INTERNATIONAL STANDARD

ISO 6508-1

Second edition
2005-12-15

Metallic materials — Rockwell hardness test —

Part 1: Test method (scales A, B, C, D, E, F, G, H, K, N, T)

Matériaux métalliques — Essai de dureté Rockwell —
Partie 1: Méthode d'essai (échelles A, B, C, D, E, F, G, H, K, N, T)

Reference number
ISO 6508-1:2005(E)

ISO copyright office
Case postale 56 • CH-1211 Geneva 20
Tel. + 41 22 749 01 11
Fax + 41 22 749 09 47
E-mail copyright@iso.org
Web www.iso.org

Published in Switzerland

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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 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 6508-1 was prepared by Technical Committee ISO/TC 164, *Mechanical testing of metals*, Subcommittee SC 3, *Hardness testing*.

This second edition cancels and replaces the first edition (ISO 6508-1:1999), which has been technically revised.

ISO 6508 consists of the following parts, under the general title *Metallic materials — Rockwell hardness test*:

— *Part 1: Test method (scales A, B, C, D, E, F, G, H, K, N, T)*

— *Part 2: Verification and calibration of testing machines (scales A, B, C, D, E, F, G, H, K, N, T)*

— *Part 3: Calibration of reference blocks (scales A, B, C, D, E, F, G, H, K, N, T)*

Introduction

The periodic checking of the testing machine described in informative Annex E is good metrological practice. It is intended to make the annex normative in the next revision of this part of ISO 6508.

Metallic materials — Rockwell hardness test —

Part 1:
Test method (scales A, B, C, D, E, F, G, H, K, N, T)

1 Scope

This part of ISO 6508 specifies the method for Rockwell and Rockwell superficial hardness tests (scales and field of application according to Table 1) for metallic materials.

Attention is drawn to the fact that, in this part of ISO 6508, the use of hardmetal for ball indenters is considered to be the standard type of Rockwell indenter ball. Steel indenter balls may be continued to be used if specified in a product specification, or by special agreement.

NOTE 1 Attention is drawn to the fact that results obtained with hardmetal balls can be significantly different than when using a steel ball. For specific materials and/or products, other specific International Standards apply (for instance ISO 3738-1 and ISO 4498-1).

NOTE 2 For certain materials, the fields of application may be narrower than those indicated.

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 6508-2:2005, *Metallic materials — Rockwell hardness test — Part 2: Verification and calibration of testing machines (scales A, B, C, D, E, F, G, H, K, N, T)*

3 Principle

Forcing an indenter of specified size, shape and material into the surface of a test piece in two steps under specified conditions (see Clause 7). Measuring the permanent depth h of indentation under preliminary test force after removal of additional test force.

From the values of h and that of the two constants N and S (see Table 2), the Rockwell hardness is calculated according to the formula:

$$\text{Rockwell hardness} = N - \frac{h}{S} \quad (1)$$

4 Symbols, abbreviated terms and designations

4.1 See Tables 1 and 2 and Figure 1.

Table 1 — Rockwell scales

Rockwell hardness scale	Hardness symbol	Type of indenter	Preliminary test force F_0	Additional test force F_1	Total test force F	Field of application (Rockwell hardness test)
A[a]	HRA	Diamond cone	98,07 N	490,3 N	588,4 N	20 HRA to 88 HRA
B[b]	HRB	Ball 1,587 5 mm	98,07 N	882,6 N	980,7 N	20 HRB to 100 HRB
C[c]	HRC	Diamond cone	98,07 N	1,373 kN	1,471 kN	20 HRC to 70 HRC
D	HRD	Diamond cone	98,07 N	882,6 N	980,7 N	40 HRD to 77 HRD
E	HRE	Ball 3,175 mm	98,07 N	882,6 N	980,7 N	70 HRE to 100 HRE
F	HRF	Ball 1,587 5 mm	98,07 N	490,3 N	588,4 N	60 HRF to 100 HRF
G	HRG	Ball 1,587 5 mm	98,07 N	1,373 kN	1,471 kN	30 HRG to 94 HRG
H	HRH	Ball 3,175 mm	98,07 N	490,3 N	588,4 N	80 HRH to 100 HRH
K	HRK	Ball 3,175 mm	98,07 N	1,373 kN	1,471 kN	40 HRK to 100 HRK
15N	HR15N	Diamond cone	29,42 N	117,7 N	147,1 N	70 HR15N to 94 HR15N
30N	HR30N	Diamond cone	29,42 N	264,8 N	294,2 N	42 HR30N to 86 HR30N
45N	HR45N	Diamond cone	29,42 N	411,9 N	441,3 N	20 HR45N to 77 HR45N
15T	HR15T	Ball 1,587 5 mm	29,42 N	117,7 N	147,1 N	67 HR15T to 93 HR15T
30T	HR30T	Ball 1,587 5 mm	29,42 N	264,8 N	294,2 N	29 HR30T to 82 HR30T
45T	HR45T	Ball 1,587 5 mm	29,42 N	411,9 N	441,3 N	10 HR45T to 72 HR45T

[a] The field of application can be extended to 94 HRA for testing carbides.

