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Rockwell hardness test — Test method

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Contents

	Page
Introduction	1
1 Scope	1
2 Normative references	2
3 Terms and definitions	2
4 Principle	2
5 Symbols, abbreviated terms and designations	2
5.1 Symbols and abbreviated terms	2
5.2 Designation of hardness	5
6 Testing machine	5
6.1 Testing machine	5
6.2 Spheroconical diamond indenter	5
6.3 Ball indenter	5
7 Test piece	6
7.1 Surface of test piece	6
7.2 Test piece finish	6
7.3 Minimum thickness of test piece or of layer under test	6
7.4 Test on convex cylindrical surfaces and spherical surfaces	6
8 Tests	6
8.1 Test temperature	6
8.2 Daily verification	7
8.3 Test after removal and replacement	7
8.4 Application and verification of diamond indenter and ball indenter	7
8.5 Support of test piece	7
8.6 Application of test force	7
8.7 Tests on convex cylindrical surface and spherical surface	8
8.8 Protection for apparatus from shock or vibration	8
8.9 Distance between the centres of two adjacent indentations	9
9 Uncertainty of the results	9
10 Test report	9
11 Conversions to other hardness scales or tensile strength values	9
Annex A (normative) HR30Tm and HR15Tm test for thin products	11
Annex B (normative) Minimum thickness of test piece in relation to Rockwell regular hardness and Rockwell superficial hardness	13

Annex C (normative)	Corrections to be added to Rockwell regular hardness value and Rockwell superficial hardness value obtained on convex cylindrical surfaces	17
Annex D (normative)	Corrections to be added to Rockwell hardness C scale values obtained on spherical test surfaces of various diameters	19
Annex E (normative)	Daily verification procedure of testing machine	20
Annex F (normative)	Inspection of diamond indenters	23
Annex G (informative)	Uncertainty of the measured hardness values	24
Annex H (informative)	CCM — Working group on hardness	31
Annex I (informative)	Rockwell hardness measurement traceability	32
Annex JA (informative)	Comparison table between JIS and corresponding International Standard	37

Foreword

This Japanese Industrial Standard has been revised by the Minister of Economy, Trade and Industry based on the provision of Article 14, paragraph (1) of the Industrial Standardization Act applied mutatis mutandis pursuant to the provision of Article 16 of the said Act in response to a proposal for revision of Japanese Industrial Standard with a draft being attached, submitted by The Japan Iron and Steel Federation (JISF), an accredited standards development organization. This edition replaces the previous edition (**JIS Z 2245**: 2016), which has been technically revised.

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Rockwell hardness test — Test method

Introduction

This Japanese Industrial Standard has been prepared based on **ISO 6508-1** : 2016, Edition 4, with some modifications of the technical contents.

The vertical lines on both sides and dotted underlines indicate changes from the corresponding International Standard. A list of modifications with the explanations is given in Annex JA.

1 Scope

This Standard specifies the method for Rockwell regular hardness and Rockwell superficial hardness tests for metallic materials, and is applicable to stationary and portable hardness testing machines. The scales and the scope of hardness are shown in Table 1 and Table 2.

For specific materials and products such as hardmetals, other standards shall apply (for instance, **ISO 3738-1** and **ISO 4498**).

NOTE 1 Attention is drawn to the fact that, in **ISO 6508-1**, the use of tungsten carbide composite for ball indenters (hereafter referred to as hardmetal indenter balls) is considered to be the standard type of ball indenters for Rockwell regular hardness and Rockwell superficial hardness, and steel ball indenters are allowed to be used only in the test complying with Annex A. This Standard will adopt hardmetal indenter balls as the standard indenter at the time of next revision (see Table 1, Table 2, 5.2, 6.3 and Table E.1). Even in this case, steel balls are planned to be used as the standard indenter in the test complying with Annex A.

NOTE 2 Attention is drawn to the fact that the result obtained with hardmetal indenter balls may be significantly different from the result obtained with steel balls.

NOTE 3 (Editor's note : this NOTE 3 is unrelated to English translation therefore omitted.)

NOTE 4 The International Standard corresponding to this Standard and the symbol of degree of correspondence are as follows.

ISO 6508-1 : 2016 *Metallic materials — Rockwell hardness test — Part 1 : Test method* (MOD)

In addition, symbols which denote the degree of correspondence in the contents between the relevant International Standard and **JIS** are IDT (identical), MOD (modified), and NEQ (not equivalent) according to **ISO/IEC Guide 21-1**.

