IS 1586 (2000): Method for Rockwell Hardness Test for Metallic Material (Scales A-B-C-D-E-F-G-H-K 15N, 30N, 45N, 15T, 30T and 45T) [MTD 3: Mechanical Testing of Metals]

BLANK PAGE

IS 1586 : 2000
(Superseding IS 3754 : 1988, IS 3804 : 1988, IS 5072 : 1988, IS 5073 : 1988 and IS 5076 : 1988)
(Reaffirmed 2006)

भारतीय मानक

धातुओं की रॉकवेल कठोरता परीक्षण करने की पद्धति (स्केल ए–बी–सी–डी–ई–एफ–जी–एच–के 15एन, 30एन, 45एन, 15टी, 30टी एवं 45टी)

(तीसरा पुनरीक्षण)

Indian Standard

METHOD FOR ROCKWELL HARDNESS TEST FOR METALLIC MATERIAL (SCALES A-B-C-D-E-F-G-H-K 15N, 30N, 45N, 15T, 30T AND 45T)

(Third Revision)

ICS 77.040.10

BUREAU OF INDIAN STANDARDS
MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG
NEW DELHI 110002

October 2000

Price Group 9

FOREWORD

This Indian Standard (Third Revision) was adopted by the Bureau of Indian Standard, after the draft finalized by the Mechanical Testing of Metals Sectional Committee had been approved by the Metallurgical Engineering Division Council.

This Indian Standard was published in 1960 and subsequently revised in 1968 and 1988.

In this revision the requirement of method for Rockwell superficial hardness test, calibration of standardized blocks and verification of Rockwell hardness testing machines have been included. In the preparation of this standard, assistance has been drawn from ASTM E 18 -97a 'Standard test methods for Rockwell hardness and Rockwell superficial hardness of metallic materials' issued by American Society for Testing and Materials, USA.

This revised standard supersedes the following Indian Standards:

IS No.	*Title*
3754 : 1988	Method for calibration of standardized blocks to be used for Rockwell hardness testing machine (Scales A-B-C-D-E-F-G-H-K) (*first revision*)
3804 : 1988	Method for verification of Rockwell hardness testing machines (Scales A-B-C-D-E-F-G-H-K) (*first revision*)
5072 : 1988	Methods for Rockwell superficial hardness test (Scales 15N, 30N, 45N, 15T, 30T and 45T) (*first revision*)
5073 : 1988	Method for verification of Rockwell superficial hardness testing machines (Scales 15N, 30N, 45N, 15T and 45T) (*first revision*)
5076 : 1988	Method for calibration of standardized blocks to be used for rockwell superficial hardness testing machines (Scales 15N, 30N, 45N, 15T, 30T and 45T) (*first revision*)

For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the result of a test or analysis, shall be rounded off in accordance with IS 2 : 1960 'Rules for rounding off numerical values (*revised*)'. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

Indian Standard

METHOD FOR ROCKWELL HARDNESS TEST FOR METALLIC MATERIAL (SCALES A-B-C-D-E-F-G-H-K 15N, 30N, 45N, 15T, 30T AND 45T)

(Third Revision)

1 SCOPE

This standard specifies the method for conducting the Rockwell hardness test (scales and hardness range according to Table 1) for metallic materials.

NOTE — For certain materials, the hardness range may be narrower than those indicated.

2 REFERENCE

The following Indian Standard contains provisions which through reference in this text, constitutes provision of this standard. At the time of publication, the edition indicated was valid. All standards are subject to revision and parties to agreements based on this standard are encouraged to investigate the possibility of applying the most recent edition of the standard indicated below :

IS No.	*Title*
1501 (Part 1) : 1984	Method for Vickers hardness test for metallic materials : Part 1 HV to HV 100 (*second revision*)

3 PRINCIPLE

The test consists of forcing an indenter (diamond cone or steel ball) into the surface of a test piece in two steps under specified conditions (*see* 7) and measuring the permanent increase of depth of indentation. The unit of measurement for e is 0.002 mm for Rockwell hardness and 0.001 mm for Rockwell superficial hardness. From the value of e, a number known as the Rockwell hardness is derived.

4 SYMBOLS AND DESIGNATIONS

The symbols and designations used in this standard are given in Tables 1 and 2 and Fig. 1, 2, 3 and 4.

4.1 The Rockwell hardness 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

70 HR30N = Rockwell superficial hardness of 70 measured on the 30N scale.

5 APPARATUS

5.1 Testing Machine

Capable of applying a predetermined force or forces within the ranges shown in Table 1 and in accordance with Annex A.

5.2 Sphero-Conical Diamond Indenter

In accordance with Annex A having an angle of 120° and radius of curvature at the tip of 0.200 mm for A, C, D and all N scales.

5.3 Steel Ball Indenter

In accordance with Annex A having a diameter of 1.587 5 mm for B, F, G and all 'T' scales and 3.175 mm for E, H and K scales.

5.4 Measuring Device

See Annex A.

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 (except for tests on some reactive materials, such as titanium, where lubricants such as kerosene may be required). If lubricants have been used, it shall be stated in the test report.

6.2 Preparation shall be carried out in such a way that any alteration of surface hardness due to hot or cold working is minimized.

6.3 The thickness of the test piece or of the layer under test shall be at least ten times the permanent increase of depth e. The minimum thickness of test piece in relation to the Rockwell hardness is shown in Fig. 5, 6 and 7.

After the test, no deformation shall be visible on the surface of the test piece opposite to the indentation.

6.4 For tests on convex cylindrical surfaces and spherical surfaces, the corrections given in Tables 3, 4, 5, 6 and 7 shall be applied. In the absence of corrections for tests on concave surfaces, tests on such surfaces shall be subject to special agreement.

Table 1 Hardness Range

(*Clauses* 1, 4 *and* 5.1)

Rockwell Hardness Scale	Hardness	Type of Indenter	Preliminary Test Force, F_0 N (kgf)	Additional Test Force, F_1 N (kgf)	Total Test Force, F N (kgf)	Rockwell Hardness Range
(1)	(2)	(3)	(4)	(5)	(6)	(7)
A	HRA	Diamond cone	98.07(10)	490.3(50)	588.4(60)	20 to 88 HRA
B	HRB	Steel ball 1.587 5 mm	98.07(10)	882.6(90)	980.7(100)	20 to 100 HRB
C	HRC	Diamond cone	98.07(10)	1 373.0(140)	1 471.0(150)	20 to 70 HRC
D	HRD	Diamond cone	98.07(10)	882.6(90)	980.7(100)	40 to 77 HRD
E	HRE	Steel ball 3.175 mm	98.07(10)	882.6(90)	980.7(100)	70 to 100 HRE
F	HRF	Steel ball 1.587 5 mm	98.07(10)	490.3(50)	588.4(60)	60 to 100 HRF
G	HRG	Steel ball 1.587 5 mm	98.07(10)	1 373.0(140)	1 471.0(150)	30 to 94 HRG
H	HRH	Steel ball 3.175 mm	98.07(10)	490.3(50)	588.4(60)	80 to 100 HRH
K	HRK	Steel ball 3.175 mm	98.07(10)	1 373.0(140)	1 471.0(150)	40 to 100 HRK
15N	HR15N	Diamond cone	29.42(3)	117.7(12)	147.1(15)	70-94 HR15N
30N	HR30N	Diamond cone	29.42(3)	264.8(27)	294.2(30)	42-86 HR30N
45N	HR45N	Diamond cone	29.42(3)	411.9(42)	441.3(45)	20-77 HR45N
15T	HR15T	Steel ball 1.587 5 mm	29.42(3)	117.7(12)	147.1(15)	67-93 HR15T
30T	HR30T	Steel ball 1.587 5 mm	29.42(3)	264.8(27)	294.2(30)	29-82 HR30T
45T	HR45T	Steel ball 1.587 5 mm	29.42(3)	411.9(42)	441.3(45)	1-72 HR45T

Table 2 Symbols and Designations

(*Clause* 4)

Symbol/ Designation	Description
(1)	(2)
α	Angle of diamond cone
R	Radius of curvature at the tip of the diamond cone
D	Diameter of steel ball
F_0	Preliminary test force
F_1	Additional test force
F	Total test force
D_0	Depth of indentation under preliminary test force before application of additional test force
h_1	Increase in depth of indentation under additional test force
e	Permanent increase of depth of indentation under preliminary test force after removal of additional test force, expressed in units of 0.002 mm for Rockwell hardness and 0.001 mm for Rockwell superficial hardness
HRA, HRC, HRD	Rockwell hardness = $100 - e$
HRB, HRE, HRF, HRG, HRH, HRK	Rockwell hardness = $130 - e$
HR N, HR T	Rockwell superficial hardness = $100 - e$

