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Metallic materials — Rockwell hardness test —

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

Matériaux métalliques — Essai de dureté Rockwell —

Partie 3: Étalonnage des blocs de référence (échelles A, B, C, D, E, F, G, H, K, N, T)

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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 6508-3 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 6508-3:1999), 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

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.

Metallic materials — Rockwell hardness test —

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

1 Scope

This part of ISO 6508 specifies a method for the calibration of reference blocks to be used for the indirect verification of Rockwell hardness testing machines (scales A, B, C, D, E, F, G, H, K, N, T), as specified in ISO 6508-2.

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 376:2004, *Metallic materials — Calibration of force-proving instruments used for verification of uniaxial testing machines*

ISO 4287:1997, *Geometrical Product Specifications (GPS) — Surface texture: Profile method — Terms, definitions and surface texture parameters*

ISO 6508-1, *Metallic materials — Rockwell hardness test — Part 1: Test method (scales A, B, C, D, E, F, G, H, K, N, T)*

ISO 6508-2, *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 Manufacture of reference blocks

3.1 The block shall be specially manufactured for use as a hardness-reference block.

NOTE Attention is drawn to the need to use a manufacturing process which will give the necessary homogeneity, stability of structure and uniformity of surface hardness.

3.2 Each metal block to be calibrated shall be of a thickness not less than 6 mm.

Reference blocks should have a thickness of 6 mm to 16 mm. To minimize the effect of hardness change with increasing number of indents, a minimum thickness of 12 mm should be used for steel. For other materials, different thicknesses could be used.

3.3 The reference blocks shall be free of magnetism. It is recommended that the manufacturer ensure that the blocks, if made of steel, have been demagnetized at the end of the manufacturing process (before calibration).

3.4 The tolerance in flatness of the surfaces shall not exceed 0,01 mm. The bottom of the blocks shall not be convex.

The tolerance parallelism shall not exceed 0,02 mm on 50 mm.

3.5 The test and lower surfaces shall be free from damage, such as notches, scratches, oxide layers, etc., which interfere with the measurement of the indentations. The surface roughness Ra shall not exceed 0,000 3 mm for the test surface and 0,000 8 mm for the bottom surface: sampling length $l = 0{,}8$ mm (see ISO 4287:1997, 3.1.9).

3.6 To verify that no material is subsequently removed from the reference block, the thickness at the time of calibration shall be marked on it, to the nearest 0,1 mm, or an identifying mark shall be made on the test surface [see 8.1 e)].

4 Calibration machine

4.1 In addition to fulfilling the general conditions specified in Clause 3 of ISO 6508-2:2005, the calibration machine shall also meet the requirements given in 4.2 to 4.8.

4.2 The machine shall be verified directly in intervals not exceeding 12 months. Direct verification involves:

a) calibration of the test force;

b) verification of the indenter; the verification period can be extended for up to 5 years, if the indenter is verified for performance against at least one other reference indenter at intervals not exceeding 12 months;

c) calibration of the measuring system;

d) verification of the testing cycle; if this is not possible, at least the force versus time behaviour.

4.3 The instruments used for the verification and calibration of the calibration machine shall be traceable to national standards.

4.4 “Each test force shall be measured using an elastic proving device (of ISO 376:2004 Class 0,5 or better), or by another method having the same or better accuracy. This measurement shall agree with the nominal preliminary test force F_0, to within ± 0,2 % and the nominal total test force F, to within ± 0,1 %”.

4.5 The diamond cone indenter shall meet the following requirements:

a) The diamond cone shall have a mean included angle of (120 ± 0,1)°. In each measured section, the included angle shall be (120 ± 0,17)°.

When the roundness of the cone is not measured, at least eight axial section planes, equidistant from each other, shall be measured.

When the error in roundness of the cone does not exceed 0,004 mm, adjacent to the blend, two sections, normal to the indenter axis, shall be measured.

NOTE 1 The error of roundness is defined as the greatest radial distance between the conical surface and the circumscribing circle.

