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Copper and copper alloys — Rockwell superficial hardness test (N and T scales)

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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.

International Standard ISO 2712 was drawn up by Technical Committee ISO/TC 26, *Copper and copper alloys,* and circulated to the Member Bodies in April 1972.

It has been approved by the Member Bodies of the following countries:

Austria	Finland	Spain
Belgium	France	Sweden
Brazil	Ireland	Switzerland
Canada	Italy	Thailand
Chile	Netherlands	Turkey
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Denmark	Portugal	U.S.A.
Egypt, Arab Rep. of	Romania	U.R.S.S.

No Member Body expressed disapproval of the document.

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Copper and copper alloys — Rockwell superficial hardness test (N and T scales)

1 SCOPE AND FIELD OF APPLICATION

This International Standard specifies the method for carrying out the Rockwell superficial hardness test (N and T scales) for copper and copper alloys.

2 REFERENCES

ISO/R 286, *ISO System of limits and fits — Part 1 : General, tolerances and deviations.*

ISO/R 1079, *Verification of Rockwell superficial N and T scale hardness testing machines.*

ISO/R 1355, *Calibration of standardized blocks to be used for Rockwell N and T scale hardness testing machines.*

3 PRINCIPLE

The test consists in forcing an indenter of standard type (cone or ball) into the surface of the test piece in two operations and measuring the permanent increase, e, of the depth of indentation by means of a depth gauge under defined conditions.

The unit of measurement for e is 0,001 mm; from the measurement of e, a number, known as the Rockwell superficial hardness, is deduced.

