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Metallic materials — Brinell hardness test —

Part 1: Test method

Matériaux métalliques — Essai de dureté Brinell —

Partie 1: Méthode d'essai

Reference number
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Foreword

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The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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For an explanation on the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the WTO principles in the Technical Barriers to Trade (TBT) see the following URL: Foreword - Supplementary information

The committee responsible for this document is ISO/TC 164, *Mechanical testing of metals*, Subcommittee SC 3, *Hardness testing*.

This third edition cancels and replaces the second edition (ISO 6506-1:2005), which has been technically revised.

ISO 6506 consists of the following parts, under the general title *Metallic materials — Brinell hardness test*:

— *Part 1: Test method*

— *Part 2: Verification and calibration of testing machines*

— *Part 3: Calibration of reference blocks*

— *Part 4: Table of hardness values*

Metallic materials — Brinell hardness test —

Part 1: Test method

1 Scope

This part of ISO 6506 specifies the method for the Brinell hardness test for metallic materials. It is applicable to both fixed location and portable hardness testing machines.

For some specific materials and/or products, particular International Standards exist (e.g. ISO 4498) and make reference to this International Standard.

2 Normative references

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

ISO 4498, *Sintered metal materials, excluding hardmetals — Determination of apparent hardness and microhardness*

ISO 6506-2:2014, *Metallic materials — Brinell hardness test — Part 2: Verification and calibration of testing machines*

ISO 6506-3:2014, *Metallic materials — Brinell hardness test — Part 3: Calibration of reference blocks*

ISO 6506-4, *Metallic materials — Brinell hardness test — Part 4: Table of hardness values*

3 Principle

An indenter (tungsten carbide composite ball with diameter, D) is forced into the surface of a test piece and, after removal of the force, F, the diameter of the indentation, d, left in the surface is measured.

The Brinell hardness is proportional to the quotient obtained by dividing the test force by the curved surface area of the indentation. The indentation is assumed to take the shape of the unloaded ball indenter, and its surface area is calculated from the mean indentation diameter and the ball diameter, using the formula given in Table 1.

4 Symbols and abbreviated terms

4.1 See Figure 1 and Table 1.

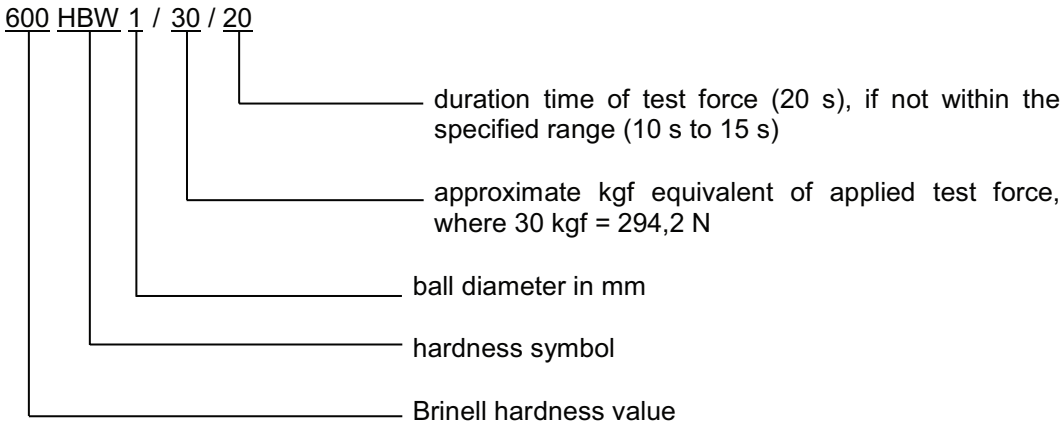
Table 1 — Symbols and abbreviated terms

Symbol/ abbreviated term	Definition	Unit
D	Diameter of the ball	mm
F	Test force	N
d	Mean diameter of the indentation $d = \frac{d_1 + d_2}{2}$	mm
d_1, d_2	Indentation diameters measured at approximately 90°	mm
h	Depth of indentation $h = \frac{D}{2}\left(1 - \sqrt{1 - \frac{d^2}{D^2}}\right)$	mm
HBW	Brinell hardness $= \text{constant (see Note)} \times \frac{\text{Test force}}{\text{idealized surface area of indentation}}$ $\text{HBW} = 0{,}102 \times \frac{2F}{\pi D^2\left(1 - \sqrt{1 - \frac{d^2}{D^2}}\right)}$	
$0{,}102 \times F/D^2$	Force-diameter index	

NOTE $\text{constant} = 0{,}102 \approx \frac{1}{9{,}806\,65}$, where 9,806 65 is the conversion factor from kgf to N.