Deviations from straightness of the generatrix of the diamond cone, adjacent to the blend, shall not exceed 0,000 5 mm over a minimum length of 0,4 mm.

b) The tip of the indenter is spherical. Its radius is determined from single values, measured in the axial section planes defined in a). The radius can be obtained by determining the intersection of two segments of the concentric circles. The distance between the concentric circles shall not be more than 0,002 mm.

The single value is the mean value of the two radii of the concentric circles. Each single value shall be within (0,2 ± 0,007) mm. The mean value of at least eight single values shall be within (0,2 ± 0,005) mm.

The surfaces of the cone and the spherical tip shall blend in a truly tangential manner.

c) The inclination of the axis of the diamond cone to the axis of the indenter holder (normal to the seating surface) shall be within 0,3°.

d) Tests shall be made in accordance with the procedure described in Clause 5, on a minimum of the four blocks given in Table 1.

Table 1 — Hardness levels for different scales

Scale	Hardness	Tolerances
HRC	23	± 3
HRC	55	
HR45N	43	
HR15N	91	

For each block, the mean hardness value of three indentations made using the indenter to be verified shall not differ from the mean hardness value of the three indentations obtained with the reference indenter by more than ± 0,4 Rockwell units. The indentations made with the indenter to be verified, and with the reference indenter, should be adjacent.

The tests shall be made in accordance with ISO 6508-1 with a calibration machine. Reference indenters shall be recalibrated at a frequency no greater than 5 years.

NOTE 2 The reference indenter is the indenter or the indenters being recognized as the reference indenter(s) at a national level.

4.6 The characteristics of the hardmetal and steel balls, see ISO 6508-2, with the exception of the following tolerances for the ball diameter:

— ± 0,002 mm for the ball of diameter 1,587 5 mm;

— ± 0,003 mm for the ball of diameter 3,175 mm.

4.7 The measuring system shall have a resolution of ± 0,000 1 mm and an expanded uncertainty (2σ) of 0,000 2 mm.

4.8 The testing cycle shall be timed with an uncertainty less than ± 0,5 s and shall conform to the testing cycle of Clause 5.

5 Calibration procedure

5.1 The reference blocks shall be calibrated in a calibration machine as described in Clause 4, at a temperature of (23 ± 5) °C, using the general procedure described in ISO 6508-1.

During calibration, the thermal drift should not exceed 1 °C.

5.2 The velocity of the indenter when it reachs the surface shall not exceed 1 mm/s.

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

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

$$T_p = T_a / 2 + T_{pm} \leqslant 3 \text{ s} \quad (1)$$

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.

5.4 Bring the measuring system to its datum position and without shock, vibration or oscillation, increase the force from F_0 to F in no less than 1 s nor greater than 8 s.

The duration of the total force F shall be equal to (4 ± 2) s.

During the final stage of the indentation process (approximately in the range of 0,6 F to 0,8 F) the indentation speed should be in the range of 0,02 mm/s to 0,04 mm/s.

5.5 The final reading shall be made no less than 3 s nor greater than 5 s after removing the additional test force F_1.

6 Number of indentations

On each reference block, five indentations shall be made uniformly distributed over the test surface. The arithmetic mean of the five hardness values characterizes the hardness value of the block.

To reduce the measurement uncertainty, more than 5 indentations should be made.

7 Uniformity of hardness

7.1 Let h_1, h_2, h_3, h_4, h_5 be the values of the measured permanent indentation depth arranged in increasing order of magnitude.

where

$$\bar{h} = \frac{h_1 + h_2 + h_3 + h_4 + h_5}{5} \quad (2)$$

The non-uniformity U of the block under the particular conditions of calibration is characterized by:

$$U = h_5 - h_1 \quad (3)$$

and is expressed as a percentage U_{rel} of $\bar{h}$ as

$$U_{rel} = \frac{100\,(h_5 - h_1)}{\bar{h}} \quad (4)$$

7.2 The maximum permissible value of non-uniformity U_{rel} of a reference block is given in Table 2 and is graphically presented in Figure A.1 and Figure A.2.