WARNING Persons carrying out tests based on this Standard should be familiar with normal laboratory practice. This Standard does not purport to address all of the safety problems, if any, associated with its use.

It is the responsibility of the user of this Standard to establish appropriate safety and health practices.

2 Normative references

Part or all of the provisions of the following standards, through reference in this text, constitute provisions of this Standard. The most recent editions of the standards (including amendments) indicated below shall be applied.

JIS B 7726 Rockwell hardness test — Verification and calibration of testing machines and indenters

JIS B 7730 Rockwell hardness test — Calibration of reference blocks

JIS G 0202 Glossary of terms used in iron and steel (Testing)

3 Terms and definitions

For the purpose of this Standard, the terms and definitions given in JIS G 0202 apply.

4 Principle

An indenter of the size, shape and material specified in this Standard is forced into the surface of a test piece under two test force levels using the specific conditions defined in Clause 8. The specified preliminary test force is applied and the initial indentation depth is measured, followed by the application and removal of a specified additional test force, returning to the preliminary test force. The final indentation depth is then measured, and Rockwell regular hardness value and Rockwell superficial hardness value are derived from the difference h in the final and initial indentation depths and the two constants N and S (see Figure 1, Table 1, Table 2 and Table 3) as shown in Formula (1) :

$$\text{Rockwell regular hardness or Rockwell superficial hardness} = N - \frac{h}{S} \dots\dots\dots(1)$$

NOTE The indentation depth means the penetration depth of an indenter.

5 Symbols, abbreviated terms and designations

5.1 Symbols and abbreviated terms

See Figure 1, Table 1, Table 2 and Table 3 for symbols and abbreviated terms.

Table 1 Rockwell regular hardness scales and abbreviated terms

Scale	Symbol of hardness	Type of indenter	Preliminary test force F_0 (N)	Total test force F (N)	Scaling constant S (mm)	Full range constant N	Scope of application
A	HRA	Diamond cone	98.07	588.4	0.002	100	20 HRA to 95 HRA
B	HRB	Ball ^{b)} 1.587 5 mm	98.07	980.7	0.002	130	10 HRB to 100 HRB
C	HRC	Diamond cone	98.07	1471	0.002	100	20 ^{a)} HRC to 70 HRC
D	HRD	Diamond cone	98.07	980.7	0.002	100	40 HRD to 77 HRD
E	HRE	Ball ^{b)} 3.175 mm	98.07	980.7	0.002	130	70 HRE to 100 HRE
F	HRF	Ball ^{b)} 1.587 5 mm	98.07	588.4	0.002	130	60 HRF to 100 HRF
G	HRG	Ball ^{b)} 1.587 5 mm	98.07	1471	0.002	130	30 HRG to 94 HRG
H	HRH	Ball ^{b)} 3.175 mm	98.07	588.4	0.002	130	80 HRH to 100 HRH
K	HRK	Ball ^{b)} 3.175 mm	98.07	1471	0.002	130	40 HRK to 100 HRK
Note ^{a)} The scope 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.							
Note ^{b)} Unless otherwise specified, a hardmetal indenter ball shall be used, and "W" shall be suffixed to the symbol of hardness (type of ball indenter used) (see an example in 5.2). When steel balls are used according to requirements, "S" shall be suffixed (see an example in 5.2).							

Table 2 Rockwell superficial hardness scales and abbreviated terms

Scale	Symbol of hardness	Type of indenter	Preliminary test force F_0 (N)	Total test force F (N)	Scaling constant S (mm)	Full range constant N	Scope of application
15N	HR15N	Diamond cone	29.42	147.1	0.001	100	70 HR15N to 94 HR15N
30N	HR30N	Diamond cone	29.42	294.2	0.001	100	42 HR30N to 86 HR30N
45N	HR45N	Diamond cone	29.42	441.3	0.001	100	20 HR45N to 77 HR45N
15T	HR15T	Ball ^{a)} 1.587 5 mm	29.42	147.1	0.001	100	67 HR15T to 93 HR15T
30T	HR30T	Ball ^{a)} 1.587 5 mm	29.42	294.2	0.001	100	29 HR30T to 82 HR30T
45T	HR45T	Ball ^{a)} 1.587 5 mm	29.42	441.3	0.001	100	10 HR45T to 72 HR45T
Note ^{a)} Unless otherwise specified, a hardmetal indenter ball shall be used, and "W" shall be suffixed to the symbol of hardness (type of ball indenter used) (see an example in 5.2). When steel balls are used according to requirements, "S" shall be suffixed (see an example in 5.2).							

