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**Rockwell hardness test — Verification
and calibration of testing machines and
indenters**

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Foreword

This translation has been made based on the original Japanese Industrial Standard revised by the Minister of Economy, Trade and Industry through deliberations at the Japanese Industrial Standards Committee as the result of proposal for revision of Japanese Industrial Standard submitted by Japan Testing Machinery Association (JTM)/Japanese Standards Association (JSA) with the draft being attached, based on the provision of Article 12 Clause 1 of the Industrial Standardization Law applicable to the case of revision by the provision of Article 14.

Consequently **JIS B 7726:2010** is replaced with this Standard.

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Rockwell hardness test — Verification and calibration of testing machines and indenters

Introduction

This Japanese Industrial Standard has been prepared based on **ISO 6508-2 : 2015**, Edition 3, with some modifications of the technical contents in order to correspond to the needs of users in Japan.

The portions with continuous sidelines or dotted underlines are the matters in which the contents of the corresponding International Standard have been modified. A list of modifications with the explanations is given in Annex JA.

1 Scope

This Standard specifies two separate methods of verification of testing machines (direct and indirect) for determining Rockwell hardness in accordance with **JIS Z 2245**.

This Standard is applicable to stationary and portable Rockwell hardness and Rockwell superficial hardness testing machines (hereafter referred to as testing machines) related to metal materials.

NOTE 1 Attention is drawn to the fact, in **ISO 6508-1 : 2015**, that the use of tungsten carbide composite for ball indenters (hereafter referred to as hardmetal ball) is considered to be the standard type of Rockwell indenter ball. Steel indenter balls may continue to be used only when complying with **ISO 6508-1**, Annex A. This Standard is intended to adopt hardmetal balls as the standard indenter at the time of next revision.

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

NOTE 3 Rockwell hardnesses are classified into Rockwell regular hardness and Rockwell superficial hardness in **ISO 6508-1** while they are respectively described as “Rockwell hardness” and “Rockwell superficial hardness” in this Standard.

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

ISO 6508-2 : 2015 *Metallic materials — Rockwell hardness test — Part 2 : Verification and calibration of testing machines and indenters* (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**.

2 Normative references

The following standards contain provisions which, 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 7728 *Calibration of force-proving instruments used for the verification of uniaxial testing machines*

NOTE : Corresponding International Standard : ISO 376 *Metallic materials — Calibration of force-proving instruments used for the verification of uniaxial testing machines*

JIS B 7730 *Rockwell hardness test — Calibration of reference blocks*

NOTE : Corresponding International Standard : ISO 6508-3 *Metallic materials — Rockwell hardness test — Part 3 : Calibration of reference blocks*

JIS Z 2244 *Vickers hardness test — Test method*

NOTE : Corresponding International Standard : ISO 6507-1 *Metallic materials — Vickers hardness test — Part 1 : Test method*

JIS Z 2245 *Rockwell hardness test — Test method*

NOTE : Corresponding International Standard : ISO 6508-1 *Metallic materials — Rockwell hardness test — Part 1 : Test method*

JIS Z 8103 *Glossary of terms used in measurement*

3 Terms and definitions

For the purposes of this Standard, the terms and definitions given in JIS Z 2245 and JIS Z 8103, and the following apply.

3.1 Rockwell hardness testing machine

instrument including force application system and indentation depth-measuring system

3.2 depth-measuring system

device for measuring the depth of indenter integrated into the testing machine

3.3 direct verification

verification and calibration for main elements (test force, indenter, depth-measuring system, etc.) of testing machine

3.4 indirect verification

verification of entire testing machine by conducting hardness test with multiple hardness reference blocks

4 Symbols and definitions

For the purposes of this Standard, the symbols and definitions given in Table 1 apply.

Table 1 Symbols and definitions

Symbol	Unit	Definition
F_0	N	Preliminary test force
F_1	N	Additional test force
F	N	Total test force
r	(HR-) ^{a)}	Repeatability of hardness value (difference between hardness value and mean value)
H_i	(HR-) ^{a)}	Rockwell hardness
$\bar{H}$	(HR-) ^{a)}	Mean hardness of Rockwell hardnesses measured at different positions
H_{CRM}	(HR-) ^{a)}	Certified hardness of reference block
b	(HR-) ^{a)}	Bias (mean hardness minus certified hardness)
Note ^{a)} “-” in (HR-) is replaced with the symbols (A to H, K, 15N, 30N, 45N, 15T, 30T and 45T) denoting the scale.		

5 General conditions

Before a Rockwell hardness testing machine is verified, the machine shall be checked to ensure that it is properly set up in accordance with the manufacturer's instructions. Especially, it should be checked that the test force can be applied and removed without shock, vibration, or overload and in such a manner that the readings are not influenced.

