
**Metallic materials — Rockwell hardness
test —**

Part 1:

Test method (scales A, B, C, D, E, F, G, H, K,
N, T)

Matériaux métalliques — Essai de dureté Rockwell —

Partie 1: Méthode d'essai (échelles A, B, C, D, E, F, G, H, K, N, T)



Contents	Page
1 Scope	1
2 Normative reference	1
3 Principle	1
4 Symbols and designations	1
5 Testing machine	3
6 Test piece	4
7 Procedure	4
8 Uncertainty of the results	5
9 Test report	5
Annex A (normative) Conventional HR30Tm test for thin products	6
Annex B (normative) Minimum thickness of the test piece in relation to the Rockwell hardness	7
Annex C (normative) Corrections to be added to Rockwell hardness values obtained on convex cylindrical surfaces	10
Annex D (normative) Corrections to be added to Rockwell hardness C scale values obtained on spherical test surfaces of various diameters	12
Annex E (informative) Procedure for periodic checks of the testing machines by the user	13
Annex F (informative) Notes on diamond indenters	14
Bibliography	15

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 3.

Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

International Standard 6508-1 was prepared by the Technical Committee ISO/TC 164, *Mechanical testing of metals*, Subcommittee SC 3, *Hardness testing*.

This first edition of ISO 6508-1 cancels and replaces ISO 6508:1986 and ISO 1024:1989, of which it constitutes a technical revision as follows:

- Combination of the two different International Standards for the different scales (ISO 6508:1986 and ISO 1024:1989) into this part of ISO 6508.
- Addition of clause 8 concerning the accuracy of the test results.
- Addition of annex A concerning the conventional HR30Tm test for thin products.
- Addition of annex E concerning a procedure for a periodic check of the testing machines by users.
- Addition of annex F concerning notes on diamond indenters.
- Addition of a hardmetal ball as indenter.

ISO 6508 consists of the following parts, under the general title *Metallic materials — Rockwell hardness test*:

- *Part 1: Test method (scales A, B, C, D, E, F, G, H, K, N, T)*
- *Part 2: Verification and calibration of testing machines (scales A, B, C, D, E, F, G, H, K, N, T)*
- *Part 3: Calibration of reference blocks (scales A, B, C, D, E, F, G, H, K, N, T)*

Annexes A, B, C and D form a normative part of this part of ISO 6508. Annexes E and F are for information only.

Introduction

The force values in this part of ISO 6508 were calculated from kilogram force values. They were introduced before the SI-system was adopted. It was decided to keep the values based on the old units for this part of ISO 6508 but for the next revision it will be necessary to consider the advantage of introducing rounded values of test force and the consequence on the hardness scales.

Attention is drawn to the fact that in this part of ISO 6508, the use of hardmetal balls as indenters is equivalent to the use of steel balls; however, it is indicated that the measurements made with the two ball types give different results.

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Metallic materials — Rockwell hardness test —

Part 1:

Test method (scales A, B, C, D, E, F, G, H, K, N, T)

1 Scope

This part of ISO 6508 specifies the method for Rockwell and Rockwell superficial hardness tests (scales and field of application in accordance with Table 1) for metallic materials.

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

NOTE For certain materials, the fields of application may be narrower than those indicated.

2 Normative reference

The following normative document contains provisions which, through reference in this text, constitute provisions of this part of ISO 6508. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. However, parties to agreements based on this part of ISO 6508 are encouraged to investigate the possibility of applying the most recent edition of the normative documents indicated below. For undated references, the latest edition of the normative document referred to applies. Members of ISO and IEC maintain registers of currently valid International Standards.

ISO 6508-2:1999, *Metallic materials — Rockwell hardness test — Part 2: Verification and calibration of testing machines (scales A, B, C, D, E, F, G, H, K, N, T)*.

3 Principle

Forcing an indenter (diamond cone, steel or hardmetal ball) into the surface of a test piece in two steps under specified conditions (see clause 7). Measuring the permanent depth h of indentation under preliminary test force after removal of additional test force.