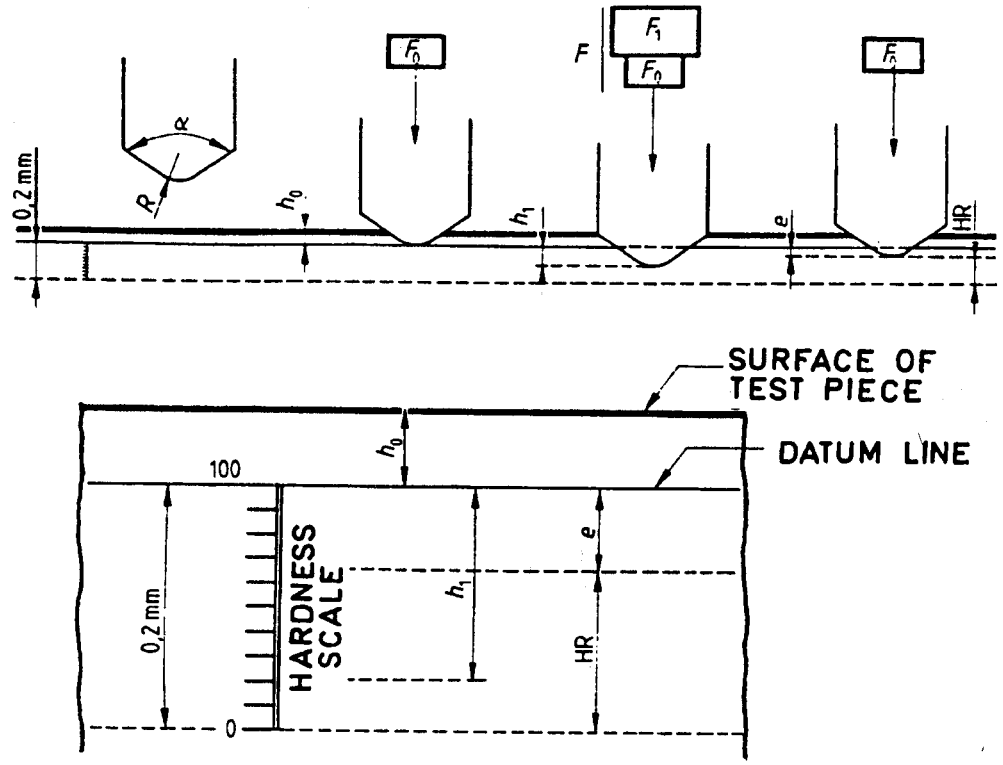

FIG. 1 SURFACE OF TEST PIECE WITH DIAMOND CONE (ROCKWELL SCALES A, C, OR D)

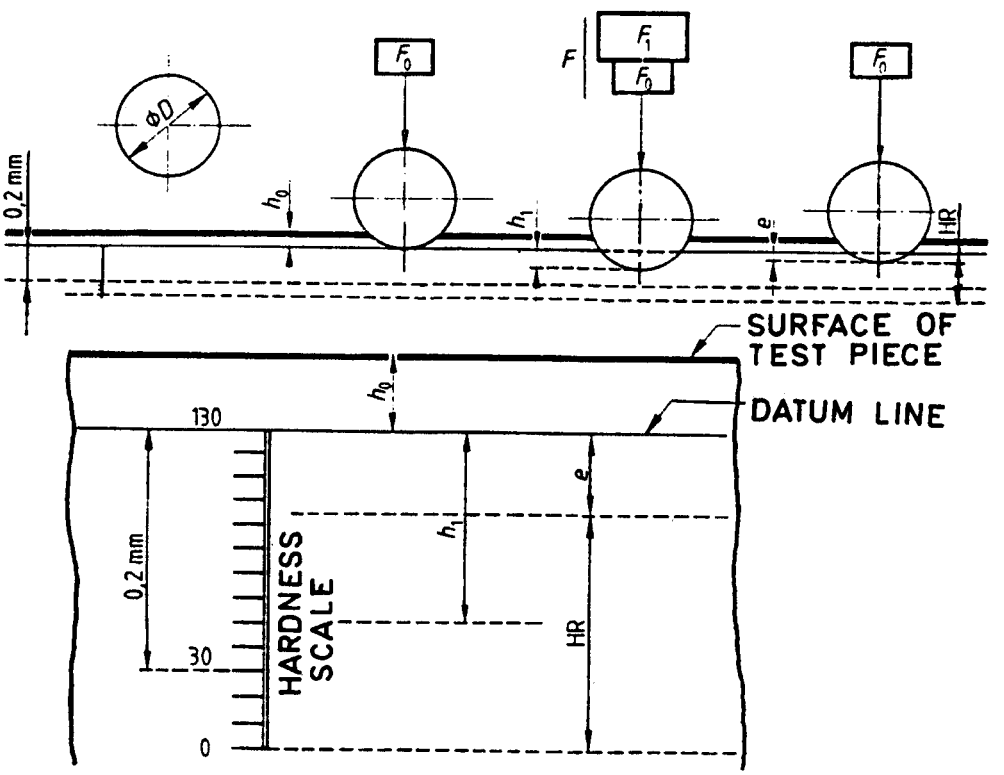

FIG. 2 SURFACE OF TEST PIECE WITH STEEL BALL (ROCKWELL SCALES B, E, F, G, H OR K)

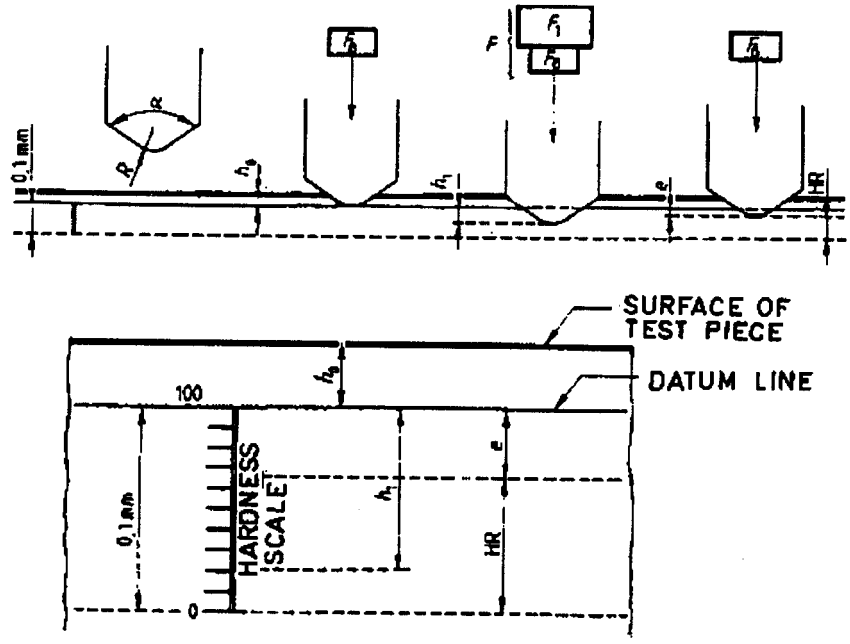

FIG. 3 SURFACE OF TEST PIECE WITH DIAMOND CONE (ROCKWELL SCALES 15N, 30N AND 45N)

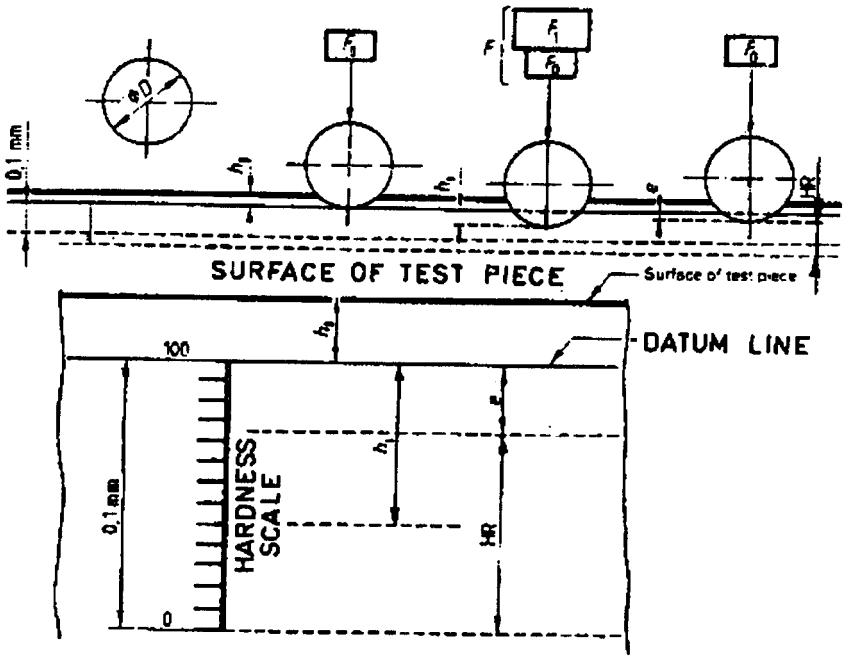

FIG. 4 SURFACE OF TEST PIECE WITH STEEL BALL (ROCKWELL SCALES 15T, 30T AND 45T)