4 SYMBOLS AND DESIGNATIONS

4.1 Test with diamond cone (Rockwell N)

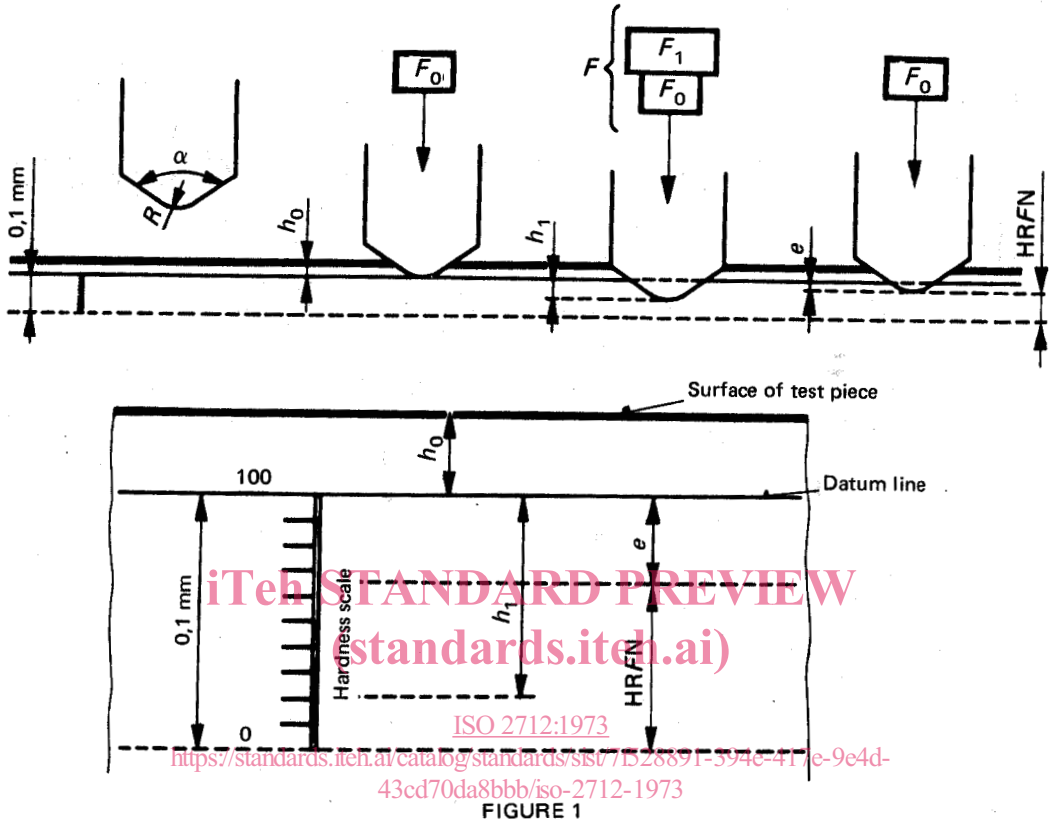

FIGURE 1

Symbol	Designation
α	Angle at the tip of the diamond cone (120°)
R	Radius of curvature at the tip of the cone (0,200 mm)
F_0	Preliminary load = 29,42 N (3 kgf)
F_1	Additional load = 117,68 N (12 kgf) or = 264,78 N (27 kgf) or = 411,88 N (42 kgf)
F	Total load = $F_0 + F_1$ = 29,42 N + 117,68 N = 147,1 N (15 kgf) or = 29,42 N + 264,78 N = 294,2 N (30 kgf) or = 29,42 N + 411,88 N = 441,3 N (45 kgf)
h_0	Depth of indentation under preliminary load before application of additional load
h_1	Increase in depth of indentation under additional load
e	Permanent increase of depth of indentation under preliminary load after removal of additional load, expressed in units of 0,001 mm
HRFN[1]	Rockwell superficial hardness FN = 100 − e

1) i.e. HR 15 N, HR 30 N or HR 45 N.