From the value of h and the two constant numbers N and S (see Table 2), the Rockwell hardness is calculated following the formula:

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

4 Symbols and designations

See Tables 1 and 2 and Figure 1.

Table 1 — Rockwell scales

Rockwell hardness scale	Hardness symbol ^a	Type of indenter mm	Preliminary test force F_0 N	Additional test force F_1 N	Total test force F N	Field of application (Rockwell hardness test)
A	HRA	Diamond cone	98,07	490,3	588,4	20 HRA to 88 HRA
B	HRB	Ball 1,587 5 mm	98,07	882,6	980,7	20 HRB to 100 HRB
C	HRC	Diamond cone	98,07	1 373	1 471	20 HRC to 70 HRC
D	HRD	Diamond cone	98,07	882,6	980,7	40 HRD to 77 HRD
E	HRE	Ball 3,175 mm	98,07	882,6	980,7	70 HRE to 100 HRE
F	HRF	Ball 1,587 5 mm	98,07	490,3	588,4	60 HRF to 100 HRF
G	HRG	Ball 1,587 5 mm	98,07	1 373	1 471	30 HRG to 94 HRG
H	HRH	Ball 3,175 mm	98,07	490,3	588,4	80 HRH to 100 HRH
K	HRK	Ball 3,175 mm	98,07	1 373	1 471	40 HRK to 100 HRK
15N	HR15N	Diamond cone	29,42	117,7	147,1	70 HR15N to 94 HR15N
30N	HR30N	Diamond cone	29,42	264,8	294,2	42 HR30N to 86 HR30N
45N	HR45N	Diamond cone	29,42	411,9	441,3	20 HR45N to 77 HR45N
15T	HR15T	Ball 1,587 5 mm	29,42	117,7	147,1	67 HR15T to 93 HR15T
30T	HR30T	Ball 1,587 5 mm	29,42	264,8	294,2	29 HR30T to 82 HR30T
45T	HR45T	Ball 1,587 5 mm	29,42	411,9	441,3	10 HR45T to 72 HR45T

^a For the scales using the ball indenters, the hardness symbol is to be completed with "S", if the steel ball indenter is used and with "W", if the hardmetal ball is used.

Table 2 — Symbols and designations

Symbol	Designation	Unit
F_0	Preliminary test force	N
F_1	Additional test force	N
F	Total test force	N
S	Scale unit, specific to the scale	mm
N	Number, 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 hardness = $100 - \frac{h}{0,002}$	
HRB HRE HRF HRG HRH HRK	Rockwell hardness = $130 - \frac{h}{0,002}$	
HRN HRT	Rockwell hardness = $100 - \frac{h}{0,001}$	

4.1 The Rockwell hardness for the scales A, C and D is denoted by the symbol HR preceded by the hardness value and completed by a letter indicating the scale.

EXAMPLE 59 HRC = Rockwell hardness of 59, measured on the C scale.

4.2 The Rockwell hardness for the scales B, E, F, G, H and K is denoted by the symbol HR preceded by the hardness value and completed by a letter indicating the scale and a letter for the applied type of ball indenter (S for steel and W for hardmetal).

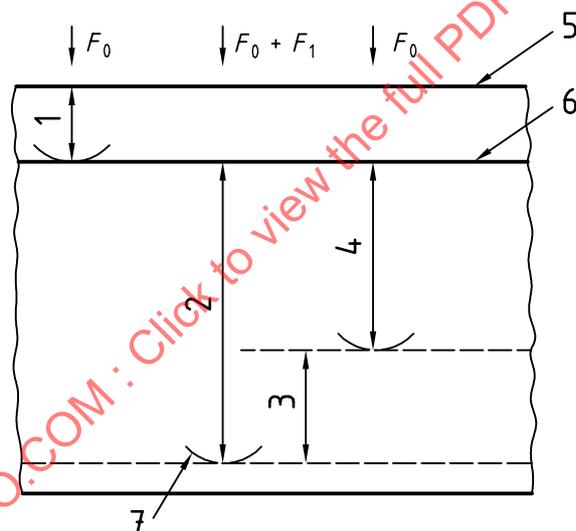
EXAMPLE 60 HRBW = Rockwell hardness of 60, measured on the B scale with a hardmetal ball indenter.