Scales using ball indenters with diameter 6.350 mm and 12.70 mm may also be used, if specified in the product standard or agreed by the parties concerned. See **ASTM E18 [11]** for additional scales using these ball indenters.

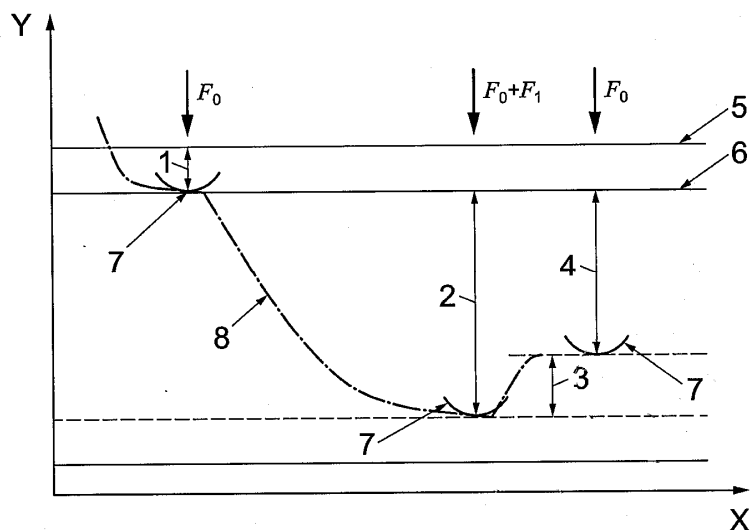
NOTE 1 For certain materials, the scope of application might be narrower than those indicated.

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	Content	Unit
F_0	Preliminary test force	N
F_1	Additional test force (total test force minus preliminary test force)	N
F	Total test force	N
HRA, HRC, HRD	Rockwell regular hardness $= 100 - \frac{h}{0.002}$	—
<u>HRB</u> , <u>HRE</u> , <u>HRF</u> , <u>HRG</u> , <u>HRH</u> , <u>HRK</u>	Rockwell regular hardness $= 130 - \frac{h}{0.002}$	—
HRN, HRT	Rockwell superficial hardness $= 100 - \frac{h}{0.001}$	—
h	Permanent depth of indentation under preliminary test force after removal of additional test force	mm
N	Scaling constant, specific to the scale	—
S	Scaling constant corresponding to 1 HR, specific to the scale	mm



Key

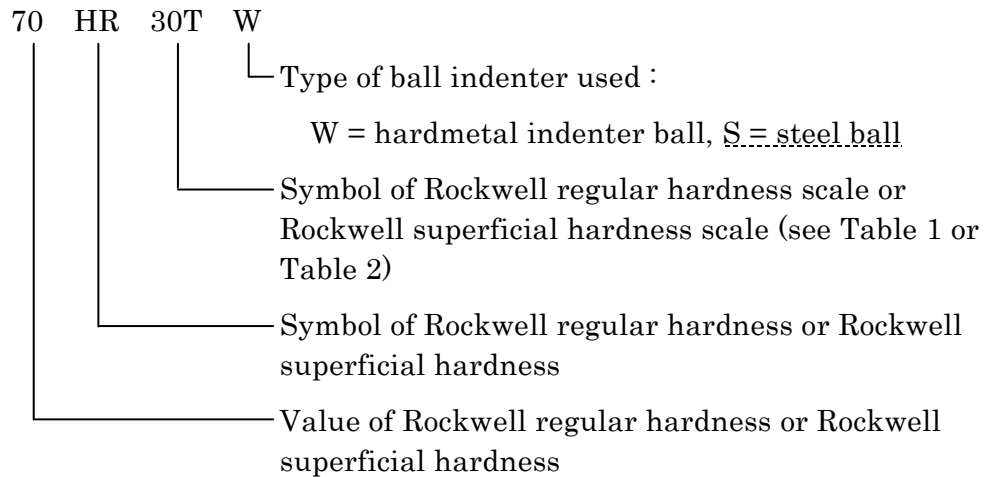
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|---|--|
| X : time | 4 : permanent indentation depth, h |
| Y : indenter position | 5 : surface of test piece |
| 1 : indentation depth by preliminary test force, F_0 | 6 : reference plane for measurement of permanent indentation |
| 2 : indentation 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 Principle diagram of Rockwell regular hardness and Rockwell superficial hardness

5.2 Designation of hardness

The following is an example of the designation of Rockwell regular hardness and Rockwell superficial hardness.