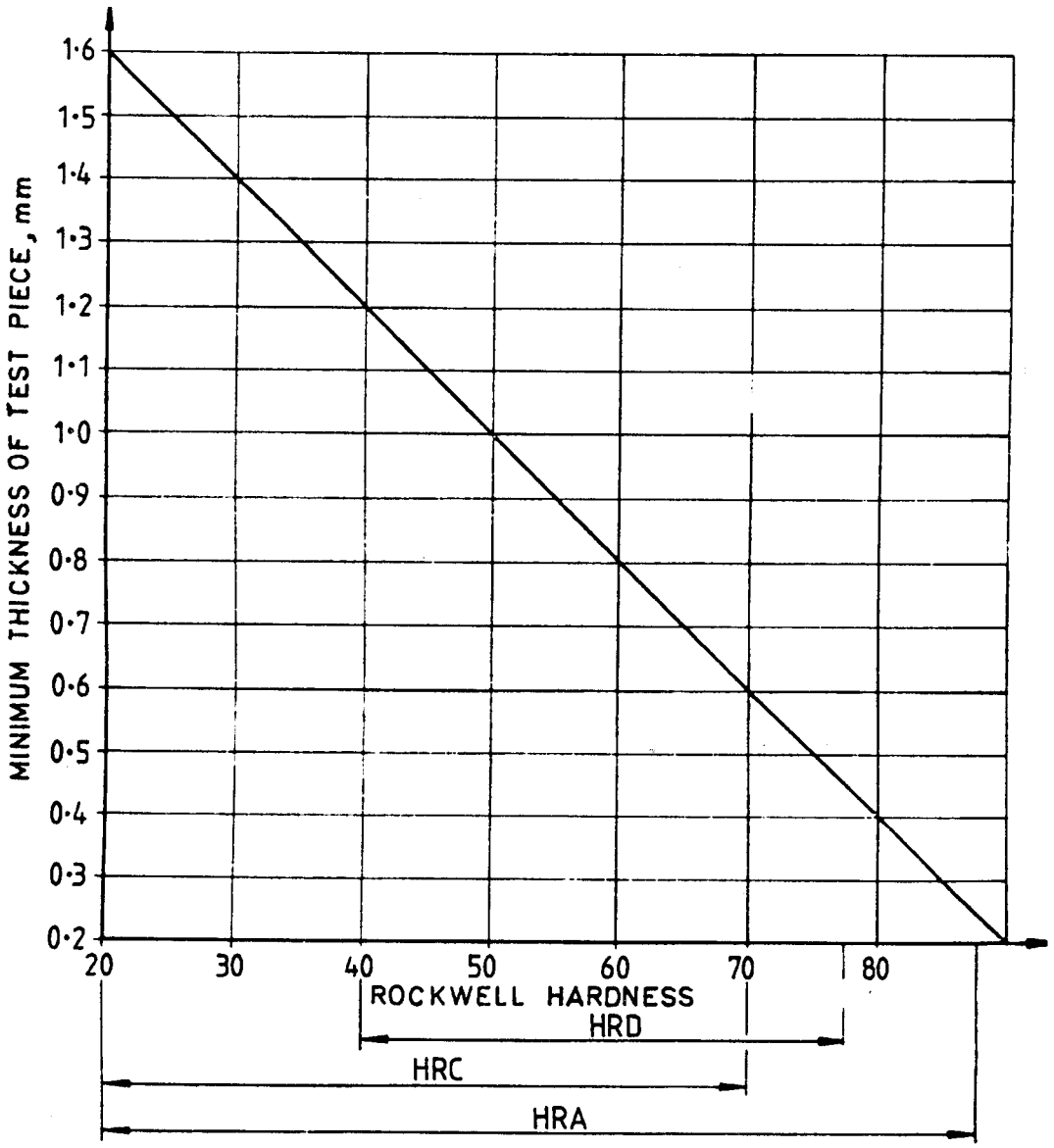

FIG. 5 TEST WITH DIAMOND CONE (HRA, HRC AND HRD)

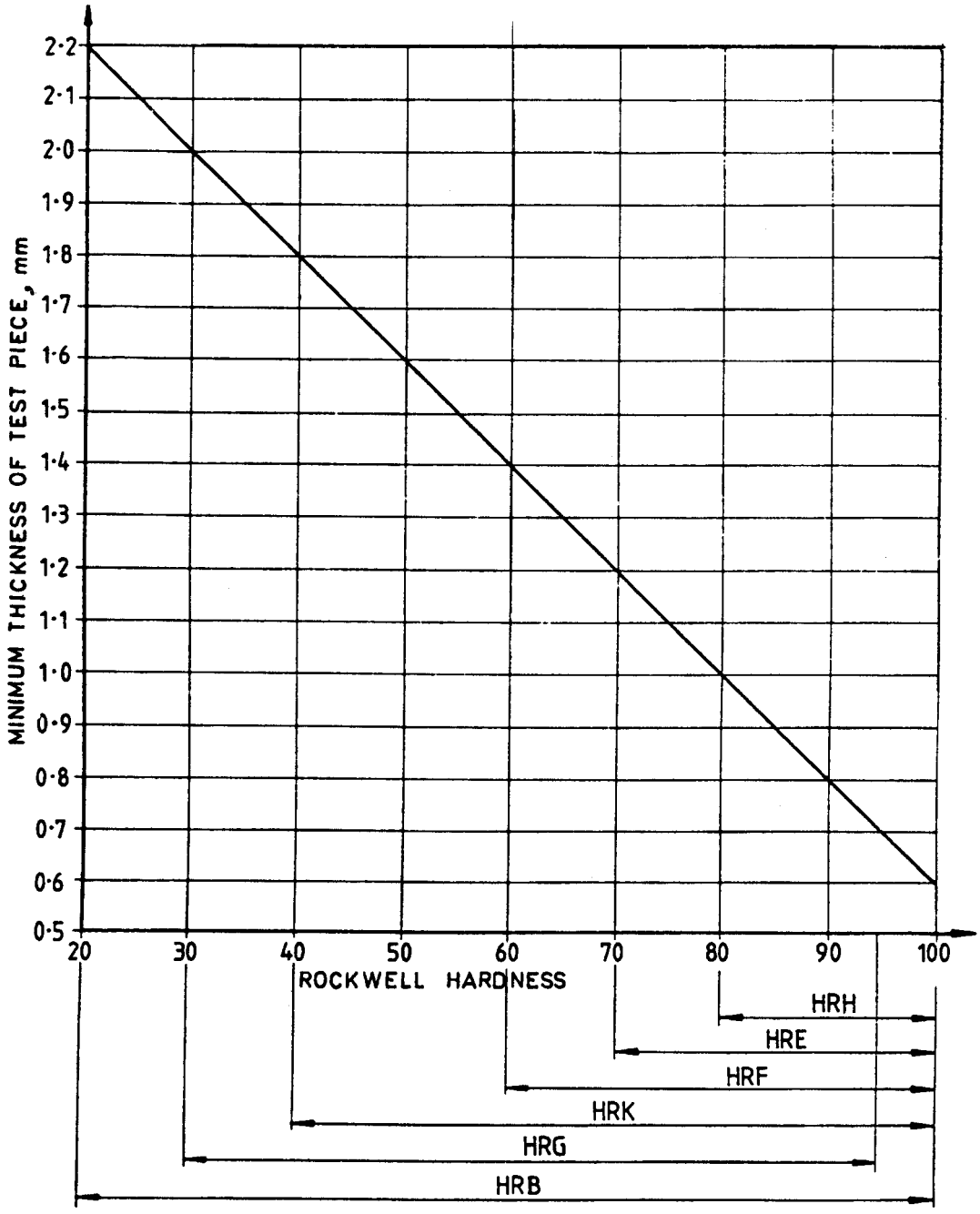

FIG. 6 TEST WITH STEEL BALL (HRB, HRE, HRF, HRG, HRH AND HRK)

