
British Standard Methods for
**Hardness test (Rockwell method) and for
verification of hardness testing machines
(Rockwell method)**

Méthodes d'essai de dureté (dureté Rockwell) et de vérification des machines
d'essai de dureté (Rockwell)

Verfahren zur Härteprüfung (Rockwell-Verfahren) und zur Prüfung von Härteprüfmaschinen
(Rockwell-Verfahren)

Foreword

This British Standard has been prepared under the direction of the Iron and Steel and Non-ferrous Metals Standards Committees. It is published as a single document in order to draw attention to the need for regular verification of hardness testing machines (Rockwell method) and to the availability of traceability to the national standard hardness scales. This British Standard supersedes BS 891 : Part 1 : 1962 and BS 891 : Part 2 : 1964, which are withdrawn.

The Technical Committee has taken full account of ISO 6508 and ISO 716 prepared by the International Organization for Standardization (ISO).

The Technical Committee has reconsidered the scope of this standard with the intention of including new developments wherever justifiable. For instance, major changes have occurred in the design of testing machines and in order to differentiate between the inherently greater accuracy of the new digital machines, grade 1 requirements are specified for these machines and less demanding grade 2 requirements are specified for older analogue machines.

In addition, requirements for anvils, including surface finish, have been specified and more demanding tolerances have been specified for indenters in order to give greater accuracy and long term reproducibility resulting from, for example, changes in the indenters.

As previously, the full direct verification procedure is carried out on a new machine or after major overhaul of a machine. Further checking that the accuracy of the machine is valid is provided by application of the indirect verification, following machine assembly and installation. Regular checks of accuracy of an installed machine, e.g. as part of quality assurance procedures or immediately after servicing, would normally be carried out by means of the indirect procedure (see appendix A). As the extent of usage of machines varies considerably it is not possible to give rules for frequency of such verifications. Guidance may be obtained on the basis of informed technical judgement from recognized calibrating authorities.

Considerable importance is attached by the committee to routine monitoring and maintenance of a testing machine's performance between verifications. Although these procedures are not part of the standard as such, a recommended form of procedure that does not impose onerous obligations upon users is given in appendix A.

Compliance with a British Standard does not of itself confer immunity from legal obligations.

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Section one. General

1 Scope

This British Standard describes a method of test for determining the Rockwell hardness of metals at room temperature. In sections three and four, methods are described for direct and indirect verification respectively of the accuracy of a machine for testing Rockwell hardness.

NOTE. The titles of the publications referred to in this standard are listed on the inside back cover.

2 Definitions

For the purposes of this British Standard the following definitions apply.

2.1 hardness scale. A scale represented by a capital letter, which is associated with the type of indenter and force being used.

2.2 error in roundness (of a cone measured in a section normal to the indenter). The greatest radial distance between any point on the conical surface and the circumscribing circle.

2.3 error in sphericity (of a ball). The greatest radial distance between any point on the ball surface and the circumscribing sphere.

2.4 indirect verification (of a hardness testing machine). A performance test, using a specified number of calibrated test blocks and indentations, which provides traceability.

2.5 direct verification (of a hardness testing machine). Traceable tests of the accuracy of the test force, indenter geometry and measuring system and the performance tests given under indirect verification (see section four).

2.6 repeatability (of a testing machine). The range of hardness values obtained on a test block in the indirect verification.

2.7 error (of a testing machine). The difference between the mean hardness value obtained on a test block in the indirect verification and the value assigned to the test block by the calibrating authority.

3 Symbols and designations of hardness

3.1 Symbols

For the purposes of this British Standard the following symbols apply.

Symbol	Term
α	Angle of the diamond cone in degrees
R	Radius of curvature at the tip of the diamond cone (in mm)
D	Diameter of steel ball (in mm)
F_0	Preliminary test force (in N)
F_1	Additional test force (in N)
F	Total test force (in N)
h_0	Depth of indentation (in mm) under preliminary test force before application of additional test force
h_1	Increase in depth of indentation (in mm) under additional test force
e	Permanent increase of depth of indentation under preliminary test force after removal of additional test force (in Rockwell units of 0.002 mm)
E	A constant depending on form of the indenter as follows: 100 units when a diamond cone indenter is used 130 units when a steel ball indenter is used
HR	Rockwell hardness number
R_a	Average surface roughness (in μm) (equivalent to CLA value)

NOTE. See BS 1134.