[b] The field of application can be extended to 10 HRBW if specified in the product specification or by special agreement.

[c] The field of application can be extended to 10 HRC if the indenter possesses the appropriate dimensions.

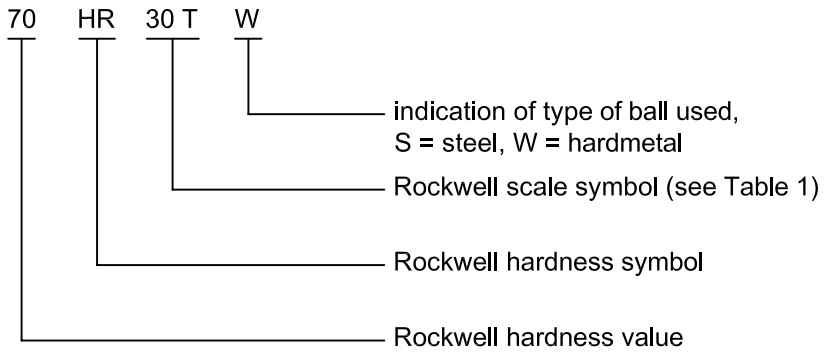
NOTE Indenter balls with diameter 6,350 mm and 12,70 mm may also be used, if specified in the product specification or by special agreement.

Table 2 — Symbols and abbreviated terms

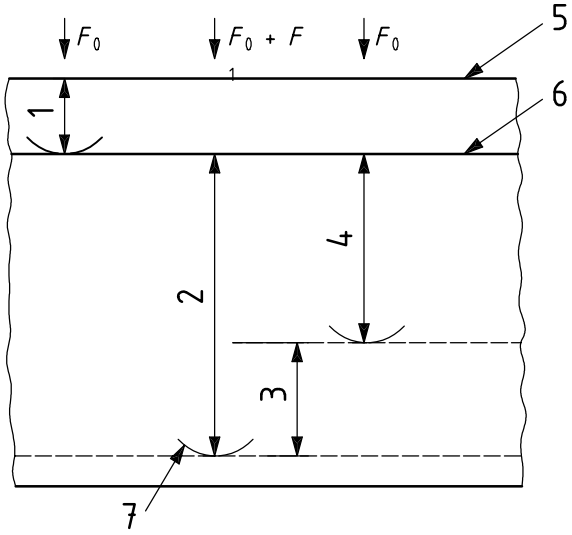
Symbol/ Abbreviated term	Designation	Unit
F_0	Preliminary test force	N
F_1	Additional test force	N
F	Total test force	N
S	Scale unit, specific to the scale	mm
N	Number, specific to the scale	
h	Permanent depth of indentation under preliminary test force after removal of additional test force (permanent indentation depth)	mm
HRA HRC HRD	Rockwell hardness $= 100 - \frac{h}{0{,}002}$	
HRB HRE HRF HRG HRH HRK	Rockwell hardness $= 130 - \frac{h}{0{,}002}$	
HRN HRT	Rockwell hardness $= 100 - \frac{h}{0{,}001}$	

4.2 The following is an example of the designation of Rockwell hardness.

EXAMPLE



NOTE The numbers representing the test forces were originally based on units of kgf. For example, the test force of 30 kgf has been converted to 294,2 N.



Key

1 Indentation depth by preliminary force F_0
2 Indentation depth by additional test force F_1
3 Elastic recovery just after removal of additional test force F_1
4 Permanent indentation depth h
5 Surface of specimen
6 Reference plane for measurement
7 Position of indenter

Figure 1 — Rockwell principle diagram

5 Testing machine

5.1 Testing machine, capable of applying predetermined forces as shown in Table 1 and in accordance with ISO 6508-2.

5.2 Conical diamond indenter, in accordance with ISO 6508-2, with an angle of 120° and radius of curvature at the tip of 0,2 mm.

5.3 Hardmetal ball indenter, in accordance with ISO 6508-2, with a diameter of 1,587 5 mm or 3,175 mm.

5.4 Measuring system, in accordance with ISO 6508-2.

NOTE A suggested procedure for periodic checks is given in Annex E. See also notes on diamond indenters in Annex F.

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, completely free from lubricants, unless specified otherwise in product or materials standards. An exception is made for reactive metals, such as titanium, which might adhere to the indenter. In such situations, a suitable lubricant such as kerosene may be used. The use of a lubricant shall be reported on the test report.

6.2 Preparation shall be carried out in such a way that any alteration of the surface hardness due to excessive heating or cold-working for example, is minimized. This shall be taken into account, particularly in the case of low-depth indentations.