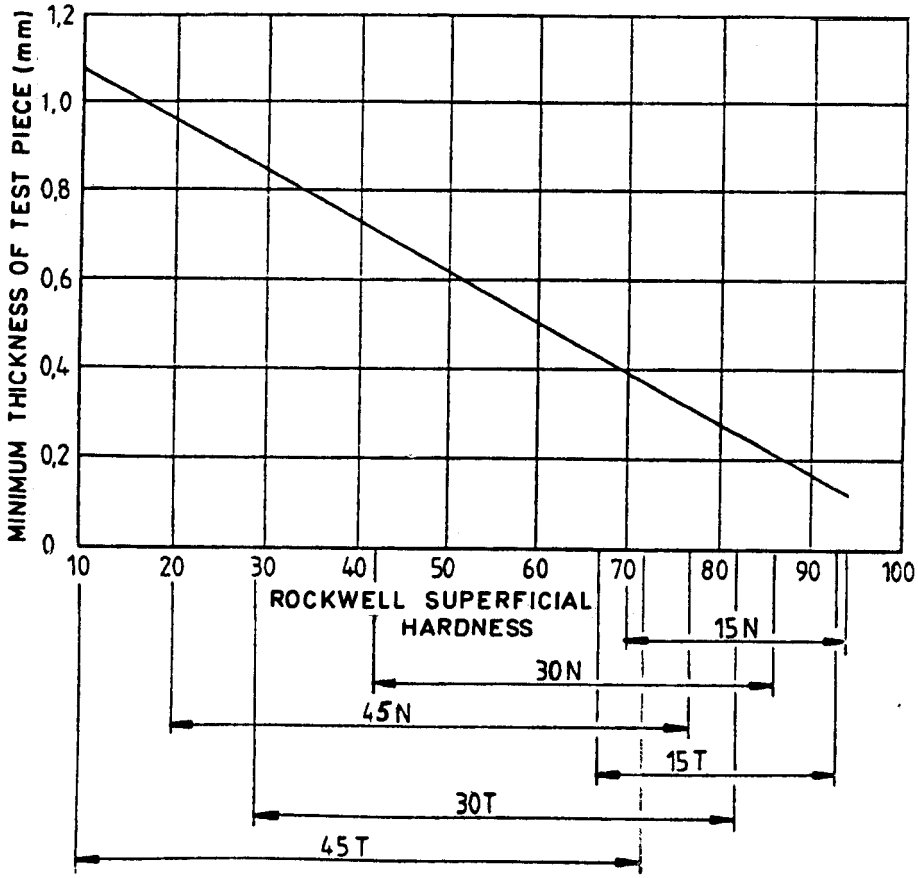

FIG. 7 MINIMUM THICKNESS OF THE TEST PIECE IN RELATION TO THE ROCKWELL SUPERFICIAL HARDNESS

Table 3 Corrections to be Added to Hardness Values HRA, HRC, HRD Obtained on Cylindrical Test Pieces with Diamond Cone

(*Clause* 6.4)

Rockwell Hardness Reading	Radius of Curvature, mm								
	3	5	6.5	8	9.5	11	12.5	16	19
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
20	—	—	—	2.5	2.0	1.5	1.5	1.0	1.0
25	—	—	3.0	2.5	2.0	1.5	1.0	1.0	1.0
30	—	—	2.5	2.0	1.5	1.5	1.0	1.0	0.5
35	—	3.0	2.0	1.5	1.5	1.0	1.0	0.5	0.5
40	—	2.5	2.0	1.5	1.0	1.0	1.0	0.5	0.5
45	3.0	2.0	1.5	1.0	1.0	1.0	0.5	0.5	0.5
50	2.5	2.0	1.5	1.0	1.0	0.5	0.5	0.5	0.5
55	2.0	1.5	1.0	1.0	0.5	0.5	0.5	0.5	0
60	1.5	1.0	1.0	0.5	0.5	0.5	0.5	0	0
65	1.5	1.0	1.0	0.5	0.5	0.5	0.5	0	0
70	1.0	1.0	0.5	0.5	0.5	0.5	0.5	0	0
75	1.0	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 the above table.

Table 4 Corrections to be Added to Hardness Values HRB, HRF, HRG Obtained on Cylindrical Test Pieces with 1.587 5 mm Steel Ball

(*Clause* 6.4)

Rockwell Hardness Reading	Radius of Curvature, mm						
	3	5	6.5	8	9.5	11	12.5
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
20	—	—	—	4.5	4.0	3.5	3.0
30	—	—	5.0	4.5	3.5	3.0	2.5
40	—	—	4.5	4.0	3.0	2.5	2.5
50	—	—	4.0	3.5	3.0	2.5	2.0
60	—	5.0	3.5	3.0	2.5	2.0	2.0
70	—	4.0	3.0	2.5	2.0	2.0	1.5
80	5.0	3.5	2.5	2.0	1.5	1.5	1.5
90	4.0	3.0	2.0	1.5	1.5	1.5	1.5
100	3.5	2.5	1.5	1.5	1.0	1.0	0.5

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

Table 5 Corrections to be Added to Rockwell Hardness HRC Values Obtained on Spherical Test Pieces

(*Clause* 6.4)

Rockwell Hardness Reading	Diameter *d* of Sphere, mm								
	4	6.5	8	9.5	11	12.5	15	20	25
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
55 HRC	6.4	3.9	3.2	2.7	2.3	2.0	1.7	1.3	1.0
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	0.8

The values (ΔH) given in the above table are calculated by the following formula :

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

where

ΔH is the correction to be added, and

H is the Rockwell hardness reading.

Table 6 Corrections[1] to be Added to Rockwell Superficial 15N, 30N and 45N Values Obtained on Convex Cylindrical Surface[2]

(*Clause* 6.4)

Rockwell Superficial Hardness Readings	Radius of Curvature[3], mm					
	1.6	3.2	5	6.5	9.5	12.5
(1)	(2)	(3)	(4)	(5)	(6)	(7)
20	(6.0)[4]	3.0	2.0	1.5	1.5	1.5
25	(5.5)	3.0	2.0	1.5	1.5	1.0
30	(5.5)	3.0	2.0	1.5	1.0	1.0
35	(5.0)	2.5	2.0	1.5	1.0	1.0
40	(4.5)	2.5	1.5	1.5	1.0	1.0
45	(4.0)	2.0	1.5	1.0	1.0	1.0
50	(3.5)	2.0	1.5	1.0	1.0	0.5
55	(3.5)	2.0	1.5	1.0	0.5	0.5
60	3.0	1.5	1.0	1.0	0.5	0.5
65	2.5	1.5	1.0	0.5	0.5	0.5
70	2.0	1.0	1.0	0.5	0.5	0.5
75	1.5	1.0	0.5	0.5	0.5	0
80	1.0	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

[1] These corrections are approximately only and represent the averages, to the nearest 0.5 Rockwell superficial hardness number, or numerous actual observations on test surfaces having the curvature given in the table.

[2] When testing convex cylindrical surfaces, the accuracy of the test will be seriously affected by the agreement of elevating screw, V-anvil and indenter and by the surface finish and straightness of the cylinder.

[3] For radii other than those given in the table, corrections may be derived by linear interpolation.

[4] The corrections given in parentheses should not be used except by agreement.

Table 7 Corrections[1] to be Added to Rockwell Superficial 15T, 30T and 45T Values Obtained on Convex Cylindrical Surfaces[2]

(*Clause* 6.4)

Rockwell Superficial Hardness Reading	Radius of Curvature[3], mm						
	1.6	3.2	5	6.5	8	9.5	12.5
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
20	(13)[4]	(9.0)	(6.0)	(4.5)	(4.5)	3.0	2.0
30	(11.5)	(7.5)	(5.0)	(3.5)	(3.5)	2.5	2.0
40	(10.0)	(6.5)	(4.5)	(3.5)	3.0	2.5	2.0
50	(8.5)	(5.5)	(4.0)	3.0	2.5	2.0	1.5
60	(6.5)	(4.5)	3.0	2.5	2.0	1.5	1.5
70	(5.0)	(3.5)	2.5	2.0	1.5	1.0	1.0
80	3.0	2.0	1.5	1.5	1.0	1.0	0.5
90	1.5	1.0	1.0	0.5	0.5	0.5	0.5

[1] These corrections are approximately only and represent the averages, to the nearest 0.5 Rockwell superficial hardness number, of numerous actual observations on test surfaces having the curvature given in the table.

[2] When testing convex cylindrical surfaces, the accuracy of the test will be seriously affected by the agreement of elevating screw, V- anvil and indenter and by the surface finish, and straightness of the cylinder.

[3] For radii other than those given in the table, corrections may be linear interpolation.

[4] The corrections given in parentheses should not be used except by agreement.

6.5 Special care should be taken when testing sheet metal that is curved. The concave side of the curved metal should face towards the indenter. If such specimens are reversed, an error will be introduced due to flattening of the metal on the anvil.

7 PROCEDURE

7.1 In general, the test should be carried out at ambient temperature within the limits of 10 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 shall be 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.

7.2.1 Products of cylindrical shape shall be suitably supported on centering V-blocks of steel with a Rockwell hardness of at least 60 HRC. Special attention shall be given to 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 observations.

7.2.2 Flat pieces should be tested on a flat anvil that has a smooth flat bearing surface whose plane is perpendicular to the axis of the penetrator. For pieces that are not perfectly flat, a flat anvil having an elevated 'spot' about 4 to 6 mm in diameter is used. This spot should be polished, smooth, flat and free from pits and heavy scratches. This spot should have a rockwell hardness of at least 60 HRC.

