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Metallic materials — Rockwell hardness test —

Part 1: Test method

Matériaux métalliques — Essai de dureté Rockwell —

Partie 1: Méthode d'essai

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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.

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 document 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 of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT), see www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 164, *Mechanical testing of metals*, Subcommittee SC 3, *Hardness testing*, in collaboration with the European Committee for Standardization (CEN) Technical Committee CEN/TC 459, *ECISS - European Committee for Iron and Steel Standardization*, in accordance with the Agreement on technical cooperation between ISO and CEN (Vienna Agreement).

This fifth edition cancels and replaces the fourth edition (ISO 6508-1:2016), which has been technically revised.

The main changes are as follows:

— removal of note related to the use of tungsten and steel ball indenters (Clause 1);

— removal of the year from the Normative References specified and various places throughout the body of the standard (Clause 2);

— addition of Clause 3, Terms and definitions;

— added additional information for the use of single-piece spherically tipped indenters (6.3 NOTE 1);

— added the table reference and table title (7.4);

— modified the uncertainty of the results section to only provide a single reference for the determination of uncertainty (Clause 9);

— modified Annex G to remove the "procedure without bias (M2)" method for determining uncertainty.

A list of all parts in the ISO 6508 series can be found on the ISO website.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Metallic materials — Rockwell hardness test —

Part 1: Test method

1 Scope

This document specifies the method for Rockwell regular and Rockwell superficial hardness tests for scales A, B, C, D, E, F, G, H, K, 15N, 30N, 45N, 15T, 30T, and 45T for metallic materials and is applicable to stationary and portable hardness testing machines.

For specific materials and/or products, other specific International Standards apply (e.g. ISO 3738-1 and ISO 4498).

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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, *Metallic materials — Rockwell hardness test — Part 2: Verification and calibration of testing machines and indenters*

ISO 6508-3, *Metallic materials — Rockwell hardness test — Part 3: Calibration of reference blocks*

3 Terms and definitions

No terms and definitions are listed in this document.

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at https://www.electropedia.org/

4 Symbols, abbreviated terms and designations

According to Table 1, Table 2, Table 3, and Figure 1.

Table 1 — Rockwell regular scales

Rockwell regular hardness scale	Hardness symbol Unit	Type of indenter	Preliminary force F_0	Total force F	Scaling constant S	Full range constant N	Applicable range of application (Rockwell regular hardness scales)
A	HRA	Diamond cone	98,07 N	588,4 N	0,002 mm	100	20 HRA to 95 HRA
B	HRBW	Ball 1,587 5 mm	98,07 N	980,7 N	0,002 mm	130	10 HRBW to 100 HRBW
C	HRC	Diamond cone	98,07 N	1,471 kN	0,002 mm	100	20 HRC[a] to 70 HRC
D	HRD	Diamond cone	98,07 N	980,7 N	0,002 mm	100	40 HRD to 77 HRD
E	HREW	Ball 3,175 mm	98,07 N	980,7 N	0,002 mm	130	70 HREW to 100 HREW
F	HRFW	Ball 1,587 5 mm	98,07 N	588,4 N	0,002 mm	130	60 HRFW to 100 HRFW
G	HRGW	Ball 1,587 5 mm	98,07 N	1,471 kN	0,002 mm	130	30 HRGW to 94 HRGW
H	HRHW	Ball 3,175 mm	98,07 N	588,4 N	0,002 mm	130	80 HRHW to 100 HRHW
K	HRKW	Ball 3,175 mm	98,07 N	1,471 kN	0,002 mm	130	40 HRKW to 100 HRKW

[a] The applicable range of application can be extended to 10 HRC if the surfaces of the diamond cone and spherical tip are polished for a penetration depth of at least 0,4 mm.