4.3 The Rockwell superficial hardness for the N scale is denoted by the symbol HR preceded by the hardness value and followed by a number (representing the total test force) and the letter N indicating the scale.

EXAMPLE 70 HR30N = Rockwell superficial hardness of 70 measured on the 30 N scale with a total test force of 294,2 N.

4.4 The Rockwell superficial hardness for the T scale is denoted by the symbol HR preceded by the hardness value and followed by a number (representing the total test force) and the letter T indicating the scale and followed by a letter for the applied type of the ball indenter (S for steel and W for hardmetal).

EXAMPLE 40 HR30TS = Rockwell superficial hardness of 40 measured on the 30 T scale with a total test force of 294,2 N and with a steel ball indenter.



Key

- | | |
|--|-----------------------------------|
| 1 Indentation depth by preliminary force F_0 | 5 Surface of specimen |
| 2 Indentation depth by additional test force F_1 | 6 Reference plane for measurement |
| 3 Elastic recovery just after removal of additional test force F_1 | 7 Position of indenter |
| 4 Permanent indentation depth h | |

Figure 1 — Rockwell principle diagram

5 Testing machine

5.1 Testing machine, capable of applying predetermined forces as shown in Table 1 and in accordance with ISO 6508-2.

5.2 Conical diamond indenter, in accordance with ISO 6508-2 with an angle of 120° and radius of curvature at the tip of 0,2 mm.

5.3 Steel or hardmetal ball indenter, in accordance with ISO 6508-2, with a diameter of 1,5875 mm or 3,175 mm.

5.4 Measuring device, in accordance with ISO 6508-2.

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.

6.2 Preparation shall be carried out in such a way that any alteration of the surface hardness due to heat or cold-working for example, is minimized. This shall be taken into account particularly in the case of low-depth indentations.

6.3 After the test, no deformation shall be visible on the surface of the test piece opposite the indentation, except in case of HR30Tm (the test shall be performed in accordance with annex A).

The thickness of the test piece or of the layer under test (minimum values given in annex B) shall be at least ten times the permanent indentation depth for cone indenters and fifteen times the permanent indentation depth for ball indenters.

6.4 For tests on convex cylindrical surfaces and spherical surfaces the corrections given in annex C (Tables C.1, C.2, C.3 or C.4) and in annex D (Table D.1) shall be applied.

NOTE In the absence of corrections for tests on concave surfaces, tests on such surfaces should be the subject of special agreement.

7 Procedure

7.1 In general, the test shall be carried out at ambient temperature within the limits of 10 °C to 35 °C. Tests carried out under controlled conditions shall be made at a temperature of (23 ± 5) °C.

7.2 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-blocks of steel 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 may result in incorrect results.

7.3 Bring the indenter into contact with the test surface and apply the preliminary test force F_0 without shock, vibration or oscillation. The duration of the preliminary test force F_0 shall not exceed 3 s.

7.4 Set the measuring device to its datum position and, without shock, vibration or oscillation, increase the force from F_0 to F in no less than 1 s nor greater than 8 s.

7.5 The total test force F shall be maintained for a duration of $4 \text{ s} \pm 2 \text{ s}$. Remove the additional test force F_1 and, while the preliminary test force F_0 is maintained, after a short time stabilisation, the final reading shall be made.

7.6 The Rockwell hardness number is derived from the permanent indentation depth h using the formulas given in Table 2 and is usually read directly from the measuring device. The derivation of the Rockwell hardness number is illustrated in Figure 1.

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

7.8 Before beginning a series of tests or when more than 24 h have elapsed since the last test, and after each change, or removal and replacement, of the indenter or test piece support, it shall be ascertained that the indenter

and the test piece support are correctly mounted in the machine. The first two readings after such a change has been made shall be disregarded.

NOTE A suggested procedure for periodic checks is given in annex E. See also notes on diamond indenters in annex F.