7.2.3 When testing special materials thinner than ten times the depth of indentation using the steel ball indenter, the product standard may specify use of a diamond 'spot' anvil. When such an anvil is used, it should be recorded in the report. It should be noted that the reading obtained may differ from a reading obtained under normal conditions.

7.2.4 Bring the indenter into contact with the test surface and apply the preliminary test force F_0 = 98.07 N without shock or vibration for (A-B-C-D-E-F-G-H-K) and 29.42 N for (15N, 30N, 45N, 15T, 30T and 45T).

7.3 Set the measuring device to its datum position and, without shock or vibration, increase the force from F_0 to F is neither less than 2 s nor greater than 8 s. The value of F is as follows:

a) F = 588.4 N for scales A, F and H;

b) F = 980.7 N for scales B, D and E;

c) F = 147.1 N for scales C, G and K;

d) F = 147.1 N for scales 15N, 15T;

e) F = 294.2 N for scales 30N, 30T; and

f) F = 441.3 N for scales 45N, 45T;

7.4 While maintaining the preliminary force F_0, remove the additional force F_1 so that:

a) For materials which under the conditions of test, show some time dependent plasticity, the duration of the total test force F shall be up to 5 s;

b) For materials which, under the conditions of test, show considerable time-dependent plasticity, the duration of total test force F shall be neither less than 10 s nor greater than 15 s.

NOTE — When the pointer comes to rest within 2 s after the application of full load, material will be categorized as (a).

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

7.6 Rockwell hardness number is derived from the permanent increase in depth of indentation e, and is usually read directly from the measuring device. The derivation of the Rockwell hardness number is illustrated in Fig. 1, 2, 3 and 4.

7.7 After each change, or removal and replacement, of the indenter or the test piece support, it shall be ascertained that the new indenter or the new support is correctly mounted in its housing. The first two readings after such a change has been made, shall be disregarded.

7.8 The distance between the centres of two adjacent indentations shall be at least four times the diameter of the indentation (but at least 2 mm) for Rockwell hardness and three times the diameter of the indentation for Rockwell superficial hardness.

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.

7.9 It is recommended that machine should be calibrated at least once in a year.

8 TEST REPORT

The test report shall include the following information:

a) Reference to this standard;

b) All details necessary for indentation of the test sample;

c) The results obtained (*see* Note 1), and

d) Details of any occurrence which may have affected the result (*see* Note 2).

NOTES

1 There is no general process for accurately converting Rockwell hardness into other scales of hardness or into tensile strength. Such conversions, therefore, should be avoided.

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 alterations in the hardness value.

ANNEX A

(*Clauses* 5.1, 5.2, 5.3 *and* 5.4)

METHOD FOR VERIFICATION OF ROCKWELL HARDNESS TESTING MACHINES (SCALES A-B-C-D-E-F-G-H-K- 15N, 30N, 45N, 15T, 30T and 45T)

A-1 This Annex prescribes the method for verifiction of testing machines for determining Rockwell hardness and Rockwell superficial hardness (scales A-B-C-D-E-F-G-H-K, 15N, 30N, 45N, 15T, 30T and 45T).

A-1.1 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.

A-1.2 If a testing machine is also to be used for other methods of hardness testing, it shall be verified independently for each method.

A-2 GENERAL CONDITION

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

a) The machine is properly set up;

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

c) The indenter-holder is firmly mounted in the plunger;

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

e) 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 influence 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 for scale (A-B-C-D-E-F-G-H-K) and 1.0 Rockwell superficial unit for scales (15N, 30N, 45N, 15T, 30T and 45T).

A-3 DIRECT VERIFICATION

A-3.0 Direct verification involves:

a) Verification of the test force;

b) Verification of the indenter, and

c) Verification of the measuring device

A-3.1 Verification of the Test Force

A-3.1.1 The preliminary test force F_0 (*see* **A-3.1.4**) and each total test force F used (*see* **A-3.1.5**) shall be measured, and, whenever applicable, this shall be done at not less than three positions of the plunger spaced through out its range of movement during testing.

A-3.1.2 The forces shall be measured by one of the following two methods:

a) Measuring by means of an elastic proving device previously calibrated to an accuracy of ± 0.2 percent, or

b) Balancing against a force, accurate to ± 0.2 percent, applied by means of standardized mass with mechanical advantage.

A-3.1.3 Three readings shall be taken for each force at each position of the plunger. Immediately before each reading is taken, the plunger shall be moved in the same direction as during testing.

A-3.1.4 The tolerances on the preliminary test force F_0 (before application and after removal of the additional test force F_1) shall be ± 2.0 percent.

A-3.1.5 The tolerances on the total test force F shall be ± 0.7 percent.

A-3.2 Verification of the Indenters

A-3.2.1 *Diamond Cone Indenter (Scales A-C-D)*

A-3.2.1.1 The surface 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.

A-3.2.1.2 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.

A-3.2.1.3 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.

A-3.2.1.4 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°.

A-3.2.1.5 The spherical tip of the diamond cone shall have a mean radius of 0.200 mm ± 0.010 mm. In each measured section, the radius shall be 0.200 mm ± 0.015 mm and local deviations from it shall not exceed 0.002 mm.

A-3.2.1.6 The hardness values given by the testing machine do not depend only on the dimensions given in **A-3.2.1.3** and **A-3.2.1.5** 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.

A-3.2.1.6.1 For this reason, an indirect verification is consdiered necessary. The performance of the indenter in a standardized machine, which complies with Annex B shall be compared with the performance of the machine's own standardizing indenter.

A-3.2.1.6.2 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 hardness range specified in Table 1 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 units 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 the both indenters are in each case adjacent. The test shall be made in accordance with **6** (*see also* Annex C).

NOTE — When the indenter is intended for use in HRA and HRD scales, additional HRA test shall be made on one block in the range 80-88 HRA. The error shall not be more than 0.8 HRA.

A-3.2.2 *Diamond Cone Indenter (Scales 15N, 30N, 45N)*

These shall be verified by following the procedure given in **3.2.2.1** to **3.2.2.6**.

A-3.2.2.1 The surface of the diamond cone and the spherical tip shall be positioned for a penetration depth of 0.20 mm and shall be free from surface defects.

A-3.2.2.2 The verification of the shape of the indenter can be made by direct measurement or by the measurement of its projection on a screen. The verification shall be made at not less than four sections.

A-3.2.2.3 The diamond cone shall have an included angle of 120 ± 0.35°. Deviations from straightness of generators of the diamond cone, adjacent to the blend, shall not exceed 0.001 mm over a minimum length of 0.35 mm.

A-3.2.2.4 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°.

A-3.2.2.5 The spherical tip of the diamond cone shall have a mean radius of 0.200 mm ± 0.010 mm. In each measured section, the radius shall be 0.200 mm ± 0.015 mm and the local deviations from it shall not exceed 0.002 mm.

The surfaces of the cone and the spherical tip shall blend in a truly tangential manner.

A-3.2.2.6 The hardness values given by the testing machine do not depend only on the dimensions given in **A-3.2.2.3** to **A-3.2.2.5** but also on the surface roughness and the position of crystallographic axes of the diamond, and the seating of the diamond in its holder.

A-3.2.2.6.1 For this reason, an indirect verification is considered necessary. The performance of the test indenter shall be compared in a standardizing machine with the performance of the machine standardizing indenter. The test shall be made in accordance with Annex A.

A-3.2.2.6.2 Tests shall be made on a minimum of two blocks in the 30N scale, one at a hardness level near the lower limit and the second near the upper limit of the hardness range of this 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 three indentations obtained with the standardizing indenter by more than ± 0.8 Rockwell superficial hardness units. The indentations with the indenter to be verified and with the standardizing indenter should be carried out in a such a way that the indentations of both indenters are in each case adjacent. The test shall be made in accordance with Annex B.

NOTE — The standardizing indenter is the indenter or the indenters being recognized as the reference indenter(s).

A-3.2.3 *Steel Ball Indenter (Scales D-E-F-G-H-K)*

A-3.2.3.1 For the purpose of verifying the size and the hardness of the steel balls, it is considered sufficient to test a sample selected at random from a batch. The ball(s) verified for hardness shall be discarded.

A-3.2.3.2 The ball shall be polished and free from surface defects.

A-3.2.3.3 The user shall either measure the balls to ensure that they meet the following requriements, or he shall obtain balls from supplier who can certify that the following conditions are met.

A-3.2.3.3.1 The diameter, when measured at not less than three positions, shall not differ from the nominal

diameter by more than tolerance given in Table 8.