6 Direct verifications of testing machine

6.1 General

6.1.1 Direct verification involves calibration and verification of the following :

- a) test forces;
- b) depth-measuring system;
- c) testing cycle;
- d) machine hysteresis test.

6.1.2 Direct verification should be carried out at a temperature of $(23 \pm 5) ^\circ\text{C}$. If the verification is made outside of this temperature range, this shall be reported in the verification report.

6.1.3 The instruments used for verification and calibration shall be traceable to national standards.

6.1.4 An indirect verification according to clause 7 shall be performed following a successful direct verification.

6.2 Calibration and verification of test force

6.2.1 Each preliminary test force F_0 (see 6.2.4) and each total test force, F , used (see 6.2.5) shall be measured, and, whenever applicable, this shall be done at not less than

three positions of the plunger spaced throughout its range of movement during testing. The preliminary test force shall be held for at least 2 s.

NOTE : For example, the calibration of preliminary test force is carried out at three positions i.e. the reference position and the positions about 5 HR back and forth from the reference position. The calibration of total test force is carried out at the position about -30 HR, -50 HR, -70 HR from the reference position.

6.2.2 Three readings shall be taken for each force at each position of the plunger. Immediately before each reading is taken, the plunger shall be moved in the same direction as during testing.

6.2.3 The forces shall be measured by one of the following methods :

- by means of a force-proving device according to **JIS B 7728** Class 1 or better and calibrated for reversibility;
- by balancing against a force, accurate to ± 0.2 %, applied by means of calibrated masses;
- by another method having the same accuracy.

Evidence should be available to demonstrate that the output of the force-proving device does not vary by more than 0.2 % in the period 1 s to 30 s following a stepped change in force.

6.2.4 The tolerance on each measurement of the preliminary test force, F_0 , (before application and after removal of the additional test force, F_1) shall be ± 2.0 %. The range of all force measurements (highest value minus lowest value) shall be ≤ 1.5 % of F_0 .

6.2.5 The tolerance on each measurement of the total test force, F , shall be ± 1.0 %. The range of the force measurements (highest value minus lowest value) shall be ≤ 0.75 % of F .

6.3 Calibration and verification of depth-measuring system

6.3.1 The depth-measuring system shall be calibrated by making known incremental movements of the indenter or the indenter holder.

6.3.2 The instrument or gauge blocks used to verify the depth-measuring system shall have a maximum expanded uncertainty of 0.000 3 mm when calculated with a 95 % confidence level.

6.3.3 Calibrate the testing machine's depth measurement system at not less than four evenly spaced increments covering the full range of the normal working depth measured by the testing machine. For this purpose, the working depth is 0.25 mm for regular Rockwell hardness scales (A, B, C, D, E, F, G, H, K), and 0.1 mm for superficial Rockwell hardness scales (N, T).

6.3.4 Some testing machines have a long-stroke depth measuring system where the location of the working range of the depth measuring system varies to suit the sample. This type of testing machine shall be able to electronically verify that the depth measuring device is continuous over the full range. These types of testers shall be verified

using the following steps :

- a) At the approximate top, midpoint, and bottom of the total stroke of the measuring device, verify the depth measurement system at no less than four evenly spaced increments of approximately 0.05 mm at each of the three locations.
- b) Operate the actuator over its full range of travel to monitor whether the displacement measurement is continuous. The displacement indication shall be continuously indicated over the full range.

6.3.5 The depth-measuring system shall correctly indicate within ± 0.001 mm for the scales A to K and within ± 0.0005 mm for scales N and T, i.e. within ± 0.5 HR of a scale unit, over each range.

6.4 Calibration of testing cycle

6.4.1 The testing cycle is to be calibrated by the testing machine manufacturer at the time of manufacture and when the testing machine undergoes repair which may have affected the testing cycle. Calibration of the complete testing cycle is not required as part of the direct verification at other times, see Table 11.

6.4.2 The testing cycle shall conform to the testing cycle defined in clause 7 of **JIS Z 2245**.

6.4.3 For testing machines that automatically control the testing cycle, the measurement uncertainty ($k = 2$) of the timing instrument used to verify the testing cycle shall not exceed 0.2 s. It is recommended that the measured times for the testing cycle, plus or minus the measurement uncertainty ($k = 2$) of the calibration measurements, not exceed the timing limits specified in **JIS Z 2245**.

6.4.4 For testing machines that require the user to manually control the testing cycle, the testing machine shall be verified to be capable of achieving the defined testing cycle.

