International Standard 716

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Metallic materials — Hardness test — Verification of Rockwell hardness testing machines (scales A — B — C — D — E — F — G — H — K)

Matériaux métalliques — Essai de dureté — Contrôle des machines d'essai de dureté Rockwell (échelles A — B — C — D — E — F — G — H — K)

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Foreword

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Draft International Standards adopted by the technical committees are circulated to the member bodies for approval before their acceptance as International Standards by the ISO Council. They are approved in accordance with ISO procedures requiring at least 75 % approval by the member bodies voting.

International Standard ISO 716 was prepared by Technical Committee ISO/TC 164, *Mechanical testing of metals*.

It cancels and replaces ISO Recommendation R 716-1968, of which it constitutes a technical revision.

Users should note that all International Standards undergo revision from time to time and that any reference made herein to any other International Standard implies its latest edition, unless otherwise stated.

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Metallic materials — Hardness test — Verification of Rockwell hardness testing machines (scales A — B — C — D — E — F — G — H — K)

1 Scope and field of application

This International Standard specifies a method of verification of testing machines for determining Rockwell hardness (scales A — B — C — D — E — F — G — H — K) in accordance with ISO 6508.

It describes a direct verification method for checking the main functions of the machine and an indirect verification method suitable for the overall checking of the machine. The indirect verification method may be used on its own for periodic routine checking of the machine in service.

If a testing machine is also to be used for other methods of hardness testing, it shall be verified independently for each method.

2 References

ISO 674, *Metallic materials — Hardness test — Calibration of standardized blocks to be used for Rockwell hardness testing machines (scales A — B — C — D — E — F — G — H — K).*[1)]

ISO 6507/1, *Metallic materials — Hardness test — Vickers test — Part 1 :* HV 5 *to* HV 100.

ISO 6508, *Metallic materials — Hardness test — Rockwell test (scales A — B — C — D — E — F — G — H — K).*

3 General conditions

Before a Rockwell hardness testing machine is verified, it shall be checked to ensure that

— the machine is properly set up;

— the plunger holding the indenter is capable of sliding in its guide, by its own weight, but without any appreciable clearance;

— the indenter-holder is firmly mounted in the plunger;

— the test force can be applied and removed without shock or vibration and in such a manner that the readings are not influenced;

— the readings are not affected either by movements of the test piece or by deformations of the frame. When a device is supplied, which locks the test piece against the upper part of the frame, the locking force shall exceed the total test force. The influece of deformations may be checked by using a plain plunger instead of the indenter, bearing directly against the anvil and using the locking device when it is supplied. The readings of the measuring device (with preliminary force applied) before application and after removal of the additional force shall not differ by more than 0,5 Rockwell unit.

4 Direct verification

Direct verification involves

— verification of the test force;

— verification of the indenter;

— verification of the measuring device.

4.1 Verification of the test force

4.1.1 The preliminary test force F_0 (see 4.1.4) and each total test force F used (see 4.1.5) 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.

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

— measuring by means of an elastic proving device previously calibrated to an accuracy of $\pm 0,2$ %;

or

— balancing against a force, accurate to $\pm 0,2$ %, applied by means of standardized masses with mechanical advantage.

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

1) At present at the stage of draft. (Revision of ISO/R 674-1968.)

4.1.4 The tolerance on the preliminary test force F_0 (before application and after removal of the additional test force F_1) shall be ±2,0 %.

4.1.5 The tolerance on the total test force F shall be ±0,7 %.

4.2 Verification of the indenters

4.2.1 Diamond cone indenter (scales A — C — D)

4.2.1.1 The surfaces of the diamond cone and spherical tip shall be polished for a penetration depth of 0,3 mm and shall blend in a truly tangential manner. Both surfaces shall be free from surface defects.

4.2.1.2 The verification of the shape of the indenter can be made by direct measurement or by measurement of its projection on a screen. The verification shall be made at not less than four sections.

4.2.1.3 The diamond cone shall have an included angle of 120° ± 0,35°.

Deviations from straightness of the generatrix line of the diamond cone, adjacent to the blend, shall not exceed 0,001 mm over a minimum length of 0,40 mm.

4.2.1.4 The angle between the axis of the diamond cone and the axis of the indenter-holder (normal to the seating surface) shall not exceed 0,5°.

4.2.1.5 The spherical tip of the diamond cone shall have a mean radius of 0,200 ± 0,010 mm. In each measured section, the radius shall be 0,200 ± 0,015 mm and local deviations from it shall not exceed 0,002 mm.

