 9.2. When the corrected depth of impression h has been determined (see 8.7), the table can thus be used to read the value of HB directly.

Table A.1

Depth of impression, h	**Ball indentation hardness HB** in N/mm^2 for test loads F_m of			
mm	**49 N**	**132 N**	**358 N**	**961 N**
0,150	23,82	64,17	174,04	467,19
0,155	22,79	61,38	166,47	446,87
0,160	21,84	58,82	159,54	428,25
0,165	20,96	56,47	153,16	411,12
0,170	20,16	54,30	147,26	395,31
0,175	19,41	52,29	141,81	380,67
0,180	18,72	50,42	136,75	367,07
0,185	18,07	48,68	132,03	354,42
0,190	17,47	47,06	127,63	342,60
0,195	16,91	45,54	123,51	331,55
0,200	16,38	44,12	119,65	321,19
0,205	15,88	42,78	116,03	311,46
0,210	15,41	41,52	112,61	302,30
0,215	14,97	40,34	109,40	293,66
0,220	14,56	39,22	106,36	285,50
0,225	14,16	38,16	103,48	277,79
0,230	13,79	37,15	100,76	270,48
0,235	13,44	36,20	98,18	263,54
0,240	13,10	35,29	95,72	256,95
0,245	12,78	34,43	93,39	250,69
0,250	12,48	33,61	91,16	244,72
0,255	12,19	32,83	89,04	239,03
0,260	11,91	32,09	87,02	233,59
0,265	11,65	31,37	85,09	228,40
0,270	11,39	30,69	83,24	223,44
0,275	11,15	30,04	81,47	218,68
0,280	10,92	29,41	79,77	214,13
0,285	10,70	28,81	78,14	209,76
0,290	10,48	28,24	76,58	205,56
0,295	10,28	27,68	75,08	201,53
0,300	10,08	27,15	73,63	197,66
0,305	9,89	26,64	72,24	193,93
0,310	9,70	26,14	70,91	190,34
0,315	9,53	25,67	69,62	186,87
0,320	9,36	25,21	68,37	183,54
0,325	9,19	24,77	67,17	180,32
0,330	9,04	24,34	66,02	177,21
0,335	8,88	23,93	64,90	174,21
0,340	8,73	23,53	63,81	171,30
0,345	8,59	23,14	62,77	168,49
0,350	8,45	22,77	61,76	165,78