4.2 The following is an example of the designation of Brinell hardness, HBW.

EXAMPLE



NOTE In former editions of this International Standard, when use of a steel ball was permitted, the Brinell hardness was denoted by HB or HBS.

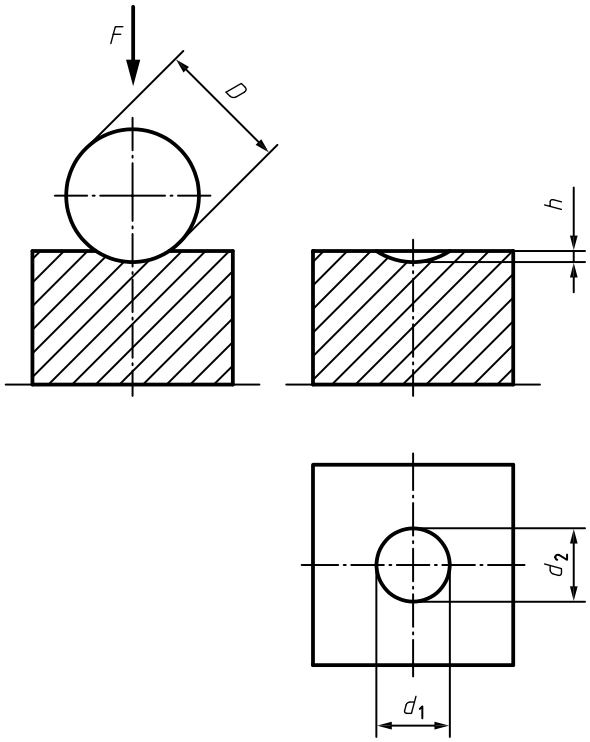


Figure 1 — Principle of test

For symbols, see Table 1.

5 Apparatus

5.1 Testing machine, capable of applying a predetermined test force or test forces within the range of 9,807 N to 29,42 kN, in accordance with ISO 6506-2.

5.2 Indenter, a polished tungsten carbide composite ball, as specified in ISO 6506-2.

5.3 Indentation diameter measuring system, as specified in ISO 6506-2.

6 Test piece

6.1 The test shall be carried out on a surface which is smooth and even; free from oxide scale, foreign matter, and, in particular, free from lubricants. The test piece shall have a surface finish that will allow an accurate measurement of the diameter of the indentation.

NOTE For indentations made with the smaller ball indenters, it might be necessary to polish or lap the surface prior to making the indentation.

6.2 Preparation shall be carried out in such a way that any alteration of the surface, for example, due to excessive heating or cold-working, is minimized.

6.3 The thickness of the test piece shall be at least eight times the depth of indentation. Values for the minimum thickness of the test piece in relation to the mean diameter of indentation are given in Annex B.

Visible deformation at the back of the test piece can indicate that the test piece is too thin.

7 Procedure

7.1 In general, the test should be carried out at ambient temperature within the limits of 10 °C to 35 °C. However, because temperature variation can affect the results, users of the Brinell test can choose to control the temperature within a tighter range, such as 23 °C ± 5 °C.

7.2 Before performing any tests, confirm that verification has been performed in accordance with Annex A.

7.3 The test forces given in Table 2 shall be used. Other test forces and force-diameter indices can be used by special agreement.

Table 2 — Test forces for the different testing conditions

Hardness symbol	Ball diameter D mm	Force-diameter index $0{,}102 \times F/D^2$	Test force value F N
HBW 10/3 000	10	30	29 420
HBW 10/1 500	10	15	14 710
HBW 10/1 000	10	10	9 807
HBW 10/500	10	5	4 903
HBW 10/250	10	2,5	2 452
HBW 10/100	10	1	980,7
HBW 5/750	5	30	7 355
HBW 5/250	5	10	2 452
HBW 5/125	5	5	1 226
HBW 5/62,5	5	2,5	612,9
HBW 5/25	5	1	245,2
HBW 2,5/187,5	2,5	30	1 839
HBW 2,5/62,5	2,5	10	612,9
HBW 2,5/31,25	2,5	5	306,5
HBW 2,5/15,625	2,5	2,5	153,2
HBW 2,5/6,25	2,5	1	61,29
HBW 1/30	1	30	294,2
HBW 1/10	1	10	98,07
HBW 1/5	1	5	49,03
HBW 1/2,5	1	2,5	24,52
HBW 1/1	1	1	9,807

7.4 The test force should be chosen so that the diameter of the indentation, d, lies between the values 0,24 D and 0,6 D. If the diameter of the indentation lies outside these limits, the ratio of indentation diameter to indenter diameter (d/D) shall be stated in the test report. Table 3 indicates recommended force-diameter indices ($0{,}102 \times F/D^2$) that are appropriate for use when testing certain materials and hardness levels. In order to test the largest representative area of the test piece, the diameter of the indenter ball should be chosen to be as large as possible.