Table 8 Ball Diameters and Tolerances

(*Clause* A-3.2.3.3.1)

Rockwell Hardness Scale	Ball Diameter	Tolerance
	mm	mm
(1)	(2)	(3)
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

A-3.2.3.3.2 The hardness of steel ball shall be not less than 850 HV 10, when determined in accordance with IS 1501 (Part 1) and applying the appropriate corrections for curvature as given in Appendix B of IS 1501 (Part 1). The maximum value of the mean diagonal of the indentation made on the ball with a Vickers indenter is 98.07 N (HV 10) is given in Table 9.

Table 9 Maximum Value of Mean Diagonal Mode on Ball

(*Clause* A-3.2.3.3.2)

Ball Diameter	Maximum Value of Mean Diagonal Made on the Ball with a Vickers Indenter at 98.07 N (HV 10)
mm	mm
(1)	(2)
3.175	0.144
1.587 5	0.141

A-3.2.4 Steel Ball Indenter (Scale 15T, 30T and 45T)

These shall be verified by following the procedure given in **A-3.2.4.1** to **A-3.2.4.3**.

A-3.2.4.1 For the purpose of verifying the size and the hardness of the steel balls, it is considered sufficient to test a sample selected at random from a batch. The ball(s) verified for hardness shall be discarded.

A-3.2.4.2 The ball shall be polished and shall be free from surface defects.

A-3.2.4.3 The user shall either measure the ball to ensure that they meet the following requirments, or he shall obtain balls from a supplier who can certify that the following conditions are met:

a) The diameter, when measured at not less than three positions, shall be 1.587 5 ± 0.003 5 mm.

b) The hardness of the steel ball shall be not less than 850 HV 10 when determined in accordance with IS 1501 (Part 1) and applying the appropriate correction for curvature as given in Annex B of IS 1501 (Part 1). (The maximum value of mean diagonal of the indentation made on the ball with a Vickers indenter at 98.07 N is, therefore, 0.141 mm.)

A-3.3 Verification of the Measuring Device

A-3.3.1 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 the increasing hardness value.

A-3.3.1.1 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 ± 0.5 of scale unit, over each range.

A-4 INDIRECT VERIFICATION

A-4.0 Indirect verification may be carried out by means of standardised blocks calibrated in accordance with Annex B.

A-4.1 Procedure

A-4.1.1 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 10 and 11 shall be used. The hardness values of the blocks shall approximate the limits of intended use.

A-4.1.2 For purposes of routine checking, a hardness testing machine may be checked at one hardness value only, corresponding approximately to that of tests to be made.

A-4.1.3 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 indentation shall be made to ensure that the machine is working freely and 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 6.

Table 10 Hardness Range of Standardized Block
(*Clause* A-4.1.1)

Rockwell Hardness Scale (1)	Hardness Range of Standardized Block (2)
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

Table 11 Hardness Range of Standardized Block
(*Clause* A-4.1.1)

Rockwell Superficial Hardness Scale (1)	Hardness Range of Standardized Block (2)
15N	70 to 75 HR15N 78 to 88 HR15N 89 to 91 HR15N
30N	42 to 50 HR30N 55 to 73 HR30N 75 to 80 HR30N
45N	20 to 31 HR45N 37 to 61 HR45N 63 to 70 HR45N
15T	73 to 80 HR15T 80 to 87 HR15T 87 to 93 HR15T
30T	43 to 56 HR30T 57 to 70 HR30T 70 to 82 HR30T
45T	12 to 33 HR45T 34 to 54 HR45T 54 to 72 HR45T

A-4.2 Repeatability

A-4.2.1 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 units of 0.002 mm, as for scale (A-B-C-D-E-F-G-H-K) and 0.001 for scales (15N, 30N, 45N, 15T, 30T and 45T).

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

$$e_5 - e_1$$

A-4.2.2 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

a) for the scale A, less than 0.03 $\bar{e}$
b) for the scale B, less than 0.06 $\bar{e}$
c) for the scale C, less than 0.03 $\bar{e}$
d) for the scale D, less than 0.03 $\bar{e}$
e) for the scale E, less than 0.06 $\bar{e}$
f) for the scale F, less than 0.06 $\bar{e}$
g) for the scale G, less than 0.06 $\bar{e}$
h) for the scale H, less than 0.06 $\bar{e}$
j) for the scale K, less than 0.06 $\bar{e}$
k) for the scales 15N, 30N and 45 N, 0.04 $\bar{e}$ or 1.2 Rockwell superficial hardness units, whichever is greater (*see* Fig. 8); and
m) for the scales 15T, 30T and 45T, $\bar{e}$ or 2.4 Rockwell superficial hardness units, whichever is greater (*see* Fig. 8)

where

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

Examples of repeatability requirements are given in Fig. 8 and Table 12.

A-4.3 Error

A-4.3.1 The error of the testing machine under the particular verification conditions is expressed by the following quantity:

$$\bar{H} - H$$

where

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

H_1, H_2..... H_5 being the hardness values corresponding to e_1, e_2 ..... e_5 respectively.

H being the specified hardness of the standardized block used.

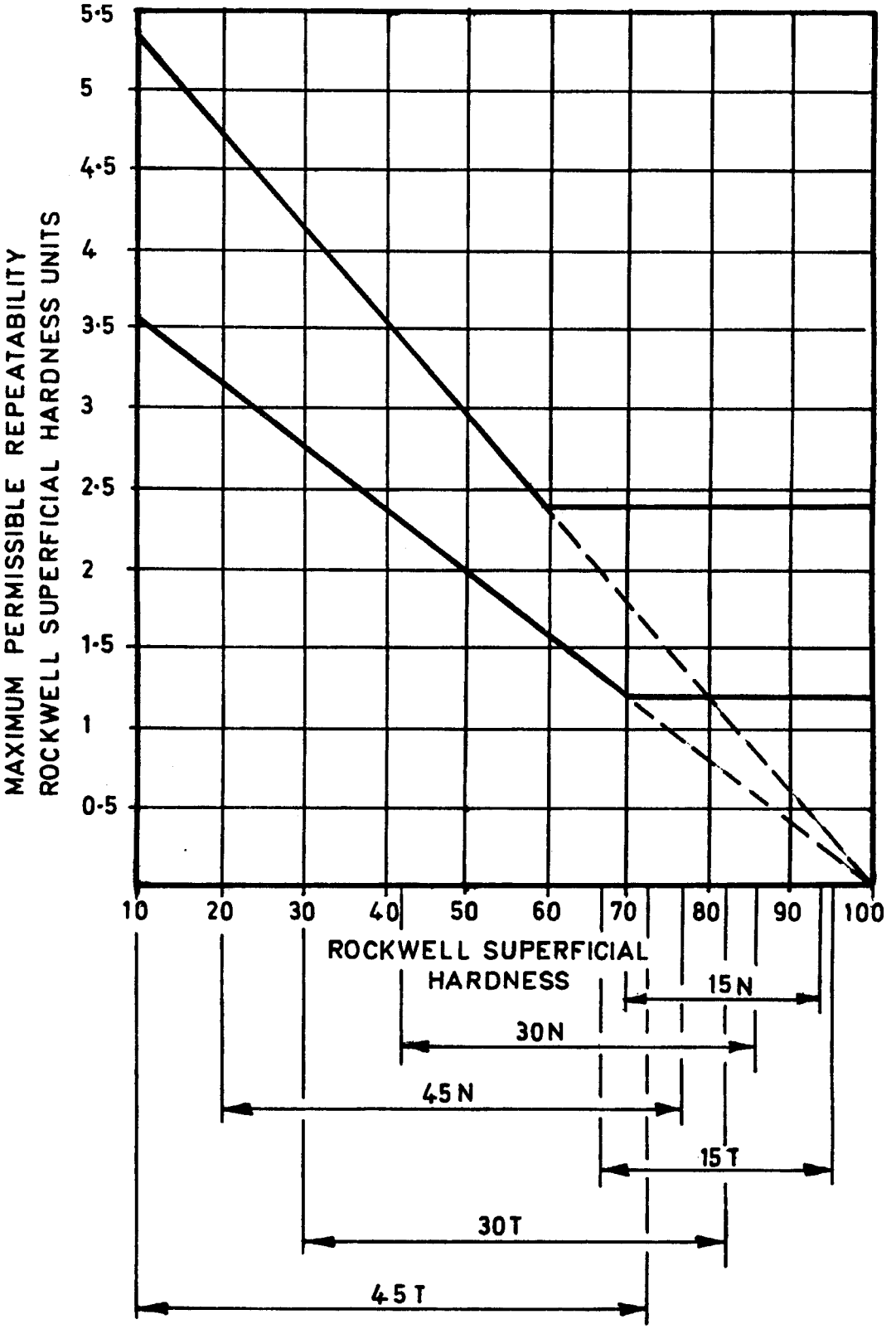

FIG. 8 REPEATABILITY OF THE TESTING MACHINE

Table 12 Examples of Repeatability Requirements Using Standardized Blocks
(*Clause* A-4.2.2)

Hardness of Standardized Block	Increase in Depth of Indentation	Repeatability Maximum Acceptable Value
HRC	HRC	HRC
(1)	(2)	(3)
65	35	1.0
59	41	1.2
55	45	1.4
35	65	2.0
30	70	2.1
20	80	2.4
HRB	HRB	HRB
100	30	1.8
80	50	3.0
60	70	4.2
40	90	5.4

A-4.3.2 The maximum error on testing machine shall not exceed the value given in Table 13.