Table 2 — Rockwell superficial scales

Rockwell superficial hardness scale	Hardness symbol Unit	Type of indenter	Preliminary force F_0	Total force F	Scaling constant S	Full range constant N	Applicable range of application (Rockwell superficial hardness scales)
15N	HR15N	Diamond cone	29,42 N	147,1 N	0,001 mm	100	70 HR15N to 94 HR15N
30N	HR30N	Diamond cone	29,42 N	294,2 N	0,001 mm	100	42 HR30N to 86 HR30N
45N	HR45N	Diamond cone	29,42 N	441,3 N	0,001 mm	100	20 HR45N to 77 HR45N
15T	HR15TW	Ball 1,587 5 mm	29,42 N	147,1 N	0,001 mm	100	67 HR15TW to 93 HR15TW
30T	HR30TW	Ball 1,587 5 mm	29,42 N	294,2 N	0,001 mm	100	29 HR30TW to 82 HR30TW
45T	HR45TW	Ball 1,587 5 mm	29,42 N	441,3 N	0,001 mm	100	10 HR45TW to 72 HR45TW

Scales using 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. See ASTM E18 [5] for additional scales using these ball sizes.

NOTE 1 For certain materials, it is possible that the applicable range of application is narrower than those indicated.

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

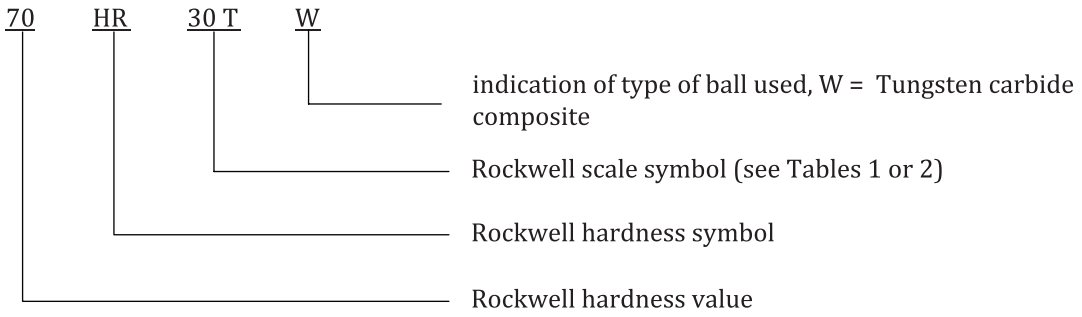
Table 3 — Symbols and abbreviated terms

Symbol/ abbreviated term	Definition	Unit
F_0	Preliminary test force	N
F_1	Additional test force (total force minus preliminary force)	N
F	Total test force	N
S	Scaling constant, specific to the scale	mm
N	Full range constant, 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 regular hardness $= 100 - \frac{h}{0{,}002}$	
HRBW HREW HRFW HRGW HRHW HRKW	Rockwell regular hardness $= 130 - \frac{h}{0{,}002}$	
HRN HRTW	Rockwell superficial hardness $= 100 - \frac{h}{0{,}001}$	

5 Rockwell hardness

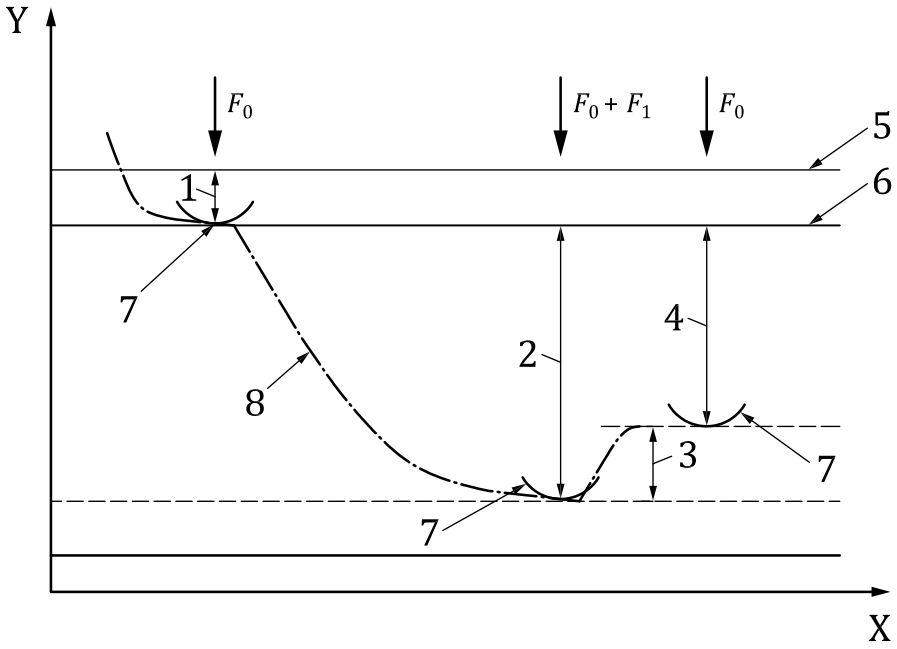
5.1 The following is an example of the designation of Rockwell hardness.