7.9 The distance between the centres of two adjacent indentations shall be at least four times the diameter of the indentation (but not less than 2 mm).

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 (but not less than 1 mm).

8 Uncertainty of the results

The uncertainty of results is dependent on various parameters which may be separated into two categories:

- a) parameters depending on the Rockwell hardness testing machine (including the uncertainty of the verification of the testing machine and of the calibration of the reference blocks);
- b) parameters depending on the application of the test method (variation of the operating conditions).

NOTE A complete evaluation of the uncertainty should be carried out according to the *Guide to the Expression of Uncertainty in Measurement* [3]. Indicative values of the extended uncertainty at a confidence level of 95 % can be taken equal to the maximum permissible error given in Table 5 of ISO 6508-2:1999.

9 Test report

The test report shall include the following information:

- a) a reference to this International Standard, i.e. ISO 6508-1;
- b) all details necessary for the complete identification of the test piece;
- c) the test temperature, if it is not in the limit $(23 \pm 5) ^\circ\text{C}$;
- d) the result obtained (see note 1);
- e) all operations not specified by this part of ISO 6508, or regarded as optional;
- f) details of any occurrence which may have affected result (see note 2).

NOTE 1 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.

NOTE 2 There is evidence that some materials may 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.

Annex A (normative)

Conventional HR30Tm test for thin products

A.1 General

This test is carried out under conditions similar to those in the HR30T test defined in this part of ISO 6508 but, by agreement, the appearance of indentations on the back of the test pieces — not permitted in the HRT test — is allowed.

This test is applicable with adequate precision to products of thickness less than 0,6 mm up to the minimum thickness indicated in the product standards and of a maximum HR30T Rockwell hardness of 80. The product standard specifies when the conventional HR30Tm hardness test shall be applied.

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

A.2 Test piece support

The test piece support shall comprise a polished and smooth diamond plate approximately 4,5 mm in diameter. This support surface shall be 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.3 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 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.4 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.

Annex B
(normative)

Minimum thickness of the test piece in relation to the Rockwell hardness

The minimum thickness of the test piece or of the layer under test is given in Figures B.1, B.2 and B.3.