A-5 VERIFICATION REPORT

The verification report shall include the following information:

a) Reference to this 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) Rockwell hardness and Rockwell superficial hardness scale (s) verified;

f) Result obtained; and

g) Date of verification and referenece to the testing institution.

Table 13 Permissible Error on Testing Machine

(*Clause* A-4.3.2)

Rockwell Hardness Scale	Hardness Range of the Standardized Block		Maximum Permissible Error Rockwell Units
		Up to and Including	
(1)	(2)	(3)	(4)
A	20	75 HRA	± 2 HRA
	>75	88 HRA	± 1.5 HRA
B	20	45 HRB	± 4 HRB
	>45	80 HRB	± 3 HRB
	>80	100 HRB	± 2 HRB
C	20	70 HRC	± 1.5 HRC
D	40	70 HRD	± 2.5 HRD
	> 70	77 HRD	± 1.5 HRD
E	70	90 HRE	± 2.5 HRE
	> 90	100 HRD	± 2 HRE
F	60	90 HRF	± 3 HRF
	> 90	100 HRF	± 2 HRF
G	30	50 HRG	± 6 HRG
	> 50	75 HRG	± 4.5 HRG
	> 75	94 HRG	± 3 HRG
H	80	100 HRH	± 2 HRH
K	40	60 HRK	± 4 HRK
	> 60	80 HRK	± 3 HRK
	> 80	100 HRK	± 2 HRK
15N	70	90 HR15N	± 1.5
30N	42	80 HR30N	± 1.5
45N	20	70 HR45N	± 1.5
15T	73	93 HR15T	± 2.5
30T	43	82 HR30T	± 2.5
45T	12	72 HR45T	± 2.5

ANNEX B

(*Clauses* A-3.2.2.6.1, A-3.2.2.6.2 *and* A-4.0)

METHOD FOR CALIBRATION OF STANDARDIZED BLOCKS TO BE USED FOR ROCKWELL HARDNESS TESTING MACHINES (SCALES A-B-C-D-E-F-G-H-K, 15N, 30N, 45N, 15T, 30T AND 45T)

B-1 This Annex specifies a method for the calibration of standardized blocks to be used in Rockwell hardness testing machines for the indirect verification of these machines, as described in Annex A.

B-2 MANUFACTURE

B-2.1 The block shall be specially prepared and the attention of the manufacturer of the block is drawn to the need to use a manufacturing process which will give necessary homogeneity, stability of structure and uniformity of surface hardness.

B-2.2 Each metal block to be standardized shall be of a thickness not less than 6 mm.

B-2.3 The standardized blocks shall be free of magnetism. It is recommended that the manufacturer shall ensure that the blocks, if made of steel, have been demagnetized at the end of the manufacturing process (before calibration).

B-2.4 The maximum deviation in flatness of the surface shall not exceed 0.010 mm. The bottom of the blocks shall not be convex.

B-2.4.1 The maximum error in parallelism shall not exceed 0.020 mm/50 mm.

B-2.5 The test surface shall be free from scratches which interfere with measurement of the indentations. The surface roughness R_a shall not exceed 0.3 μm for the test surface and 0.8 μm for the bottom surface; sampling length l = 0.80 mm.

B-2.6 To permit checking that no material is subsequently removed from the standardized block, its thickness at the time of standardization shall be marked on it to the nearest 0.1 mm, or an identifying mark shall be made on the test surface (*see* **B-7**).

B-3 STANDARDIZING MACHINES

B-3.1 In addition to fulfilling the general requirements specified in Annex A the standardizing machines shall also meet the requirements given in **B-3.2**.

B-3.2 The machine shall be verified directly. Direct verification involves:

a) Verification of the test force (*see* **B-3.2.1**),

b) Verification of the indenter (*see* **B-3.2.2** to **B-3.2.4**),and

c) Verification of the measuring device (*see* **B-3.2.5**).

B-3.2.1 *Verification of Test Force*

The preliminary force, F_0 shall be 98.07 N ± 0.2 percent for Rockwell hardness and 29.42 ± 0.5 percent for Rockwell superficial hardness at the initial application and after the additional force F_1 has been removed.

The total test force, F (*see* Table 1) shall be correct to within ± 0.1 percent of the nominal test force for Rockwell hardness test and ± 0.25 percent of nominal test force for Rockwell superficial hardness.

B-3.2.2 *Verification of Diamond Cone Indenter*

The diamond cone indenter shall meet the following requirements.

B-3.2.2.1 The diamond cone shall have a mean included angle of 120 ± 0.10°. In each measured section, the included angle shall be 120 ± 0.17°. The number of measured sections are as follows:

a) At least eight sections at random when the roundness of the cone is not measured, or

b) Two sections when the error in roundness of the cone, adjacent to the blend, measured in a section normal to the indenter axis does not exceed 0.004 mm. These sections shall be situtated at the positions of maximum and minimum error in roundness.

c) The error of roundness is defined as the greatest radial distance between any point on the conical surface and the circumscribing circle.

Deviations from straightness of the generator line of the diamond cone, adjacent to the blend, shall not exceed 0.0005 mm over a minimum length of 0.40 mm.

B-3.2.2.2 The spherical tip of the diamond cone shall have a mean radius of 0.200 mm ± 0.005 mm. In each measured section as defined in **B-3.2.2.1**, the radius shall be 0.200 mm ± 0.007 mm and local deviations from it shall not exceed 0.002 mm.

The surface of the cone and the spherical tip shall blend in a truly tangential manner.

B-3.2.2.3 The inclination of the axis of the diamond cone to the axis of the indenter holder (normal to the seating surface) shall be within 0.3°.

B-3.2.2.4 Tests shall be made in accordance with the procedure described in **B-4** on a minimum of four blocks, one at a hardness level near the lower limit

and one near the upper limit of the range of hardness specified in Table 1. 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 three indentations obtained with the standardizing indenter by more than ± 0.4 Rockwell units. The indentations with the indenter to be verified and with the standardizing indenter should be carried out in a such a way that the indentations of both indenters are in each case adjacent.

When the indenter is intended for use in HRA and HRD scales, additional HRA tests shall be made on one block in the range 80-88 HRA. The error shall not be more than 0.4 HRA.

NOTE — The standardizing indenter or the indenters being recognized as the reference indenter(s).

B-3.2.3 *Verification of Steel Ball Indenter*

The steel ball shall meet the requirements given in Annex A. The diameter of the steel ball indenter when measured at not less than three positions, shall not differ from the nominal diameter by more than:

a) ± 0.002 mm for the ball with diameter 1.587 5 mm; and

b) ± 0.003 mm for the ball with diameter 3.175.

B-3.2.4 The hardness of the steel ball shall be not less than 850 HV 10, when determined in accordance with IS 1501 (Part 1) and applying the appopriate corrections for curvature as given in Annex B of IS 1501 (Part 1).

B-3.2.5 *Verification of Test Force*

The measuring device shall be capable of measuring vertical displacement within ± 0.1 of a Rockwell unit and ± 0.2 of a Rockwell superficial hardness units.

B-4 STANDARDIZING PROCEDURE

B-4.1 The standardized blocks shall be calibrated in a standardizing machine as described in **B-3** at a temperature of 23 ± 5°C, using the general procedure described in **6.**

B-4.2 The mechanism which controls the application of the test force shall either:

a) employ a device such as, a spring, to reduce the velocity of penetration of the indenter during the period of penetration, or

b) employ a device to maintain a constant velocity of the indenter during the period of increasing force.

B-4.3 Standard Machine (Type a) [*See* **B-4.2 (a)].**

B-4.3.1 The initial velocity (that is, the velocity of the indenter prior to penetration of the test block) shall not be greater than 1 mm/s.

B-4.3.2 Bring the indenter into contact with the test surface and apply the preliminary test force without shock or vibration. The duration of the preliminary test force, F_0 (*see* Table 1) shall not be less than 1 s nor greater than 10 s.

B-4.3.3 Set the measuring device to its datum position and without shock or vibration increase the force from F_0 to F in not less than 2 s nor greater than 8 s.

B-4.3.4 The duration of the additional test force F_1 shall not be less than 3 s nor greater than 5 s.

B-4.3.5 The final reading shall be made immediately after the additional test force has been removed.

B-4.4 Standard Machine (Type b) [*See* **B-4.2 (b)].**

B-4.4.1 The constant velocity of the indenter shall not be less than 0.005 mm/s and nor greater than 0.020 mm/s.