4.2.1.6 The hardness values given by the testing machine do not depend only on the dimensions given in 4.2.1.3 and 4.2.1.5, but also on the surface roughness and the position of the crystallographic axes of the diamond, and the seating of the diamond in its holder.

For this reason, an indirect verification of the indenter is considered necessary. The performance of the indenter in a standardizing machine, which complies with clause 4 of ISO 674, shall be compared with the performance of the machine's own standardizing indenter.

Tests shall be made on a minimum of two blocks, one at a hardness level near the lower limit and the other one near the upper limit of the field of application specified in table 1 of ISO 6508 for the HRC-scale. 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 standardizing indenter by more than ±0,8 unit for the HRC-scale. The indentations with the indenter to be verified and with the standardizing indenter should be carried out in such a way that the indentations of both indenters are in each case adjacent. The test shall be made in accordance with ISO 674.

NOTE — When the indenter is intended for use in HRA and HRD scales, additional HRA tests shall be made on one block in the range 80 to 88 HRA. The error shall not be more than 0,8 HRA.

4.2.2 Steel ball indenter (scales B — E — F — G — H — K)

4.2.2.1 For the purpose of verifying the size and the hardness of the steel balls, it is considered sufficient to test one sample selected at random from a batch. The ball(s) verified for hardness shall be discarded.

4.2.2.2 The ball shall be polished and free from surface defects.

4.2.2.3 The user shall either measure the balls to ensure that they meet the following requirements, or he shall obtain balls from a supplier who can certify that the following conditions are met.

4.2.2.3.1 The diameter, when measured at not less than three positions, shall not differ from the nominal diameter by more than the tolerance given in table 1.

Table 1

Values in millimetres

Rockwell hardness scale	Ball diameter	Tolerance
B	1,587 5	±0,003 5
F	1,587 5	±0,003 5
G	1,587 5	±0,003 5
E	3,175	±0,004
H	3,175	±0,004
K	3,175	±0,004

4.2.2.3.2 The hardness of the steel ball shall be not less than 850 HV 10, when determined in accordance with ISO 6507/1, and applying the appropriate correction for curvature as given in annex B of that standard (see table 2).

Table 2

Values in millimetres

Ball diameter	Maximum value of mean diagonal made on the ball with a Vickers indenter at 98,07 N (HV 10)
3,175	0,144
1,587 5	0,141

4.3 Verification of the measuring device

The depth-measuring device shall be verified over not less than three intervals, including the intervals corresponding to the lowest and highest hardnesses for which the scales are normally used, by making known incremental movements of the indenter in the direction of increasing hardness values.

The instrument used to verify the depth-measuring device shall have an accuracy of 0,000 2 mm. The depth-measuring device shall correctly indicate within ±0,001 mm, i.e. within ±0,5 of a scale unit, over each range.

5 Indirect verification

Indirect verification may be carried out by means of standardized blocks calibrated in accordance with ISO 674.

5.1 Procedure

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

The testing machine shall be verified for each scale for which it is normally used. For each scale to be verified, standardized blocks from at least two of the hardness ranges given in table 3 shall be used. The hardness values of the blocks shall approximate the limits of intended use.

Table 3

Rockwell hardness scale	Hardness range of standardized block
A	20 to 40 HRA 45 to 75 HRA 80 to 88 HRA
B	20 to 50 HRB 60 to 80 HRB 85 to 100 HRB
C	20 to 30 HRC 35 to 55 HRC 60 to 70 HRC
D	40 to 47 HRD 55 to 63 HRD 70 to 77 HRD
E	70 to 78 HRE 84 to 90 HRE 93 to 100 HRE
F	60 to 75 HRF 80 to 90 HRF 94 to 100 HRF
G	30 to 50 HRG 55 to 75 HRG 80 to 94 HRG
H	80 to 94 HRH 96 to 100 HRH
K	40 to 60 HRK 65 to 80 HRK 85 to 100 HRK

5.1.2 For purposes of routine checking, a hardness testing machine may be checked at one hardness value only, corresponding approximately to that of the tests to be made.

5.1.3 On each standardized block, five indentations shall be made and each hardness number observed to within 0,2 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 standardized block, the indenter and the anvil are seating correctly. The results of these preliminary indentations shall be ignored. The test shall be made in accordance with ISO 6508.

5.2 Repeatability

5.2.1 For each standardized block, let e_1, e_2, . . . , e_5 be the values of the measured increase in depth of indentation, arranged in increasing order of magnitude, where e is in units of 0,002 mm, as defined in ISO 6508.