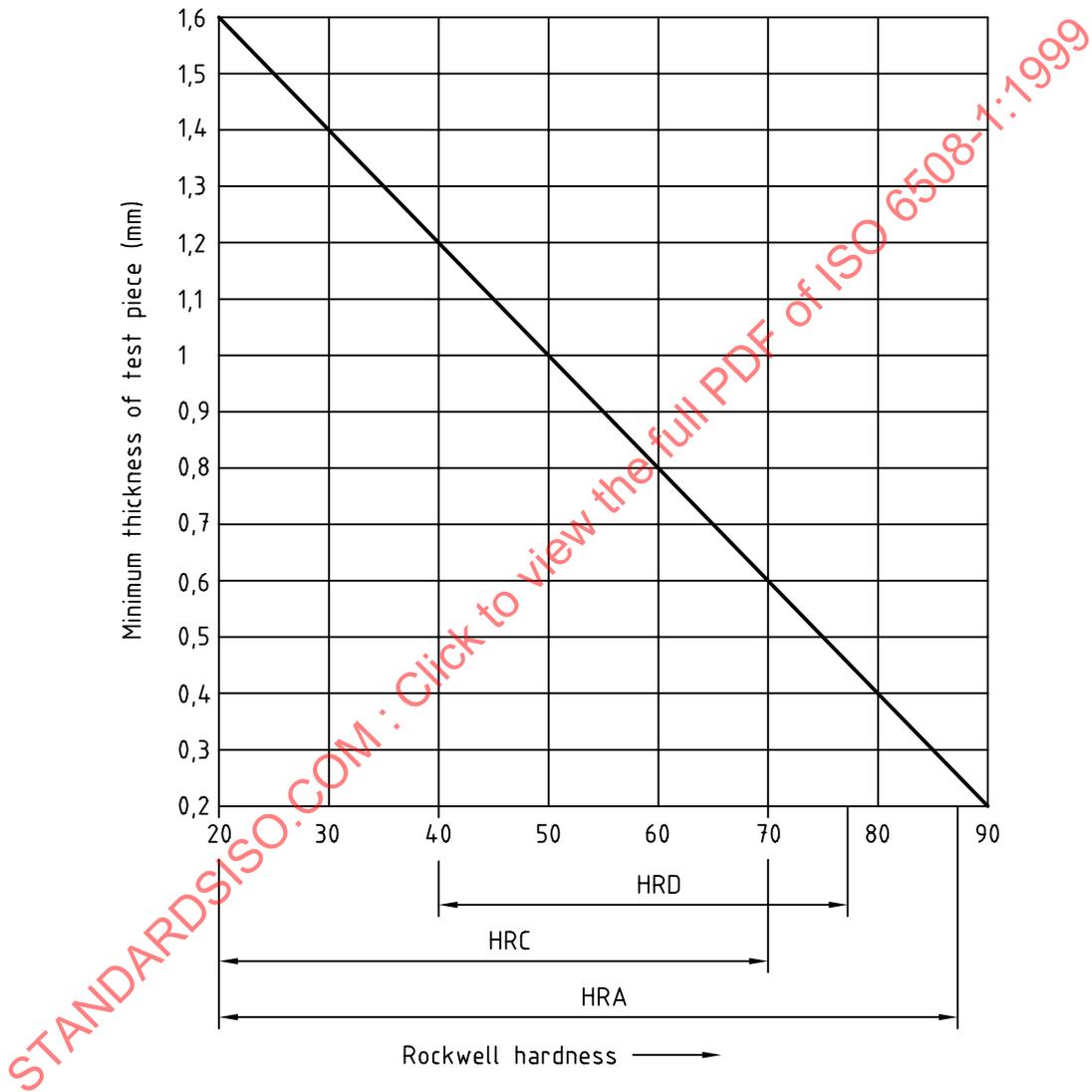


Figure B.1 — Test with diamond cone indenter (scales A, C and D)