6.5 Verification of machine hysteresis

6.5.1 The machine shall be checked to ensure that the readings are not affected by a hysteretic flexure of testing machine components (e.g. frame, specimen holder, etc.) during a test. The influence of any hysteresis behaviour shall be checked by making repeated hardness tests using a spherical indenter of at least 10 mm diameter, bearing directly against the specimen holder or through a spacer such that no permanent deformation occurs. A parallel block placed between the indenter holder and the specimen holder may be used instead of a blunt indenter. The material of the blunt indenter and of the spacer or parallel block shall have a hardness of at least 60 HRC.

6.5.2 Perform repeated Rockwell tests using the setup defined in **6.5.1**. The tests shall be conducted using the Rockwell scale with the highest test force that is used during normal testing. Repeat the hysteresis verification procedure for a maximum of 10 measurements and average the last three tests.

6.5.3 The average of the last three tests shall indicate a hardness number of (130 ± 1.0) Rockwell units when the regular Rockwell ball scales B, E, F, G, H, and K are used

or within (100 ± 1.0) Rockwell units when any other Rockwell scale is used.

7 Indirect verifications of testing machine

7.1 General

7.1.1 Indirect verification involves the calibration and verification of the testing machine by performing tests on reference blocks.

7.1.2 Indirect verification should be carried out at a temperature of (23 ± 5) °C by means of reference blocks calibrated in accordance with **JIS B 7730**. If the verification is made outside of this temperature range, this shall be reported in the verification report.

7.2 Procedure of indirect verification

For the indirect verification of a testing machine, the following procedure shall be applied.

- The testing machine shall be verified for each scale for which it will be used.
- For each scale to be verified, reference blocks from each of the hardness ranges given in Table 2 shall be used.
- The hardness values of the blocks shall be chosen to approximate the limits of the intended use.
- It is recommended to perform the same test cycle used when the reference blocks were calibrated.
- Only the calibrated surfaces of the test blocks are to be used for testing.
- On each reference block, a minimum of five indentations shall be uniformly distributed over the test surface and each hardness number observed to within 0.2 HR of a scale unit.
- Before making these indentations, at least two preliminary indentations shall be made to ensure that the machine is working freely and that the reference block, the indenter, and the specimen holder are seating correctly.
- The results of these preliminary indentations shall be ignored.
- The test shall be carried out in accordance with **JIS Z 2245**.

Table 2 Hardness ranges for different scales

Rockwell hardness scale	Hardness range of reference block	Rockwell hardness scale	Hardness range of reference block
A	20 to 40 HRA 45 to 75 HRA 80 to 95 HRA	K	40 to 60 HRK 65 to 80 HRK 85 to 100 HRK
B	10 to 50 HRB 60 to 80 HRB 85 to 100 HRB	15N	70 to 77 HR15N 78 to 88 HR15N 89 to 94 HR15N
C	10 to 30 HRC 35 to 55 HRC 60 to 70 HRC	30N	42 to 54 HR30N 55 to 73 HR30N 74 to 86 HR30N
D	40 to 47 HRD 55 to 63 HRD 70 to 77 HRD	45N	20 to 31 HR45N 32 to 61 HR45N 63 to 77 HR45N
E	70 to 77 HRE 84 to 90 HRE 93 to 100 HRE	15T	67 to 80 HR15T 81 to 87 HR15T 88 to 93 HR15T
F	60 to 75 HRF 80 to 90 HRF 94 to 100 HRF	30T	29 to 56 HR30T 57 to 69 HR30T 70 to 82 HR30T
G	30 to 50 HRG 55 to 75 HRG 80 to 94 HRG	45T	10 to 33 HR45T 34 to 54 HR45T 55 to 72 HR45T
H	80 to 94 HRH 96 to 100 HRH		

7.3 Repeatability

7.3.1 For each reference block, let $H_1, H_2, H_3, H_4, \dots, H_n$ be the values of the measured hardness arranged in increasing order of magnitude. The repeatability range, r , of the testing machine in Rockwell units, under the particular verification conditions, is determined by Formula (1) :

$$r = H_n - H_1 \dots\dots\dots(1)$$

The mean hardness value of all indentations $\bar{H}$ is defined according to Formula (2) :

$$\bar{H} = \frac{H_1 + H_2 + H_3 + H_4 + \dots + H_n}{n} \dots\dots\dots(2)$$

where, $H_1, H_2, H_3, H_4, \dots, H_n$: are the hardness values corresponding to all the indentations;

n is the total number of indentations.

7.3.2 The repeatability of the testing machine being verified shall be considered satisfactory if it satisfies the conditions given in Table 3. Permissible repeatability is presented graphically in Figures A.1 and A.2.