Table 3 — Recommended force-diameter indices for different metallic materials

Material	Brinell hardness HBW	Force-diameter index $0{,}102 \times F/D^2$
Steel, nickel alloys, titanium alloys		30
Cast iron[a]	<140	10
	≥140	30
Copper and copper alloys	< 35	5
	35 to 200	10
	>200	30
Light metals and their alloys	<35	2,5
	35 to 80	5
		10
		15
	>80	10
		15
Lead, tin		1
Sintered metal	According to ISO 4498	

[a] For the testing of cast iron, the nominal diameter of the ball shall be 2,5 mm, 5 mm, or 10 mm.

7.5 The test piece shall be placed on a rigid support. The contact surfaces shall be clean and free from foreign matter (scale, oil, dirt, etc.). It is important that the test piece lies firmly on the support so that displacement cannot occur during the test.

7.6 Bring the indenter into contact with the test surface and apply the test force in a direction perpendicular to the surface; without shock, vibration, or overrun, until the applied force attains the specified value. The time from the initial application of force to the time the full test force is reached shall be 7^{+1}_{-5} s. Maintain the test force for 14^{+1}_{-4} s. For certain materials, where a longer duration of the test force is required, this time shall be applied with a tolerance of ±2 s.

NOTE The requirements for the time durations are given with asymmetric limits. For example, 7^{+1}_{-5} s indicates that 7 s is the nominal time duration, with an acceptable range of not less than 2 s (7 s – 5 s) to not more than 8 s (7 s + 1 s).

7.7 Throughout the test, the testing machine shall be protected from significant shock or vibration, which can influence the test result.

7.8 The distance from the edge of the test piece to the centre of each indentation shall be a minimum of two and a half times the mean indentation diameter. The distance between the centres of two adjacent indentations shall be at least three times the mean indentation diameter.

7.9 The optical measurement of the indentation diameter can be performed with either a manual or an automatic measuring system. The visual field for the optical device should be evenly illuminated, and the type of illumination shall be unchanged from that used during the machine's direct and indirect verifications and its daily verification.

For manual measuring systems, measure the diameter of each indentation in two directions approximately perpendicular to each other. The arithmetic mean of the two readings shall be taken for the calculation of the Brinell hardness.

For test pieces with a ground surface, it is recommended that the direction of the indentation measurements be at approximately 45° to the direction of grinding.

NOTE 1 It should be noted that for anisotropic materials, for example those which have been heavily cold-worked, there might be a difference between the lengths of the two diameters of the indentation. The specification for the product might indicate limits for such differences.

For automatic measuring systems, other validated algorithms to compute the mean diameter are allowed. These algorithms include

— the average of a greater number of measurements, and

— an assessment of the projected area of the indentation.

7.10 Calculate the Brinell hardness value for tests on flat surfaces using the formula given in Table 1, rounding the result to three significant figures. The Brinell hardness value can also be determined using the calculation table given in ISO 6506-4.

8 Uncertainty of the results

A complete evaluation of the uncertainty should be done according to Reference [1].

For hardness, independent of the type of sources, there are two possibilities for the determination of the uncertainty.

— One possibility is based on the evaluation of all relevant sources appearing during a direct calibration. As a reference, a EURAMET guideline[2] is available.

— The other possibility is based on indirect calibration using a hardness reference block, see References [2] to [5]. A guideline for the determination is given in Annex C.

It may not always be possible to quantify all the identified contributions to the uncertainty. In this case, an estimate of type A standard uncertainty can be obtained from the statistical analysis of repeated indentations into the test piece. Care should be taken, if standard uncertainties of type A and B are summarized, that the contributions are not counted twice (see 4.3.10 of Reference [1]).

9 Test report

At least the following information shall be recorded and included in the report, unless otherwise agreed by the parties involved:

a) a reference to this part of ISO 6506 (i.e. ISO 6506-1);

b) all details necessary for the complete identification of the test piece;

c) the date of the test;

d) the test temperature if it is not within the limits 10 °C to 35 °C;

e) the ratio of indentation diameter to indenter diameter, if it falls outside the limits of 0,24 to 0,60;

f) the result obtained, in HBW, reported in accordance with the designation specified in 4.2;

g) where conversion to another hardness scale is also performed, the basis and method of this conversion shall be specified (see Reference [6]);

NOTE There is no general process of accurately converting Brinell hardness into other scales of hardness or into tensile strength.

h) additional requirements outside the scope of this part of ISO 6506;

i) details of any occurrence which may have affected the result.