INTERNATIONAL STANDARD

ISO 6506-1

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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
ISO 6506-1:1999(E)

Contents

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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.

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.

International Standard 6506-1 was prepared by the Technical Committee ISO/TC 164, *Mechanical testing of metals*, Subcommittee SC 3, *Hardness testing*.

This first edition of ISO 6506-1 cancels and replaces ISO 6506:1981 and ISO 410:1982, of which it constitutes a technical revision as follows:

— Deletion of the steel ball indenter.

— Integration of the table for the determination of Brinell hardness values for use in tests made on flat surfaces (ISO 410:1982) into annex C of this part of ISO 6506.

— Deletion of the 2 mm ball indenter.

— Addition of annex A concerning a procedure for periodic checks of the testing machines by the user.

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*

Annexes B and C form a normative part of this part of ISO 6506. Annex A is for information only.

Introduction

The force values in this part of ISO 6506 were calculated from kilogram force values. They were introduced before the SI-system was adopted. It was decided to keep the values based on the old units for this part of ISO 6506 but for the next revision it will be necessary to consider the advantage of introducing rounded values of test force and possible consequences on the hardness scales.

Attention is drawn to the fact that in this part of ISO 6506, only the use of the hardmetal ball indenter is specified.

The designation of the Brinell hardness is HBW and should not be confused with the former designation HB, or HBS when a steel ball indenter was used.

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 and is applicable up to the limit of 650 HBW.

For specific materials and/or products, particular International Standards exist (i.e. ISO 4498-1).

2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this part of ISO 6506. 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 6506 are encouraged to investigate the possibility of applying the most recent editions of the normative documents 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 4498-1, *Sintered metal materials, excluding hardmetals — Determination of apparent hardness — Part 1: Materials of essentially uniform section hardness*.

ISO 6506-2:1999, *Metallic materials — Brinell hardness test — Part 2: Verification and calibration of testing machines.*

3 Principles

An indenter (hardmetal ball with diameter D) is forced into the surface of a test piece and the diameter of the indentation d left in the surface after removal of the force F 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 be spherical with a radius corresponding to half of the diameter of the ball.

4 Symbols and designations

See Figure 1 and Table 1.

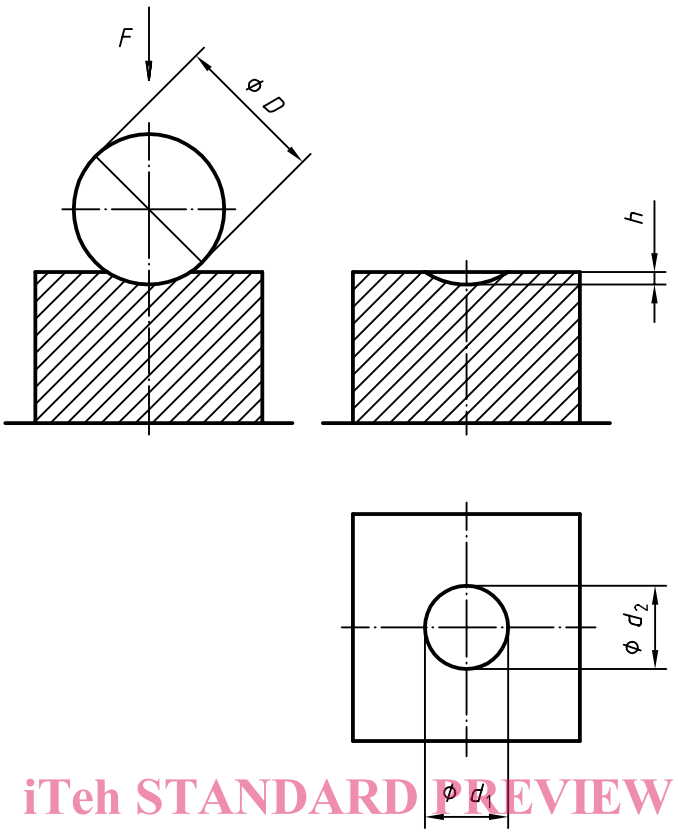

Figure 1 — Principle of test

Table 1 — Symbols and designations

Symbol	Designation	Unit
D	Diameter of the ball	mm
F	Test force	N
d	Mean diameter of the indentation	mm
	$\left(d = \frac{d_1 + d_2}{2}\right)$	
d_1, d_2	Indentation diameters measured at 90°	mm
h	Depth of indentation	mm
	$= \frac{D - \sqrt{D^2 - d^2}}{2}$	
HBW	Brinell hardness	
	$= \text{Constant} \times \frac{\text{Test force}}{\text{Surface area of indentation}}$	
	$= 0{,}102 \times \frac{2F}{\pi D\left(D - \sqrt{D^2 - d^2}\right)}$	
$0{,}102 \times F/D^2$	force-diameter ratio	N/mm^2

NOTE

$\text{Constant} = \frac{1}{g_n} = \frac{1}{9{,}806\ 65} = 0{,}102$

g_n = acceleration due to gravity

4.1 The Brinell hardness is denoted by HBW.

NOTE In former standards, in cases when a steel ball had been used, the Brinell hardness was denoted by HB or HBS.