EXAMPLE 70 HR30TW, where:



NOTE 1 Previous versions of this document allowed the use of steel indenter balls, which required the suffix S.

NOTE 2 For the HR30TSm and HR15TSm scales specified in Annex A, a capital S and a lower-case m are used indicating the use of steel indenter balls and a diamond spot specimen holder.



Key

X time
Y indenter position
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
8 indentation depth vs. time curve

Figure 1 — Rockwell principle diagram

5.2 Principle:

An indenter of specified size, shape and material is forced into the surface of a test specimen under two force levels using the specific conditions specified in Clause 8. The specified preliminary force is applied and the initial indentation depth is measured, followed by the application and removal of a specified additional force, returning to the preliminary force. The final indentation depth is then measured and the Rockwell hardness value (H) is derived from the difference, h, in the final and initial indentation depths and the two constants N and S (see Figure 1, Table 1, and Table 2) as shown in Formula (1):

$$H = N - \frac{h}{S} \tag{1}$$

6 Testing machine

6.1 Testing machine, shall be capable of applying the test forces for some or all of the Rockwell hardness scales as shown in Table 1 and Table 2, performing the procedure specified in Clause 8, and complying with all of the requirements specified in ISO 6508-2.

6.2 Spheroconical diamond indenter, shall be in accordance with ISO 6508-2, with an included angle of 120° and radius of curvature at the tip of 0,2 mm. Diamond indenters shall be certified for use for either:

— only the regular Rockwell diamond scales,

— only the superficial Rockwell diamond scales, or

— both the regular and the superficial Rockwell diamond scales.

6.3 Ball indenter, shall be tungsten carbide composite in accordance with ISO 6508-2, with a diameter of 1,587 5 mm or 3,175 mm (see NOTE 1 and NOTE 2).

NOTE 1 Ball indenters normally consist of a spherical ball and a separate appropriately designed holder. Single-piece spherically tipped indenters are allowed, provided that the surface of the indenter that makes contact with the test piece meets the size, shape, finish, and hardness requirements for the calibration and verification of the ball indenter as specified in ISO 6508-2, and meets the performance requirements for the indirect verification of the ball holder assembly as specified in ISO 6508-2.

NOTE 2 Attention is drawn to the fact that the use of tungsten carbide composite for ball indenters is the standard type of Rockwell indenter ball. Steel indenter balls can only be used when performing Rockwell HR30TSm and HR15TSm tests according to Annex A.

7 Test piece

7.1 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.

7.2 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.

7.3 The thickness of the test piece, or of the layer under test (minimum values are given in Annex B), shall be at least 10 times the permanent indentation depth for diamond indenters and 15 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.

In general, no deformation should be visible on the back of the test piece after the test, although not all such marking is indicative of a bad test.

Follow Annex A for special requirements for testing very thin sheet metal using the HR30TSm and HR15TSm scales.

7.4 For tests on convex cylindrical surfaces and spherical surfaces, see 8.11.

8 Procedure

8.1 This document has been developed with a laboratory temperature requirement of 10 °C to 35 °C.

For environments outside the stated requirement, it is the responsibility of the testing laboratory to assess the impact on testing data produced with testing machines operated in such environments. When testing is performed outside the recommended temperature limits of 10 °C to 35 °C, the temperature shall be recorded and reported.