3.2 Hardness value

When defining a hardness value, the scale that has been used for the test shall be stated. The symbol HR shall be preceded by the hardness value and followed by a capital letter representing the scale that has been used.

Example. 50 HRC indicates a Rockwell hardness of 50 in the C scale, obtained using a diamond indenter with a preliminary test force of 98.07 N and a total test force of 1471 N (see table 1).

Section two. Determination of Rockwell hardness

4 Principle

An indenter comprising a diamond cone or a hardened steel ball mounted rigidly in a suitable holder is forced into the material with a preliminary test force F_0 (see figures 1(a) and 2(a)). When equilibrium has been reached, an indicating device, which follows the movements of the indenter and so responds to changes in depth of penetration, is set to a datum position.

While the preliminary test force is still applied it is augmented by an additional test force F_1 with a resulting increase in penetration (see figures 1(b) and 2(b)). When equilibrium has again been reached, the additional force is removed but the preliminary force is maintained.

Removal of F_1 allows a partial recovery, so reducing the depth of penetration (see figures 1(c) and 2(c)). The permanent increase in depth of penetration e resulting from the application and removal of the additional force is used to deduce the Rockwell hardness number by means of the following equation:

$$HR = E - e$$

The unit of measurement for e is 0.002 mm.

The type of indenter used, the magnitudes of the preliminary, additional and total test forces and the constant E for the Rockwell scales of hardness covered by this standard are given in table 1. Also given is the field of application for each hardness scale in terms of the Rockwell hardness range.

5 Test apparatus

5.1 Hardness testing machine (Rockwell), capable of applying a preliminary test force of 98.07 N and total test forces of 588.4 N, 980.7 N and 1471 N to the accuracy specified in 11.3.

5.2 Indenter, comprising a diamond cone or hardened steel ball, complying with clause 12 and mounted in a holder.

5.3 Measuring device, capable of measuring changes in penetration depth to the accuracy specified in clause 13.

5.4 Flat anvils, complying with clause 14.

6 Conditions of test

6.1 Test piece surfaces

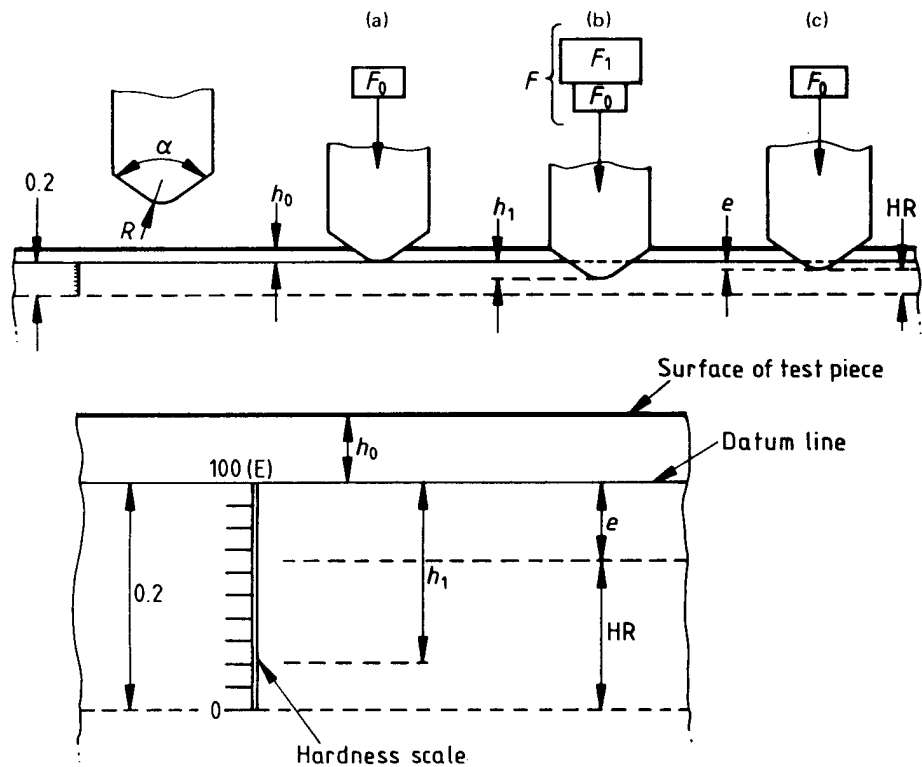
Test piece surfaces shall be smooth and free from scale and foreign matter. In particular, the surface in contact with the anvil and the surface to be indented shall be clean and dry unless otherwise specified in the product standard.