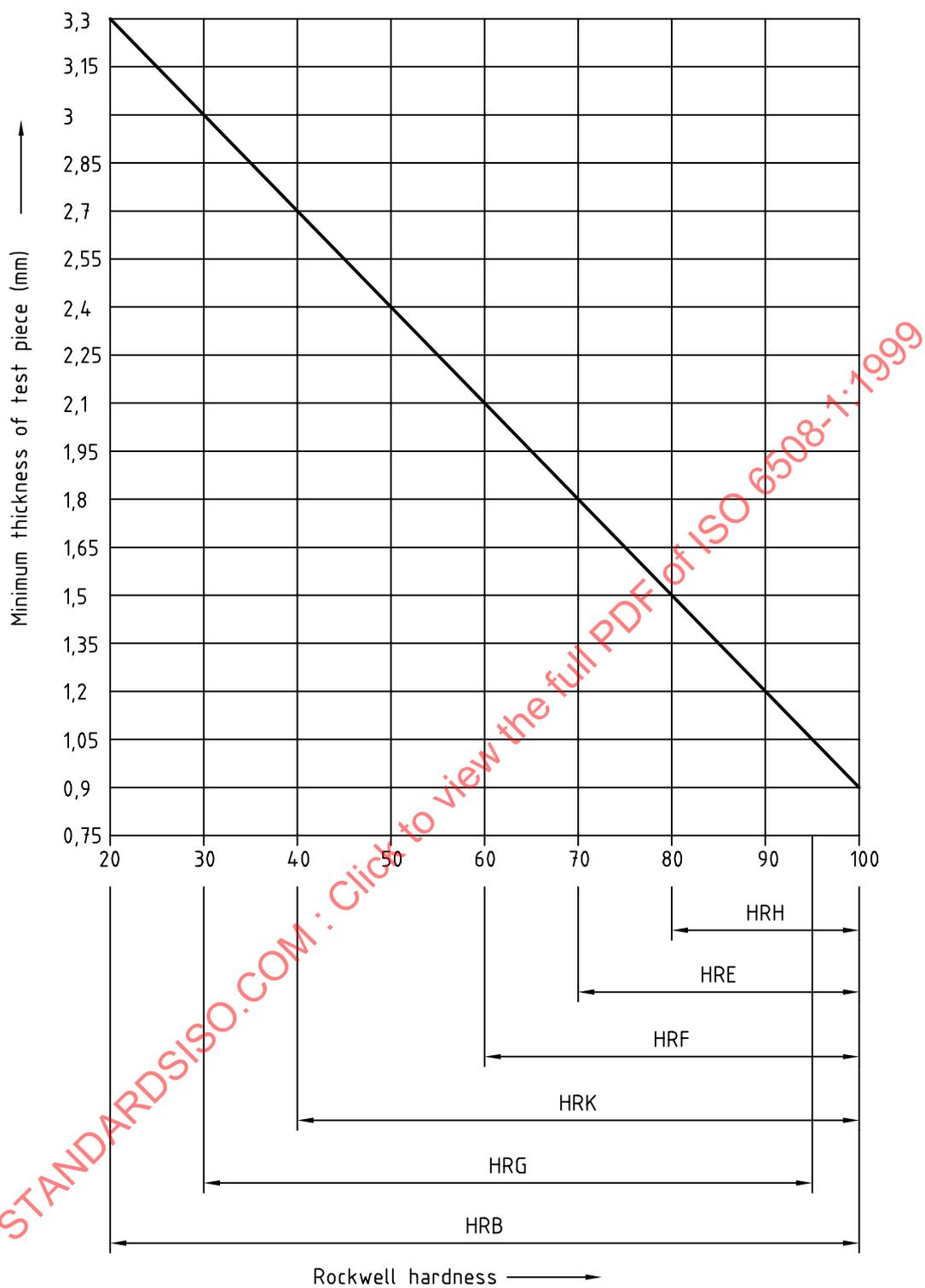


Figure B.2 — Test with ball indenters (scales B, E, F, G, H and K)