Example



NOTE 1 In ISO 6508-1, only hardmetal indenter balls, W, are described as indenters.

NOTE 2 In ISO 6508-1, the usage of steel balls is allowed only for HR30T_{Sm} and HR15T_{Sm} scales defined in Annex A. Capital S and a lower-case m is used indicating the use of steel indenter balls and a diamond spot specimen holder, respectively.

6 Testing machine

6.1 Testing machine

The 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 8, and complying with all of the requirements defined in JIS B 7726.

6.2 Spheroconical diamond indenter

A spheroconical diamond indenter (hereafter referred to as diamond indenter) shall be in accordance with JIS B 7726. Diamond indenters should 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

The hardmetal indenter balls and steel indenter balls shall be in accordance with JIS B 7726. Unless otherwise specified, hardmetal indenter balls shall be used.

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 8.3 of JIS B 7726.

7 Test piece

7.1 Surface of test piece

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 metals, such as titanium, which might react and 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 Test piece finish

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 Minimum thickness of test piece or of layer under test

The minimum thickness of the test piece or of the layer under test shall be 10 times the permanent indentation depth h for diamond indenters and 15 times the permanent indentation depth h for ball indenters, unless it can be demonstrated that the use of a thinner test piece does not affect the measured hardness value. The relation between Rockwell regular hardness and the minimum thickness of the test piece or the layer under test shall be in accordance with Annex B.

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).

See Annex A for special requirements for testing very thin sheet metal using the HR30Tm and HR15Tm scales.

NOTE In ISO 6508-1, application of only HR30Tm and HR15Tm scales (a combination of a steel ball indenter and a diamond spot specimen holder) to the very thin sheet test pieces specified in Annex A is allowed.

7.4 Test on convex cylindrical surfaces and spherical surfaces

For tests on convex cylindrical surfaces and spherical surfaces, see 8.7.

8 Tests

8.1 Test temperature

This Standard 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 carried out outside the 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 Daily verification

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.

8.3 Test after removal and replacement

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

8.4 Application and verification of diamond indenter and ball indenter

The diamond indenter and 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 reference blocks (one from the low and high ranges as defined in Table 2 of **JIS B 7726**) for each Rockwell scale that is normally used. This does not apply to replacing a ball.

8.5 Support of test piece

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.

Test pieces 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 test piece support of the testing machine, since any perpendicular misalignment might result in incorrect results.

8.6 Application of test force

The test force shall be applied as follows.

- a) Bring the indenter into contact with the surface to be indented and apply the preliminary test force, F_0 , without shock, vibration or the like. The preliminary force application time should not exceed 2 s. The duration of the preliminary test force shall be 3_{-2}^{+1} s.

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

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

- b) Measure the initial indentation depth (indentation depth by the preliminary test

force, F_0). For many manual (dial-indicator) testing machines, this is done by setting the indicating dial to its set-point or zero position. For many automatic (digital) testing machines, the depth measurement is made automatically without the user's input and might not be displayed.

- c) Apply the additional test force F_1 without shock, vibration, oscillation or overload to increase the test force from the initial test force F_0 to the total test force, F . For the Rockwell regular 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 HRT 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.

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.

- d) The total test force, F , shall be maintained for a duration of 5_{-3}^{+1} s. Remove the additional test force, F_1 , and, while the preliminary test force, F_0 , is maintained, after 4_{-3}^{+1} 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, HRFW/10 s).

- e) Measure the final indentation depth while the preliminary test force F_0 is applied. The Rockwell regular hardness value or Rockwell superficial hardness value is calculated from the permanent indentation depth, h , using Formula (1) and the information given in Table 1, Table 2, and Table 3. For most Rockwell regular hardness and Rockwell superficial hardness machines, the depth measurement is made in a manner that automatically calculates and displays the Rockwell regular hardness value and Rockwell superficial hardness value.

The derivation of the Rockwell regular hardness test and Rockwell superficial hardness test described in a) to e) is illustrated in Figure 1.

8.7 Tests on convex cylindrical surface and spherical surface

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) or 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 special agreement.

8.8 Protection for apparatus from shock or vibration

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