INTERNATIONAL STANDARD ISO 2039

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

Plastics and ebonite — Determination of hardness by the ball indentation method

First edition — 1973-11-15

UDC 678.5/.8 : 620.178.15

Ref. No. ISO 2039-1973 (E)

Descriptors : plastics, elastomers, ebonite, tests, hardness tests, indentation hardness tests.

Price based on 3 pages

FOREWORD

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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.

International Standard ISO 2039 was drawn up by Technical Committee ISO/TC 61, *Plastics,* and circulated to the Member Bodies in December 1970.

It has been approved by the Member Bodies of the following countries :

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The Member Bodies of the following countries expressed disapproval of the document on technical grounds :

Australia
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Plastics and ebonite — Determination of hardness by the ball indentation method

1 SCOPE AND FIELD OF APPLICATION

This International Standard specifies a method for determining the hardness of plastics by means of a loaded ball indenter. The method may also be used for the testing of hard rubber — ebonite.

2 REFERENCE

ISO/R 291, *Plastics — Standard atmospheres for conditioning and testing.*

3 DEFINITION

For the purpose of this International Standard the ball-indentation hardness is defined as 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. It is expressed in decanewtons per square millimetre.

4 SIGNIFICANCE OF THE TEST

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

5 PRINCIPLE OF THE METHOD

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 :

$$\text{Ball-indentation hardness} = \frac{\text{Applied load}}{\text{Surface area of impression}}$$

There are two methods, designated A and B.

Method A is particularly useful for evaluating the hardness of superficial layers (penetration being limited to small depths : 100 μm). It requires the more precise apparatus.

Method B is used more for measuring the hardness of thicker layers (depth of penetration 350 μm). The apparatus may therefore be less precise (see 6.5).

6 APPARATUS

6.1 The apparatus shall consist 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 apparatus shall be equipped with a device to measure the depth of penetration of the indenter with the accuracy indicated in 6.5.

The frame shall not be deformed under the maximum load by more than 0,03 mm for method A or 0,05 mm for method B, the deformation being measured along the main axis of the applied force.

6.2 The indenter shall be made from hardened steel of Vickers hardness 800 daN/mm² and shall be polished. The ball shall not show any deformation or damage after the test.

Diameter of the ball :

Method A

The reference ball is the 5 mm diameter ball. If, with any of the loads given in 6.4, the 5 mm ball does not permit the requirements given in 6.5 to be respected, it is possible to use, in order of preference, the 10 mm, 7,5 mm or 2,5 mm ball.

Method B

5,0 mm.

The diameter of the ball shall be within ± 1 % of the nominal diameter.

6.3 The initial load (tolerance ± 1 %) shall be as follows :

Method A

0,245 daN for a test load up to and including 9,8 daN.

0,98 daN for a test load greater than 9,8 daN.

Method B

0,98 daN.

6.4 The test load (tolerance ± 1 %) which includes the initial load shall have one of the following values :

Method A

From 2,45 to 43,14 daN, in increments of 2,45 daN up to and including 24,5 daN, and then 4,9 daN up to 43,14 daN.

Method B

4,9 daN – 13,24 daN – 35,8 daN – 96,1 daN.

NOTE – The values in decanewtons are calculated from the values in kilograms-force indicated by the apparatus. When the apparatus has been graduated in SI units the values in decanewtons will be rounded (see 10.3).

6.5 The depth measurement range of the apparatus shall be as follows :

Method A

0,1 mm, with possibility to measure to about ± 0,001 mm.

Method B

0,4 mm, with possibility to measure to about ± 0,005 mm.

6.6 A stop watch shall be provided.

7 TEST SPECIMEN

The test specimen shall be a smooth flat sheet or block of sufficient size to exclude the edge effect on the test result; for example 50 mm × 50 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.

8 CONDITIONING

The test specimens shall be conditioned, prior to testing, in accordance with ISO/R 291.

9 PROCEDURE

9.1 Unless otherwise specified, tests shall be carried out in the standard atmosphere specified in ISO/R 291.

9.2 The test specimen shall rest completely on the supporting plate. The surfaces shall be perpendicular to the direction of the applied load.

Apply the initial load (F_o – see 6.3). Set the depth-indicating device to zero and then apply the test load, which includes the initial load. Carry out the loading without impact, over a period of 2 to 3 s.

9.3 The test load shall be chosen from the specified values to obtain the following depths of impression :

Method A

between 0,07 and 0,10 mm.

Method B

between 0,15 and 0,35 mm.

If the values of the depth of impression after 30 s are outside these ranges (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 the correct depth of impression. The number of test measurements which do not give the correct depths of impression shall be reported.

9.4 The test shall be carried out 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, the minimum distance between points of application of the indentor shall be 10 mm.

9.5 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 6.5 for the method used.

9.6 Make ten tests on one or more test specimens.

9.7 Determine the deformation of the frame of the apparatus, h_2, in millimetres. This determination is made by replacing the specimen by a hardened steel plate and applying the test load after having removed the ball.

10 CALCULATION AND EXPRESSION OF RESULTS

10.1 Calculate the reduced test load, F_r, in newtons, corresponding to the reduced depth of impression, as follows :

Method A

$$F_r = F_m \left(\frac{h_r}{h} \right)^{1,23} \times \left(\frac{5}{D} \right)^{0,63}$$

where $h_r = 0{,}08$ mm.

Method B

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

where $h_r = 0{,}25$ mm.

For both methods, $h = h_1 - h_2$.

In these formulae,

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

h_r is the reduced depth of impression, in millimetres;

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 is the depth of impression, in millimetres, after correcting for the deformation of the frame;

D is the diameter of the ball, in millimetres.

NOTE – For method A, the value of h_r and the constants are taken from a publication by M.A. Dumez, *Industrie des plastiques modernes et élastomères,* No. 6, July 1964.

For method B, the value of h_r and the constants are taken from a paper by H.H. Racke and Th. Fett, *Materialprüfung,* **10** (1968) No. 7, p. 226.

10.2 Calculate the ball indentation hardness from the formula

$$H = \frac{1}{5\pi} \times \frac{F_r}{h_r}$$

where

H is the ball indentation hardness in decanewtons per square millimetre;

F_r is the reduced test load in decanewtons (see 10.1);

h_r is the reduced depth of impression, in millimetres.

10.3 For values of H lower than 24,5 daN/mm² round off to the nearest 0,1 daN/mm².

For values of H greater than 24,5 daN/mm² round off to the nearest whole number.

11 TEST REPORT

The test report shall include the following particulars :

a) complete identification of the material tested;

b) the test method used (A or B);

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

d) number of tests averaged;

e) number of tests which resulted in incorrect depths of impression;

f) ball indentation hardness, average value and standard deviation;

g) date of test.