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Metallic materials — Rockwell hardness test —

Part 1: Test method

Matériaux métalliques — Essai de dureté Rockwell —

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 6508-1:2005), 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*

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

— *Part 3: Calibration of reference blocks*

Metallic materials — Rockwell hardness test —

Part 1: Test method

1 Scope

This part of ISO 6508 specifies the method for Rockwell regular and Rockwell superficial hardness tests (scales and applicable range of application according to Table 1) for metallic materials and is applicable to stationary and portable hardness testing machines.

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

NOTE Attention is drawn to the fact that the use of tungsten carbide composite for ball indenters is considered to be the standard type of Rockwell indenter ball. Steel indenter balls are allowed to continue to be used only when complying with Annex A.

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 6508-2:2015, *Metallic materials — Rockwell hardness test — Part 2: Verification and calibration of testing machines*

ISO 6508-3:2015, *Metallic materials — Rockwell hardness test — Part 3: Calibration of reference blocks*

3 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 defined in Clause 7. 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 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:

$$\text{Rockwell hardness} = N - \frac{h}{S} \tag{1}$$

4 Symbols, abbreviated terms and designations

4.1 See Table 1, Table 2, Table 3, and Figure 1.

Table 1 — Rockwell Regular scales

Rockwell Regular hardness cale	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 to 95 HRA
B	HRBW	Ball 1,587 5 mm	98,07 N	980,7 N	0,002 mm	130	10 to 100 HRBW
C	HRC	Diamond cone	98,07 N	1,471 kN	0,002 mm	100	20[a] to 70 HRC
D	HRD	Diamond cone	98,07 N	980,7 N	0,002 mm	100	40 to 77 HRD
E	HREW	Ball 3,175 mm	98,07 N	980,7 N	0,002 mm	130	70 to 100 HREW
F	HRFW	Ball 1,587 5 mm	98,07 N	588,4 N	0,002 mm	130	60 to 100 HRFW
G	HRGW	Ball 1,587 5 mm	98,07 N	1,471 kN	0,002 mm	130	30 to 94 HRGW
H	HRHW	Ball 3,175 mm	98,07 N	588,4 N	0,002 mm	130	80 to 100 HRHW
K	HRKW	Ball 3,175 mm	98,07 N	1,471 kN	0,002 mm	130	40 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 to 94 HR15N
30N	HR30N	Diamond cone	29,42 N	294,2 N	0,001 mm	100	42 to 86 HR30N
45N	HR45N	Diamond cone	29,42 N	441,3 N	0,001 mm	100	20 to 77 HR45N
15T	HR15TW	Ball 1,587 5 mm	29,42 N	147,1 N	0,001 mm	100	67 to 93 HR15TW
30T	HR30TW	Ball 1,587 5 mm	29,42 N	294,2 N	0,001 mm	100	29 to 82 HR30TW
45T	HR45TW	Ball 1,587 5 mm	29,42 N	441,3 N	0,001 mm	100	10 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 E 18 for additional scales using these ball sizes.

NOTE 1 For certain materials, the applicable range of application might be narrower than those indicated.

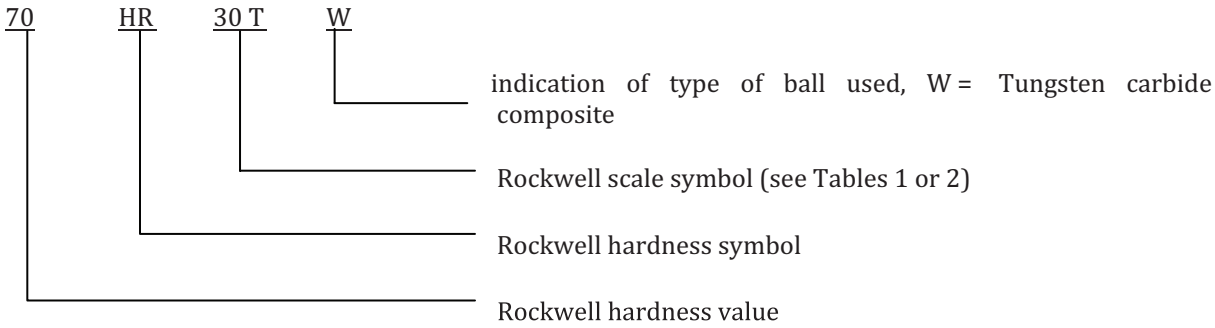
NOTE 2 The numbers representing the test forces were originally based on units of kgf. For example, the total test force of 30 kgf has been converted to 294,2 N.

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 $= 100 - \frac{h}{0{,}001}$	