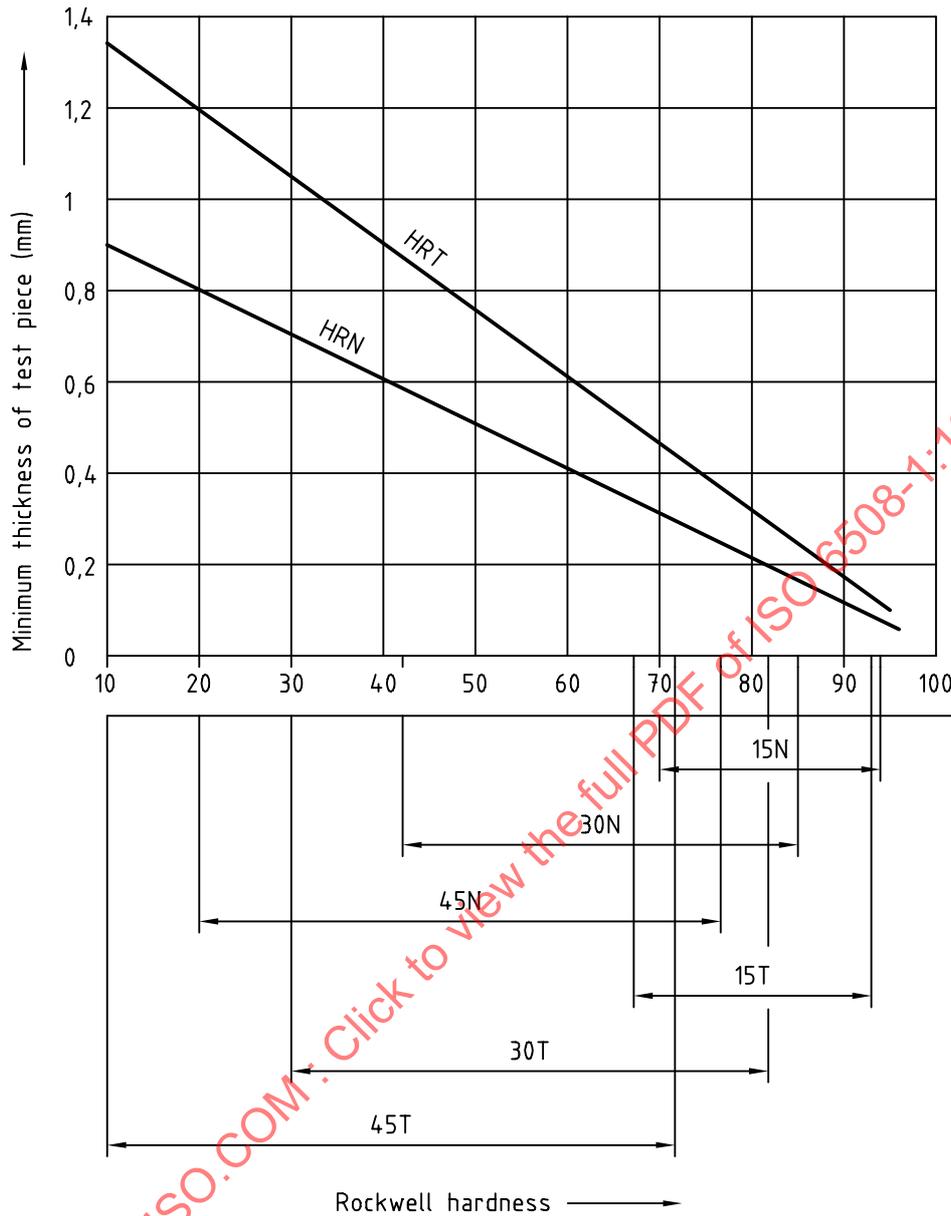


Figure B.3 — Rockwell superficial test (scales N and T)

Annex C (normative)

Corrections to be added to Rockwell hardness values obtained on convex cylindrical surfaces

For tests on convex cylindrical surfaces the corrections given in Tables C.1, C.2, C.3 or C.4 shall be applied.

Table C.1 — Test with diamond cone indenter (scales A, C and D)

Rockwell hardness reading	Radius of curvature mm								
	3	5	6,5	8	9,5	11	12,5	16	19
20				2,5	2	1,5	1,5	1	1
25			3	2,5	2	1,5	1	1	1
30			2,5	2	1,5	1,5	1	1	0,5
35		3	2	1,5	1,5	1	1	0,5	0,5
40		2,5	2	1,5	1	1	1	0,5	0,5
45	3	2	1,5	1	1	1	0,5	0,5	0,5
50	2,5	2	1,5	1	1	0,5	0,5	0,5	0,5
55	2	1,5	1	1	0,5	0,5	0,5	0,5	0
60	1,5	1	1	0,5	0,5	0,5	0,5	0	0
65	1,5	1	1	0,5	0,5	0,5	0,5	0	0
70	1	1	0,5	0,5	0,5	0,5	0,5	0	0
75	1	0,5	0,5	0,5	0,5	0,5	0	0	0
80	0,5	0,5	0,5	0,5	0,5	0	0	0	0
85	0,5	0,5	0,5	0	0	0	0	0	0
90	0,5	0	0	0	0	0	0	0	0

NOTE Corrections greater than 3 HRA, HRC and HRD are not considered acceptable and are not therefore included in above table.

Table C.2 — Test with 1,5875 mm ball indenter (scales B, F and G)

Rockwell hardness reading	Radius of curvature mm						
	3	5	6,5	8	9,5	11	12,5
20				4,5	4	3,5	3
30			5	4,5	3,5	3	2,5
40			4,5	4	3	2,5	2,5
50			4	3,5	3	2,5	2
60		5	3,5	3	2,5	2	2
70		4	3	2,5	2	2	1,5
80	5	3,5	2,5	2	1,5	1,5	1,5
90	4	3	2	1,5	1,5	1,5	1
100	3,5	2,5	1,5	1,5	1	1	0,5

NOTE Corrections greater than 5 HRB, HRF and HRG are not considered acceptable and are not therefore included in above table.