Table 2 — Maximum permissible value of non-uniformity

Rockwell hardness scale	Maximum permissible value of non-uniformity U_{rel} [a] %
A	1,5 or 0,4 HRA
B	2,0 or 1,0 HRB
C	1,0 or 0,4 HRC
D	1,0 or 0,4 HRD
E	2,0 or 1,0 HRE
F	2,0 or 1,0 HRF
G	2,0 or 1,0 HRG
H	2,0 or 1,0 HRH
K	2,0 or 1,0 HRK
N	2,0 or 0,6 HRN
T	3,0 or 1,2 HRT

[a] The greater of the two values shall apply.

7.3 The determination of the uncertainty of measurement of hardness reference blocks is given in Annex B.

8 Marking

8.1 Each reference block shall be marked with the following:

a) the arithmetic mean of the hardness values found in the calibration test, for example: 66,3 HRC;

b) the name or mark of the supplier or manufacturer;

c) the serial number;

d) the name or mark of the calibration agency;

e) the thickness of the block, or an identifying mark on the test surface (see 3.6);

f) the year of calibration, if not indicated in the serial number.

8.2 Any mark put on the side of the block shall be upright when the test surface is the upper face.

8.3 Each delivered reference block shall be accompanied with a document giving at least the following information:

a) a reference to this part of ISO 6508;

b) the identity of the block;

c) the date of calibration;

d) the arithmetic mean of the hardness values and the value characterizing the non-uniformity of the block (see 7.1).

9 Validity

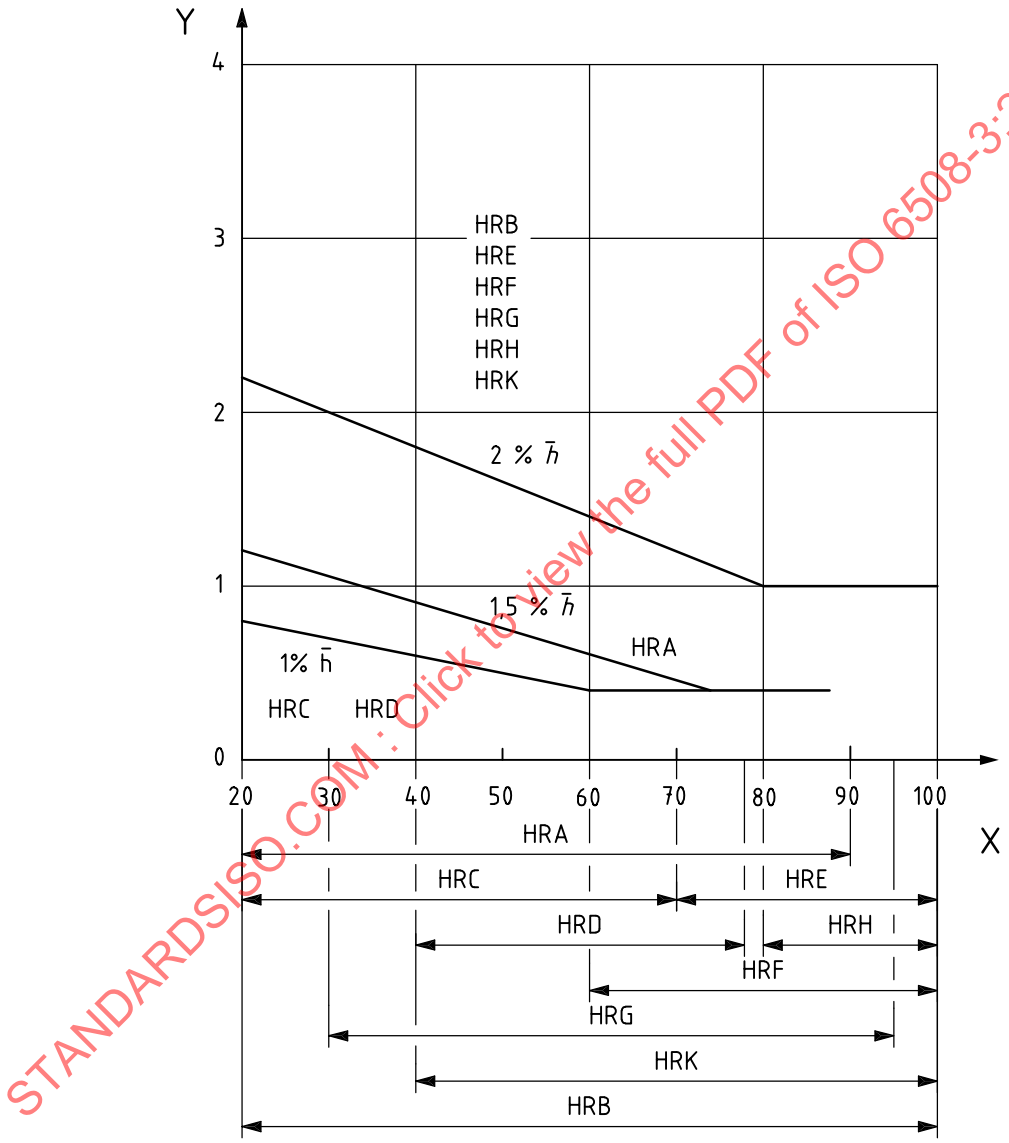
The hardness reference block is only valid for the scale for which it was calibrated.