The repeatability of the testing machine under the particular verification conditions is determined by the following quantity:

$$e_5 - e_1$$

5.2.2 The repeatability of the testing machine being verified is not considered satisfactory unless the repeatability at each hardness at which the machine is verified is

- for the scale A, less than $0{,}03\,\bar{e}$
- for the scale B, less than $0{,}06\,\bar{e}$
- for the scale C, less than $0{,}03\,\bar{e}$
- for the scale D, less than $0{,}03\,\bar{e}$
- for the scale E, less than $0{,}06\,\bar{e}$
- for the scale F, less than $0{,}06\,\bar{e}$
- for the scale G, less than $0{,}06\,\bar{e}$
- for the scale H, less than $0{,}06\,\bar{e}$
- for the scale K, less than $0{,}06\,\bar{e}$

where

$$\bar{e} = \frac{e_1 + e_2 + \ldots + e_5}{5}$$

Examples of repeatability requirements are given in annex B.

5.3 Error

5.3.1 The error of the testing machine under the particular verification conditions is expressed by the following quantity:

$$\bar{H} - H$$

where

$$\bar{H} = \frac{H_1 + H_2 + \ldots + H_5}{5}$$

$H_1, H_2, \ldots, H_5$ being the hardness values corresponding to $e_1, e_2, \ldots, e_5$, respectively,

H being the specified hardness of the standardized block used.

5.3.2 The maximum error of the testing machine shall not exceed the values given in table 4.

6 Verification report

The verification report shall include the following information:

a) reference to this International Standard;

b) method of verification (direct or indirect);

c) identification data of the hardness testing machine;

d) means of verification (test blocks, elastic proving devices, etc.);

e) the Rockwell hardness scale(s) verified;

f) the result obtained;

g) date of verification and reference to the testing institution.

Table 4

Rockwell hardness scale	Hardness range of the standardized block	Maximum permissible error Rockwell units
A	20 to ⩽ 75 HRA	±2 HRA
	> 75 to ⩽ 88 HRA	±1,5 HRA
B	20 to ⩽ 45 HRB	±4 HRB
	> 45 to ⩽ 80 HRB	±3 HRB
	> 80 to ⩽ 100 HRB	±2 HRB
C	20 to ⩽ 70 HRC	±1,5 HRC
D	40 to ⩽ 70 HRD	±2 HRD
	> 70 to ⩽ 77 HRD	±1,5 HRD
E	70 to ⩽ 90 HRE	±2,5 HRE
	> 90 to ⩽ 100 HRE	±2 HRE
F	60 to ⩽ 90 HRF	±3 HRF
	> 90 to ⩽ 100 HRF	±2 HRF
G	30 to ⩽ 50 HRG	±6 HRG
	> 50 to ⩽ 75 HRG	±4,5 HRG
	> 75 to ⩽ 94 HRG	±3 HRG
H	80 to ⩽ 100 HRH	±2 HRH
K	40 to ⩽ 60 HRK	±4 HRK
	> 60 to ⩽ 80 HRK	±3 HRK
	> 80 to ⩽ 100 HRK	±2 HRK

Annex A

Notes on diamond indenters

(This annex forms an integral part of the Standard.)

Experience has shown that a number of initially satisfactory indenters can become defective after use for a comparatively short time. This is due to small cracks, pits or other flaws in the surface. If such faults are detected in time, many indenters may be reclaimed by regrinding. If not, any small defects on the surface rapidly worsen and make the indenter useless.

Therefore,

— the condition of indenters shall be checked initially and at frequent intervals using appropriate optical devices (microscope, magnifying glass, etc),

— if the flaw is not on the active part of the indenter, it may be ignored, but if it is on the active part, even if small, the indenter shall not be used,

— the verification of the indenter is no longer valid when the indenter has become unusable because of defects,

— reground or otherwise repaired indenters shall be reverified.

Annex B

Examples of repeatability requirements using standardized blocks

(This annex forms an integral part of the Standard.)

Values in Rockwell units

Hardness of standardized block	Increase in depth of indentation	Repeatability Maximum acceptable value
65 HRC	35 HRC	1,0 HRC
59 HRC	41 HRC	1,2 HRC
55 HRC	45 HRC	1,4 HRC
35 HRC	65 HRC	2,0 HRC
30 HRC	70 HRC	2,1 HRC
20 HRC	80 HRC	2,4 HRC
100 HRB	30 HRB	1,8 HRB
80 HRB	50 HRB	3,0 HRB
60 HRB	70 HRB	4,2 HRB
40 HRB	90 HRB	5,4 HRB

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