6.3 After the test, no deformation shall be visible on the surface of the test piece opposite the indentation, except for HR30Tm (in this case, the test shall be performed in accordance with Annex A).

The thickness of the test piece, or of the layer under test (minimum values given in Annex B), shall be at least ten times the permanent indentation depth for cone indenters and fifteen times the permanent indentation depth for ball indenters, unless it can be demonstrated that the use of a thinner test piece does not affect the measured hardness value.

6.4 For tests on convex cylindrical surfaces and spherical surfaces, the corrections given in Annex C (Tables C.1, C.2, C.3 or C.4) and in Annex D (Table D.1) shall be applied.

In the absence of corrections for tests on concave surfaces, tests on such surfaces should be the subject of a special agreement.

7 Procedure

7.1 The test is normally carried out at ambient temperature within the limits of 10 °C to 35 °C. However, because temperature variation may affect the results, users of the Rockwell test may choose to control the temperature within a tighter range.

NOTE The temperature of the test material and the temperature of the hardness testing machine may effect the test results; consequently users should ensure that the test temperature does not adversally affect the hardness measurement.

7.2 The test piece shall be placed on a rigid support and supported in such a manner that the surface to be indented is in a plane normal to the axis of the indenter and the line of the indenting force, as well as to avoid a displacement of the test piece. If a locking device is used, it should be used in accordance with Clause 3 of ISO 6508-2:2005.

Before beginning a series of tests or when more than 24 h have elapsed since the last test, and after each change, or removal and replacement, of the indenter or test piece support, it shall be ascertained that the indenter and the test piece support are correctly mounted in the machine. The first two readings after such a change has been made shall be disregarded.

Products of cylindrical shape shall be suitably supported, for example, on centering V-blocks of steel with a Rockwell hardness of at least 60 HRC. Special attention shall be given to the correct seating, bearing and alignment of the indenters, the test piece, the centering V-blocks and the specimen holder of the testing machine, since any perpendicular misalignment may result in incorrect results.

7.3 Bring the indenter into contact with the test surface and apply the preliminary test force F_0 without shock, vibration or oscillation. The duration of the preliminary test force F_0 shall not exceed 3 s.

NOTE For testing machines with electronic control, the application time of the preliminary test force (T_a) and the duration time of the preliminary test force (T_{pm}) are combined by the following formula:

$$T_p = T_a/2 + T_{pm} \leqslant 3 \text{ s} \qquad (2)$$

where

T_p is the total time of preliminary test force;

T_a is the application time of preliminary test force;

T_{pm} is the duration time of preliminary test force.

7.4 Set the measuring system to its datum position and, without shock, vibration or oscillation, increase the force from F_0 to F in not less than 1 s and not more than 8 s.

NOTE In normal practice, the duration from F_0 to F is between 2 s and 3 s on a test piece of about 60 HRC. For the Rockwell scales N and T, it is recommended that the duration is between 1 s and 1,5 s on a test piece of about 78 HR30N.

7.5 The total test force F shall be maintained for a duration of 4 s ± 2 s. Remove the additional test force F_1 and, while the preliminary test force F_0 is maintained, after a short time stabilisation, the final reading shall be made.

As an exception for test materials exhibiting excessive plastic flow (indentation creep) during the application of the total test force, special considerations may be necessary since the indenter will continue to penetrate. When materials require the use of a total force duration that exceeds the 6 s allowed by the tolerances, this requirement should he specified in the product specification. In these cases, the actual extended total force duration used shall be reported following the test results (for example, 65 HRFW, 10 s).

7.6 The Rockwell hardness number is derived from the permanent indentation depth h using the formulas given in Table 2 and is usually read directly from the measuring system. The derivation of the Rockwell hardness number is illustrated in Figure 1.

7.7 Throughout the test, the apparatus shall be protected from shock or vibration.

7.8 The distance between the centres of two adjacent indentations shall be at least four times the diameter of the indentation (but not less than 2 mm).

The distance from the centre of any indentation to an edge of the test piece shall be at least two and a half times the diameter of the indentation (but not less than 1 mm).

8 Uncertainty of the results

A complete evaluation of the uncertainty should be done according to the *Guide to the expression of uncertainty in measurement* (GUM) [3].

Independent of the type of sources, for hardness 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, an EA guideline [4] is available.

— The other possibility is based on indirect calibration using a hardness reference block [abbreviated as CRM (certified reference material)] (see [2–5] in the Bibliography). A guideline for the determination is given in Annex G.

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 may 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 summarised, that the contributions are not counted twice (see Clause 4 of GUM:1993).

9 Test report

The test report shall include the following information:

a) a reference to this part of ISO 6508, i.e. ISO 6508-1;

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

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

d) the result obtained (see the second-last paragraph of this clause);

e) all operations not specified in this part of ISO 6508, or regarded as optional;

f) details of any occurrence which may have affected the result (see Note);

g) the actual extended total-force duration time used, if greater than the 6 s allowed by the tolerances.