The calibration validity should be limited to a duration of 5 years. Attention is drawn to the fact that, for Al- and Cu-alloys, the calibration validity could be reduced to 2 - 3 years.

Annex A
(normative)

Uniformity of reference blocks

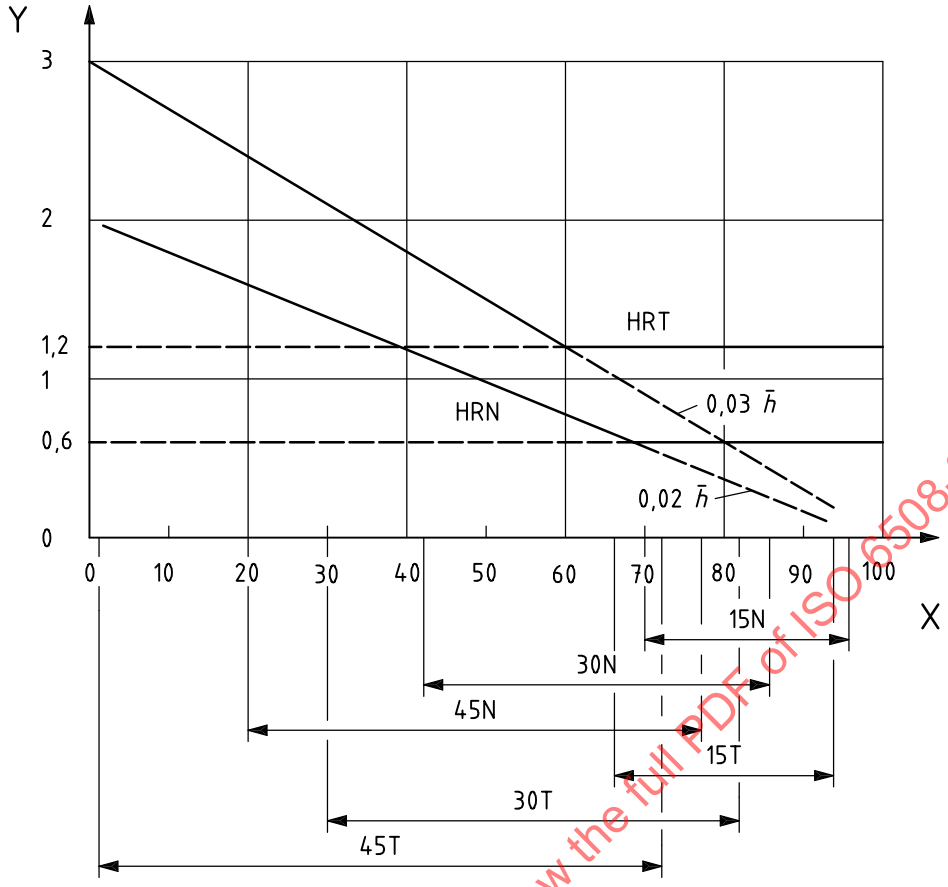
Maximum permissible values of non-uniformity are given in Figures A.1 and A.2.