NOTE If significant temperature gradients are present during testing and/or calibration, measurement uncertainty can increase and out of tolerance conditions can occur.

8.2 The daily verification specified in Annex E shall be performed before the first test of each day for each scale to be used.

The condition of diamond indenters should be checked according to Annex F.

8.3 After each change, or removal and replacement, of the indenter, indenter ball, or test piece support, perform at least two tests and discard the results, then determine that the indenter and the test piece support are correctly mounted in the machine by performing the daily verification process specified in Annex E.

8.4 The diamond or ball indenter shall have been the indenter used during the last indirect verification.

If the indenter was not used during the indirect verification and is being used for the first time, it shall be verified in accordance with the daily verification given in Annex E using at least two test blocks (one from the low and high ranges as specified by ISO 6508-2:2023, Table 1) for each Rockwell scale that is normally used. This does not apply to replacing a ball.

8.5 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.

Products of cylindrical shape shall be suitably supported, for example, on centring V-block or double cylinders made of material 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 centring V-blocks, and the specimen holder of the testing machine, since any perpendicular misalignment might result in incorrect results.

8.6 Bring the indenter into contact with the test surface and apply the preliminary test force, F_0, without shock, vibration, oscillation, or overload.

The preliminary force application time should not exceed 2 s. The duration of the preliminary test force, F_0, shall be $3\,^{+1}_{-2}$ s.

NOTE The requirements for the time durations are given with asymmetric limits.

EXAMPLE $3\,^{+1}_{-2}$ s indicates that 3 s is the ideal time duration, with an acceptable range of not less than 1 s (3 s - 2 s) to not more than 4 s (3 s + 1 s).

8.7 Measure the initial indentation depth.

For many manual (dial-indicator) machines, this is done by setting the indicating dial to its set-point or zero position. For many automatic (digital) machines, the depth measurement is made automatically without the user's input and might not be displayed.

8.8 Apply the additional force F_1 without shock, vibration, oscillation, or overload to increase the force from F_0 to the total force, F.

For the regular Rockwell scale tests, apply the additional test force, F_1, in not less than 1 s and not more than 8 s. For all HRN and HRTW Rockwell superficial test scales, apply the additional test force, F_1, in less than or equal to 4 s.

It is recommended to perform the same test cycle used during indirect verification.

NOTE There is evidence that some materials are sensitive to the rate of straining which causes small changes in the value of the yield stress. The corresponding effect on the termination of the formation of an indentation can make an alteration in the hardness value.

8.9 The total test force, F, shall be maintained for a duration of 5^{+1}_{-3} s. Remove the additional test force, F_1, and, while the preliminary test force, F_0, is maintained, after 4^{+1}_{-3} s, 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 can 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, the actual extended total force duration used shall be reported following the test results (for example, 65 HRF/10 s).

8.10 Measure the final indentation depth while the preliminary test force is applied.

The Rockwell hardness number is calculated from the permanent indentation depth, h, using the formula given in Formula (1) and the information given in Table 1, Table 2, and Table 3. For most Rockwell hardness machines, the depth measurement is made in a manner that automatically calculates and displays the Rockwell hardness number.

The derivation of the Rockwell hardness number is illustrated in Figure 1.

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

The correction values shall be reported on the test report.

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

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

8.13 The distance between the centres of two adjacent indentations shall be at least three times the diameter of the indentation. 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.

9 Uncertainty of the results

A complete evaluation of the uncertainty should be done according to ISO/IEC Guide 98-3.

A guideline for the determination is given in Annex G.

10 Test report

The laboratory shall record at least the following information and that information shall be included in the test report, unless agreed by the parties concerned:

a) a reference to this document, i.e. ISO 6508-1:2023;

b) all details necessary for the complete identification of the test piece, including the curvature of the test surface;

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

d) the hardness result in the format specified in 5.2;

e) all operations not specified in this document, or regarded as optional;

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