B-4.4.2 Bring the indenter into contact with the test surface and apply the preliminary test force without shock or vibration. The duration of the preliminary test force, F_0 (*see* Table 1) shall not be less than 1 s nor greater than 10 s.

B-4.4.3 Set the measuring device to its datum position and without shock or vibration increase the force from F_0 to F.

B-4.4.4 The duration of the additional test force, F_1, shall be not less than 3 s nor greater than 5 s.

B-4.4.5 The final reading shall be made immediately after the additional test force has been removed.

B-5 NUMBER OF INDENTATIONS

On each standardised block, five indentations shall be made uniformly distributed over the entire test surface.

B-6 UNIFORMITY OF HARDNESS

B-6.1 Rockwell Hardness Scales (A-B-C-D-E-F-G-H-K)

B-6.1.1 Let $e_1, e_2 \ldots e_5$ be the values in Rockwell units of the measured increase in depth of indentations, arranged in increasing order of magnitude.

The non-uniformity of the block under the particular conditions of standardization is characterized by

$$e_5 - e_1$$

and is expressed in percent of e

where

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

B-6.1.2 The block is not sufficiently uniform in hardness for standardization purposes unless the uniformity satisfies the conditions give in Table 14.

Table 14 Maximum Permissible Non-Uniformity

(*Clause* B-6.1.2)

Rockwell Hardness Scale	Maximum Permissible Non-Uniformity, e_5, e_1
(1)	(2)
A	1.5 percent of e or 0.4 HRA[1)]
B	3 percent of e
C	1.5 percent of e
D	1.5 percent of e
E	3 percent of e
F	3 percent of e
G	3 percent of e
H	3 percent of e
K	3 percent of e

[1)] The greater of which shall apply.

B-6.2 Rockwell Superficial Hardness (Scales 15N, 30N, 45N, 15T, 30T and 45T)

B-6.2.1 Let e_1, e_2... e_5 be the values in scales units of the measured increase in depth of indentations, arranged in increasing order of magnitude.

The non-uniformity of the block under the particular conditions of standardization is characterized by e_5,...e_1 and expressed in percent e

where

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

B-6.2.2 The block is not sufficiently uniform in hardness for standardization purposes unless the uniformity satisfies the following conditions:

a) For scales 15N, 30N and 45N, the maximum permissible non-uniformity shall be 0.02 e or 0.6 superficial hardness scale unit, whichever is greater (*see* Fig.9); and

b) For scales 15T, 30T and 45T, the maximum permissible non-uniformity shall be less than 0.03 e or 1.2 superficial hardness scale unit, whichever is greater (*see* Fig.9).

B-7 MARKING

B-7.1 Each standardized block shall be marked with the following:

a) Arithmetic mean of the hardness values found in the standardizing test,

b) Name or mark of the supplier,

c) Serial number,

d) Name or trade-mark of the standardizing authority,

e) Thickness of the block or an identifying mark on the test surface, and

f) Year of calibration.

B-7.2 Any mark put on the side of the block shall be upright when the test surface is the upper face.

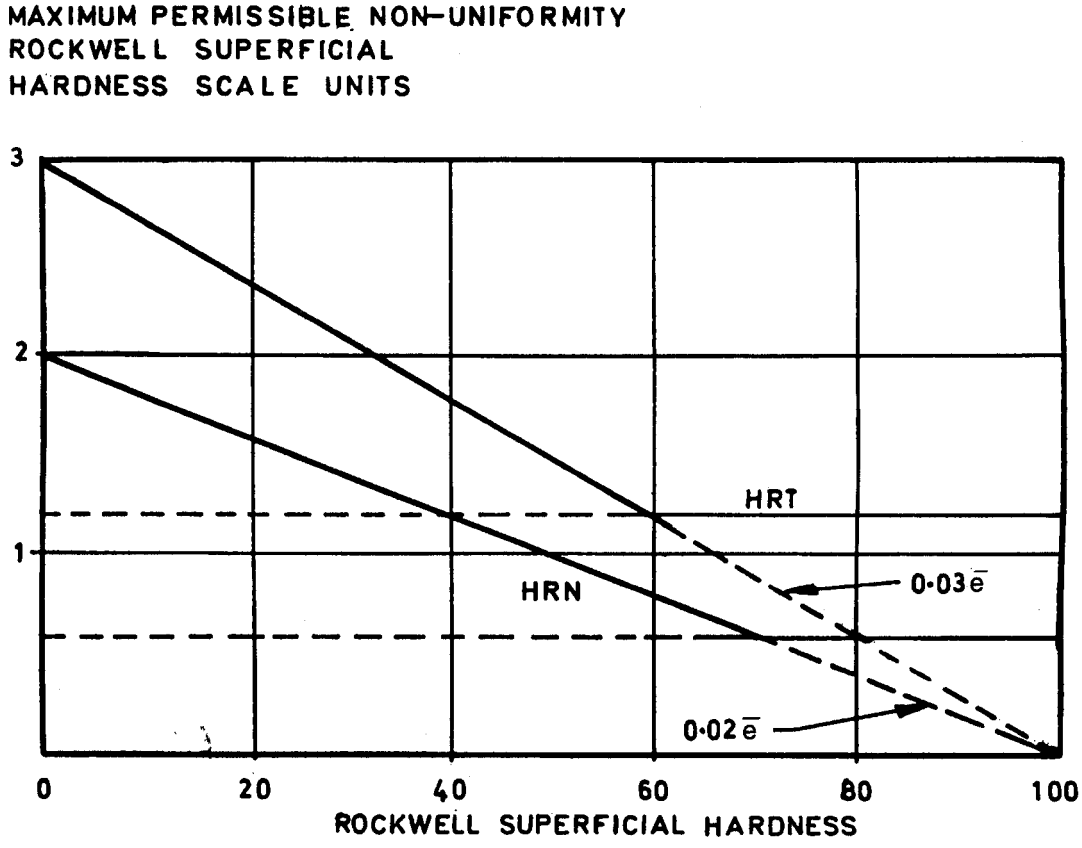

FIG. 9 UNIFORMITY OF TEST BLOCKS

ANNEX C

(*Clause* A-3.2.1.6.2)

NOTES ON DIAMOND INDENTERS

C-1 Experience has shown that a number of initially perfect indenters can become defective after use for a comparatively short time. This is due to small cracks, pits or other flaws on 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:

a) The condition of indenters should be checked initially at frequent intervals using appropriate optical devices (microscope, magnifying glass, etc);

b) 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 should not be used;

c) The verification of the indenter is no longer valid when the indenter has become unusable because of defects; and

d) Reground or otherwise repaired indenters should be reverified.

Bureau of Indian Standards

BIS is a statutory institution established under the *Bureau of Indian Standards Act,* 1986 to promote harmonious development of the activities of standardization, marking and quality certification of goods and attending to connected matters in the country.

Review of Indian Standards

Amendments are issued to standards as the need arises on the basis of comments. Standards are also reviewed periodically; a standard along with amendments is reaffirmed when such review indicates that no changes are needed; if the review indicates that changes are needed, it is taken up for revision. Users of Indian Standards should ascertain that they are in possession of the latest amendments or edition by referring to the latest issue of 'BIS Handbook' and 'Standards : Monthly Additions'.

This Indian Standard has been developed from Doc : No. MTD 3 (4145).

Amendments Issued Since Publication

Amend No.	Date of Issue	Text Affected

BUREAU OF INDIAN STANDARDS

Headquarters:

Manak Bhavan, 9 Bahadur Shah Zafar Marg, New Delhi 110002
Telephones : 323 01 31, 323 94 02, 323 33 75

Telegrams. Manaksanstha
(Common to all offices)

Regional Offices:

Telephone

Central : Manak Bhavan, 9 Bahadur Shah Zafar Marg
NEW DELHI 110002
323 76 17
323 38 41

Eastern : 1/14 C. I. T. Scheme VII M, V. I. P. Road, Maniktola
CALCUTTA 700054
337 84 99, 337 85 61
337 86 26, 337 86 62

Northern : SCO 335-336, Sector 34-A, CHANDIGARH 160022
60 38 43
60 20 25

Southern : C. I. T. Campus, IV Cross Road, CHENNAI 600113
235 02 16, 235 04 42
235 15 19, 235 23 15

Western : Manakalaya, E9 MIDC, Marol, Andheri (East)
MUMBAI 400093
832 92 95, 832 78 58
832 78 91, 832 78 92

Branches : AHMADABAD. BANGALORE. BHOPAL. BHUBANESHWAR. COIMBATORE. FARIDABAD. GHAZIABAD. GUWAHATI. HYDERABAD. JAIPUR. KANPUR. LUCKNOW. NAGPUR. PATNA. PUNE. THIRUVANANTHAPURAM.

Printed at New India Printing Press, Khurja, India