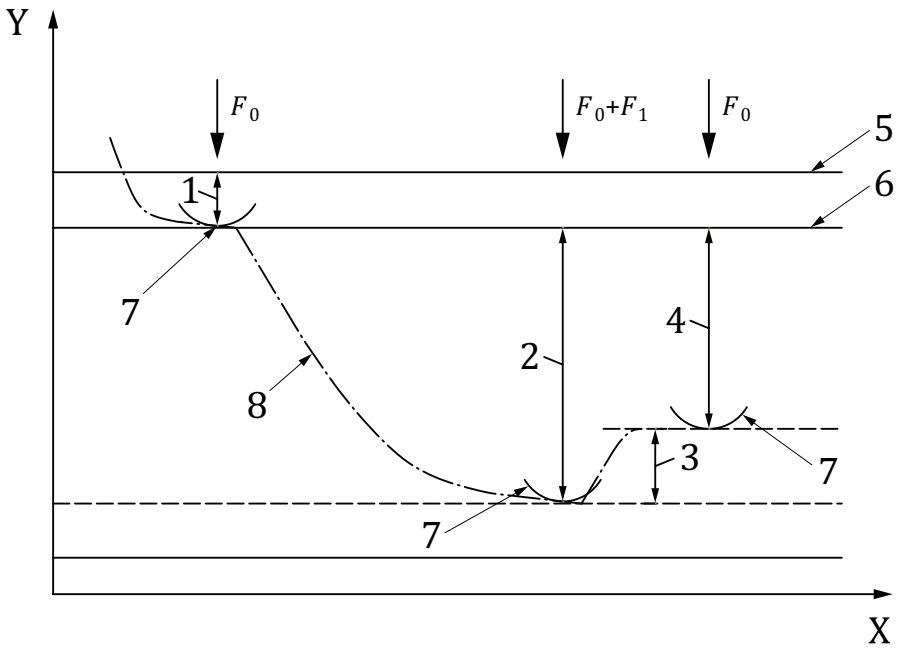
4.2 The following is an example of the designation of Rockwell hardness.

EXAMPLE



NOTE 1 Previous versions of this part of ISO 6508 allowed the use of steel indenter balls, which required the suffix S.

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



Key

X	time	4	permanent indentation depth, h
Y	indenter position	5	surface of specimen
1	indentation depth by preliminary force, F_0	6	reference plane for measurement
2	indentation depth by additional test force, F_1	7	position of indenter
3	elastic recovery just after removal of additional test force, F_1	8	indentation depth vs. time curve

Figure 1 — Rockwell principle diagram

5 Testing machine

5.1 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 defined in Clause 7, and complying with all of the requirements defined in ISO 6508-2:2015.

5.2 Spheroconical diamond indenter, shall be in accordance with ISO 6508-2:2015, 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.

5.3 Ball indenter, shall be tungsten carbide composite in accordance with ISO 6508-2:2015, 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 defined in ISO 6508-2:2015, 6.3.1, and meets the performance requirements of ISO 6508-2:2015, 6.3.2.

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.

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 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.

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

6.4 For tests on convex cylindrical surfaces and spherical surfaces, see 7.11.

7 Procedure

7.1 This part of ISO 6508 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.

7.2 The daily verification defined 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.

7.3 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 defined in Annex E.

7.4 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 defined in ISO 6508-2:2015, Table 1) for each Rockwell scale that is normally used. This does not apply to replacing a ball.

7.5 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 centering 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 centering V-blocks, and the specimen holder of the testing machine, since any perpendicular misalignment might result in incorrect results.

7.6 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).

7.7 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.

7.8 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 might be 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.

7.9 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 might 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).

7.10 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.

7.11 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.

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

7.13 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.

8 Uncertainty of the results

A complete evaluation of the uncertainty should be done according to ISO/IEC Guide 98-3.[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 EURAMET Guide CG-16[4] is available.

— The other possibility is based on indirect calibration using a hardness reference block (abbreviated as CRM certified reference material).[2][3][4][5] A guideline for the determination is given in Annex G.

9 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 part of ISO 6508 (i.e. ISO 6508-1);

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 defined in 4.2;

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

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

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

h) the date the test was performed;

i) if conversion to another hardness scale is also performed, the basis and method of this conversion shall be specified (see ISO 18265).

10 Conversions to other hardness scales or tensile strength values

There is no general process for accurately converting Rockwell hardness into other scales, or hardness into tensile strength. Such conversions, therefore, should be avoided, unless a reliable basis for conversion can be obtained by comparison tests (see also ISO 18265).

Annex A
(normative)

Special HR30TSm and HR15TSm test for thin products

A.1 General

This test is applicable to thin sheet metal products having a maximum thickness of 0,6 mm to the minimum thickness indicated in the product standards, and of a maximum hardness of 82 HR30TSm or 93 HR15TSm. The product standard shall specify when the Special HR30TSm or HR15TSm hardness test is to be applied.

This test is carried out under conditions similar to those in the HR30TW or HR15TW test defined in this part of ISO 6508. The appearance of deformation on the bottom of the test pieces below the indent is permitted.

NOTE 1 The Sm in the scale designations indicates that a steel ball indenter and a diamond spot specimen holder are used for this testing.

NOTE 2 Prior to testing, hardness tests should be made on thin sheet samples of a known hardness to verify that the specimen holder surface does not affect the measurement results.

The following requirements shall be met, in addition to those specified in this part of ISO 6508.

A.2 Ball indenter

A hardened steel ball indenter, that meets the requirements of ISO 6508-2:2015, with a diameter of 1,587 5 mm shall be used for this testing.

A.3 Test piece support

The test piece support shall comprise a polished and smooth flat diamond surface approximately 4,5 mm in diameter. This support surface shall be approximately centred on the axis of the indenter and shall be perpendicular to it. Care shall be taken to ensure that it is seated correctly on the machine table.

A.4 Test piece preparation

If it is necessary to remove material from the test piece, this should be done on both sides of the test piece. Care shall be taken to ensure that this process does not change the condition of the base metal, for example, by heating or work hardening. The base metal shall not be made thinner than the minimum allowable thickness.

A.5 Position of the test piece

The distance between the centres of two adjacent indentations or between the centre of one of the indentations and the edge of the test piece shall be at least 5 mm, unless otherwise specified.