Key

X Rockwell hardness
Y non-uniformity

Figure A.1 — Rockwell hardness (scales A, B, C, D, E, F, G, H and K)



Key

X Rockwell hardness
Y non-uniformity

Figure A.2 — Rockwell superficial hardness (scales N and T)

Annex B
(informative)

Uncertainty of the mean hardness value of hardness-reference blocks

The metrological chain necessary to define and disseminate hardness scales is shown in Figure B.1 in ISO 6508-1:2005.

B.1 Direct verification of the hardness-calibration machine

B.1.1 Calibration of the test force

See ISO 6508-2:2005, Annex B.

B.1.2 Calibration of the depth-measuring device

See ISO 6508-2:2005, Annex B.

B.1.3 Verification of the indenter

See ISO 6508-2:2005, Annex B.

B.1.4 Verification of the test cycle

See ISO 6508-2:2005, Annex B.

B.2 Indirect calibration of the hardness-calibration machine

NOTE In this Annex, the index "CRM (Certified Reference Material)" means, according to the definitions of the hardness testing standards, "Hardness Reference Block".

By the indirect verification with primary hardness-reference blocks, the overall function of the hardness-calibration machine is checked and the repeatability, as well as the deviation of the hardness-calibration machine from the actual hardness value, are determined.

The uncertainty of measurement of the indirect calibration of the hardness-calibration machine follows from the equation:

$$u_{\mathrm{CM}} = \sqrt{u^2_{\mathrm{CRM\text{-}P}} + u^2_{x\mathrm{CRM\text{-}1}} + u^2_{\mathrm{CRM\text{-}D}} + u^2_{\mathrm{ms}}} \qquad \text{(B.1)}$$

where

$u_{\mathrm{CRM\text{-}P}}$ is the calibration uncertainty of the primary hardness-reference block, according to the calibration certificate for $k = 1$;

$u_{x\mathrm{CRM\text{-}1}}$ is the standard uncertainty of the hardness-calibration machine due to its repeatability;

$u_{\mathrm{CRM\text{-}D}}$ is the hardness change of the primary hardness-reference block since its last calibration due to drift;

u_{ms} is the uncertainty due to the resolution of the hardness-calibration machine.

EXAMPLE

Primary hardness-reference block:	45,4 HRC
Uncertainty of measurement of the primary hardness-reference block	$u_{\text{CRM-1}} = \pm$ 0,25 HRC ($k = 1$)
Time drift of the primary hardness-reference block	$u_{\text{CRM-D}} = 0$
Resolution of the depth measuring system	$\delta_{\text{ms}} = 0{,}1$ µm

Table B.1 — Results of the indirect verification

No.	Measured hardness value H, HRC
1	$45{,}3_{\text{min}}$
2	45,6
3	$45{,}8_{\text{max}}$
4	45,7
5	45,4
Mean value $\overline{H}$	45,56
Standard deviation $s_{x\text{CRM-1}}$	0,207
Standard uncertainty of measurement $u_{x\text{CRM-1}}$	0,11
HRC: Rockwell hardness.	

$$u_{x\text{CRM-1}} = \frac{t \cdot s_{x\text{CRM-1}}}{\sqrt{n}} \qquad \text{(B.2)}$$

($t = 1{,}14$ for $n = 5$)

Table B.2 — Budget of uncertainty of measurement

Quantity X_i	Estimated value x_i	Standard uncertainty of measurement $u(x_i)$	Distribution type	Sensitivity coefficient c_i	Uncertainty contribution $u_i(H)$
u_{CRM}	45,5 HRC	0,25 HRC	Normal	1,0	0,25 HRC
$u_{x\text{CRM-1}}$	0 HRC	0,11 HRC	Normal	1,0	0,11 HRC
u_{ms}	0 HRC	0,029 µm	Rectangular	0,5[a]	0,01 HRC
$u_{\text{CRM-D}}$	0 HRC	0 HRC	Triangular	1,0	0 HRC
Combined uncertainty of measurement u_{CM}					0,27 HRC

HRC: Rockwell hardness

[a] The sensitivity coefficient follows from:

$$c = \frac{HR}{h} \qquad \text{(B.3)}$$

for $h = 0{,}000\,029$ mm