4.2 The letters HBW are preceded by the hardness value and supplemented by an index indicating the test conditions in the order:

a) the diameter of the ball, in millimetres;

b) a figure representing the test force (see Table 2);

c) the duration of application of test force, in seconds, if different from the specified time (see 7.5).

EXAMPLE 1 350 HBW 5/750 = Brinell hardness of 350 determined with a ball of 5 mm diameter and with a test force of 7,355 kN applied for 10 s to 15 s.

EXAMPLE 2 600 HBW 1/30/20 = Brinell hardness of 600 determined with a ball of 1 mm diameter and with a test force of 294,2 N applied for 20 s.

5 Testing machine

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

5.2 Indenter, a polished hardmetal ball, as specified in ISO 6506-2.

5.3 Measuring device, as specified in ISO 6506-2.

NOTE A suggested procedure for periodic checks by the user is given in annex A.

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.

6.2 Preparation shall be carried out in such a way that any alteration of the surface, for example due to heat- 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 is to be carried out at ambient temperature within the limits of 10 °C to 35 °C. Tests carried out under controlled conditions shall be made at a temperature of (23 ± 5) °C.

7.2 The test forces given in Table 2 shall be used.

7.3 The test force shall be chosen so that the diameter of the indentation d lies between the values 0,24 D and 0,6 D.

The force-diameter ratio ($0{,}102 \times F/D^2$) shall be chosen according to the material and the hardness test as indicated in Table 3.

In order to test the largest representative area of the test piece, the diameter of the testing ball shall be chosen to be as large as possible.

When the thickness of the test piece permits, a 10 mm diameter ball is preferred.

7.4 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 lie firmly on the support so that displacement cannot occur during the test.

7.5 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 not be less than 2 s nor greater than 8 s. Maintain the test force for 10 s to 15 s. For certain materials, where a longer dwell time is required; this time shall be applied with a tolerance of ± 2 s.

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

7.7 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.

Table 2 — Test forces for the different testing conditions

Hardness symbol	Ball diameter D mm	Force-diameter ratio $0{,}102 \times F/D^2$ N/mm^2	Nominal value of test force 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

Table 3 — The force-diameter ratio for different metallic materials

Material	Brinell hardness HBW	Force-diameter ratio $0{,}102 \times F/D^2$ N/mm^2
Steel - Nickel alloys Titanium alloys		30
Cast iron[a]	< 140 ⩾ 140	10 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	See ISO 4498-1	

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

7.8 Measure the diameter of each indentation in two directions perpendicular to each other. The arithmetic mean of the two readings shall be taken for the calculation of the Brinell hardness.

NOTE For some testing machines, the following should be used:

— the average of a greater number of symmetrically placed measurements;

— an assessment of the projected indentation area into the material surface.

7.9 Table C.1 (see annex C) contains calculation tables which shall be used to determine the Brinell hardness for tests on flat surfaces.

8 Uncertainty of the results

The uncertainty of results is dependent on various parameters which may be separated into two categories:

a) parameters dependent on the Brinell hardness testing machine (including the uncertainty of the verification of the testing machine and on the calibration of the reference blocks);

b) parameters dependent on the application of the test method (variation of the operating conditions).

NOTE A complete evaluation of the uncertainty should be carried out according to the *Guide to the Expression of Uncertainty in Measurement*[1]. Indicative values of the extended uncertainty at a confidence level of 95 % can be taken to be equal to the maximum permissible error given in Table 2 of ISO 6506-2:1999.

9 Test report

The test report shall include the following information:

a) a reference to this International Standard, i.e. ISO 6506-1;

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

c) the test temperature if it is not within the limits (23 ± 5) °C;

d) the result obtained;

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

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

NOTE 1 There is no general process of accurately converting Brinell hardness into other scales of hardness or into tensile strength. These conversions should therefore be avoided, unless a reliable basis for the conversion can be obtained by comparative tests.

NOTE 2 It should be noted that for anisotropic materials, for example those which have been heavily cold-worked, there may be a difference between the lengths of the two diameters of the indentation. The specification for the product may indicate limits for such differences.

Annex A
(informative)

Procedure for periodic checks of the testing machines by the user

The indirect verification procedure is too time consuming and costly for routine checking. The following procedure is recommended for this purpose.

Make at least one periodic check of the testing machine each day that it is used.

Before making the check, make at least two preliminary indentations to ensure that the test piece, indenter and anvil are seated correctly. The results of these preliminary indentations should be ignored.

Make at least one hardness indentation on a reference block with approximately the same hardness as the material being tested. If the difference between mean value of the hardness readings of the test material and the hardness of the reference block are within the limits given in Table 2 of ISO 6506-2:1999, the machine may be regarded as satisfactory. If not, an indirect verification should be performed.