6.2 Test piece thickness

No deformation shall be visible on the underside of the test piece after the test. The thickness of the test piece shall be at least 10 times the depth of the indentation (see figure 3).

Table 1. Rockwell hardness scales

Scale	Indenter	Preliminary force, F_0	Additional force, F_1	Total force, F	Constant, E	Range
HRA	Diamond cone	98.07	490.3	588.4	100	20 to 88 HRA
HRB	1.5875 mm steel ball	98.07	882.6	980.7	130	30 to 100 HRB
HRC	Diamond cone	98.07	1373	1471	100	20 to 70 HRC
HRD	Diamond cone	98.07	882.6	980.7	100	40 to 77 HRD
HRE	3.175 mm steel ball	98.07	882.6	980.7	130	70 to 100 HRE
HRF	1.5875 mm steel ball	98.07	490.3	588.4	130	60 to 100 HRF
HRG	1.5875 mm steel ball	98.07	1373	1471	130	30 to 94 HRG
HRH	3.175 mm steel ball	98.07	490.3	588.4	130	80 to 100 HRH
HRK	3.175 mm steel ball	98.07	1373	1471	130	40 to 100 HRK



Dimensions are in millimetres.

Figure 1. Surface of test piece with diamond cone (Rockwell scales HRA, HRC or HRD)

6.3 Location of indentations

The distance between the centre of any indentation and the edge of the test piece shall be at least 2.5 times the diameter of the indentation and not less than 1 mm. The distance between the centres of two adjacent indentations shall be at least three times the diameter of the indentation (see figure 4).

7 Test procedure

Locate the test piece rigidly in relation to the indenter. Apply the test forces along the axis of the indenter and normal to the surface of the test piece, in such a manner that the indenter is forced into the test piece without shock or vibration.

NOTE 1. It is important that the test piece lies firmly on the support so that displacement can not occur during the test.

NOTE 2. Test piece misalignments of 10° or more may cause unacceptable errors.

NOTE 3. An anvil having a protuberance of about 6 mm diameter may be used, with advantage, for test pieces that are not flat.

Bring the indenter into contact with the test surface and apply the preliminary test force F_0 . Set the measuring

device reading to the value corresponding to the constant E and increase the force, in not less than 2 s and not more than 8 s, by the additional force F_1 to obtain a total test force F . Maintain F for a period (i.e. a dwell time) of 2 s to 6 s unless otherwise stated in the product standard. After removal of F_1 , maintain F_0 until the reading of the depth measuring device has been taken.

NOTE 4. After any removal and replacement of the indenter or test piece support, it should be ascertained that the item is correctly mounted in its housing. After such a change has been made, the first two readings should be disregarded.

8 Calculations

For tests on flat surfaces, derive the Rockwell hardness number from the permanent increase in depth of indentation e (see clause 4).

NOTE 1. The Rockwell hardness number is usually read directly from the measuring device.

For tests on convex cylindrical surfaces apply the corrections given in appendix C.

NOTE 2. In the absence of established conversions for tests on concave cylindrical and spherical surfaces, hardness values should be regarded as comparative.