Table C.3 — Rockwell superficial test (scale N)^{a,b}

Rockwell superficial hardness reading	Radius of curvature ^c mm					
	1,6	3,2	5	6,5	9,5	12,5
20	(6) ^d	3	2	1,5	1,5	1,5
25	(5,5) ^d	3	2	1,5	1,5	1
30	(5,5) ^d	3	2	1,5	1	1
35	(5) ^d	2,5	2	1,5	1	1
40	(4,5) ^d	2,5	1,5	1,5	1	1
45	(4) ^d	2	1,5	1	1	1
50	(3,5) ^d	2	1,5	1	1	1
55	(3,5) ^d	2	1,5	1	0,5	0,5
60	3	1,5	1	1	0,5	0,5
65	2,5	1,5	1	0,5	0,5	0,5
70	2	1	1	0,5	0,5	0,5
75	1,5	1	0,5	0,5	0,5	0
80	1	0,5	0,5	0,5	0	0
85	0,5	0,5	0,5	0,5	0	0
90	0	0	0	0	0	0

^a These corrections are approximate only and represent the averages, to the nearest 0,5 Rockwell superficial hardness units, of numerous actual observations on test surfaces having the curvatures given in the table.

^b When testing convex cylindrical surfaces the accuracy of the test will be seriously affected by misalignment of elevating screw, V-anvil and indenter and by imperfections in the surface finish and straightness of the cylinder.

^c For radii other than those given in the table, corrections may be derived by linear interpolation.

^d The corrections given in parentheses shall not be used except by agreement.

Table C.4 — Rockwell superficial test (scale T)^{a,b}

Rockwell superficial hardness reading	Radius of curvature ^c mm						
	1,6	3,2	5	6,5	8	9,5	12,5
20	(13) ^d	(9) ^d	(6) ^d	(4,5) ^d	(3,5) ^d	3	2
30	(11,5) ^d	(7,5) ^d	(5) ^d	(4) ^d	(3,5) ^d	2,5	2
40	(10) ^d	(6,5) ^d	(4,5) ^d	(3,5) ^d	3	2,5	2
50	(8,5) ^d	(5,5) ^d	(4) ^d	3	2,5	2	1,5
60	(6,5) ^d	(4,5) ^d	3	2,5	2	1,5	1,5
70	(5) ^d	(3,5) ^d	2,5	2	1,5	1	1
80	3	2	1,5	1,5	1	1	0,5
90	1,5	1	1	0,5	0,5	0,5	0,5

^a These corrections are approximate only and represent the averages, to the nearest 0,5 Rockwell superficial hardness units, of numerous actual observations on test surfaces having the curvatures given in the table.

^b When testing convex cylindrical surfaces the accuracy of the test will be seriously affected by misalignment of elevating screw, V-anvil and indenter and by imperfections in the surface finish and straightness of the cylinder.

^c For radii other than those given in the table, corrections may be derived by linear interpolation.

^d The corrections given in parentheses shall not be used except by agreement.

Annex D (normative)

Corrections to be added to Rockwell hardness C scale values obtained on spherical test surfaces of various diameters

For tests on convex spherical surfaces the corrections given in Table D.1 shall be applied.

Table D.1

Rockwell hardness reading	Diameter of sphere <i>d</i> mm								
	4	6,5	8	9,5	11	12,5	15	20	25
55 HRC	6,4	3,9	3,2	2,7	2,3	2	1,7	1,3	1
60 HRC	5,8	3,6	2,9	2,4	2,1	1,8	1,5	1,2	0,9
65 HRC	5,2	3,2	2,6	2,2	1,9	1,7	1,4	1	0,8

The values of the correction to be added to Rockwell hardness C scale ΔH , given in Table D.1, are calculated using the following formula:

$$\Delta H = 59 \times \frac{\left(1 - \frac{H}{160}\right)^2}{d}$$

where

H is the Rockwell hardness reading;

d is the diameter of the sphere, expressed in millimetres.