4.2 Test with steel ball (Rockwell T)

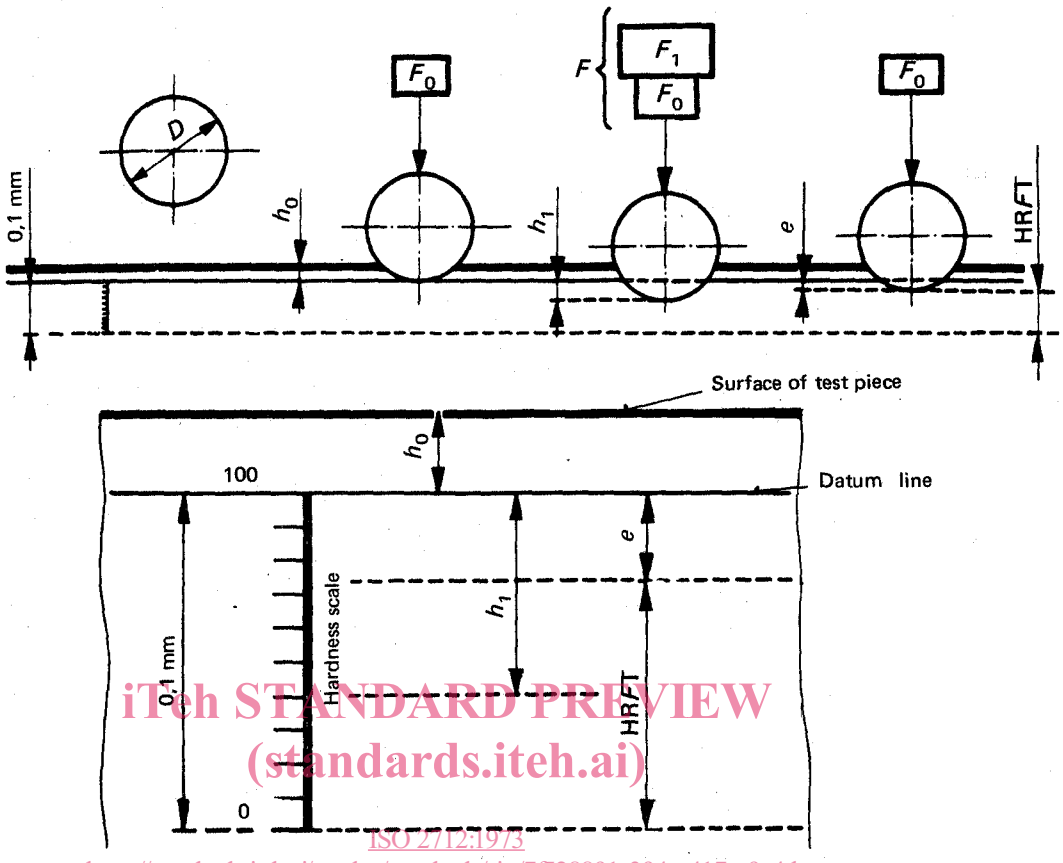

FIGURE 2

Symbol	Designation
D	Diameter of ball = 1,587 5 mm (1/16 in)
F_0	Preliminary load = 29,42 N (3 kgf)
F_1	Additional load = 117,68 N (12 kgf) or = 264,78 N (27 kgf) or = 411,88 N (42 kgf)
F	Total load = $F_0 + F_1$ = 29,42 N + 117,68 N = 147,1 N (15 kgf) or = 29,42 N + 264,78 N = 294,2 N (30 kgf) or = 29,42 N + 411,88 N = 441,3 N (45 kgf)
h_0	Depth of indentation under preliminary load before application of additional load
h_1	Increase in depth of indentation under additional load
e	Permanent increase of depth of indentation under preliminary load after removal of additional load, expressed in units of 0,001 mm
HR*FT*[1]	Rockwell superficial hardness $FT = 100 - e$

1) i.e. HR 15 T, HR 30 T or HR 45 T.

NOTE – The Rockwell superficial hardness is denoted by the symbol HR preceded by the hardness value and supplemented by the total load (in kgf) and the letter which together denote the particular hardness scale.

Example : 70 HR 30 N = a Rockwell superficial hardness of 70 measured on the N scale.

5 TESTING EQUIPMENT

5.1 Testing machines

The testing machine shall be verified in accordance with ISO/R 1079.

5.2 Standardized blocks for verification of testing machines

Standardized blocks shall be calibrated in accordance with ISO/R 1355 except that, if copper or copper alloy blocks are used, the duration of the application of the additional load (section 8 of ISO/R 1355) shall be in accordance with 6.5 a) of this International Standard.

5.3 Indenter (N Scale)

The conical indenter shall be a diamond in the form of a right circular cone with a rounded tip mounted rigidly in a suitable holder. The diamond cone must have an included angle of 120 ± 0,5° and its axis must be in line with the axis of the holder within a tolerance of 0,5°. The tip of the cone shall be rounded to a radius of 0,2 mm and the contour of the tip of the cone shall not depart from the nominal contour by more than 0,002 mm. The surface of the cone shall blend in a truly tangential manner with the surface of the sphere. The indenter shall be free from cracks or other surface defects.

5.4 Indenter (T Scale)

The indenter shall be a steel ball having a diameter of 1,587 5 mm (1/16 in) mounted rigidly in a suitable holder. No diameter of the ball shall differ from the nominal diameter by more than ± 0,003 5 mm (± 0.000 15 in)[1]. The ball shall be of hardened steel with a hardness of at least 850 HV 10[2] taking into account the curvature of the ball in assessing its Vickers hardness. (The maximum value of the mean diagonal of the indentation made by a Vickers indenter under a test load of 98 N (10 kgf) is 0,141 mm.) The ball shall be polished and free from surface defects.

5.5 Indicator (depth gauge)

The indicator shall be graduated in units of 0,001 mm; depth readings on the indicator dial, over the working range (see figure 1 and 6.6) shall be accurate to ± 0,5 of a scale unit, i.e. to ± 0,000 5 mm.

5.6 Test piece support

The test piece shall be placed on a rigid support. The contact surface shall be clean and free from foreign matter (scale, oil, dirt, etc.). It is important that the test piece lies firmly on the support so that displacement cannot occur during the test.

5.6.1 In the case of the N scale test, the support shall consist of a spot anvil of hardened steel of approximately 4,5 mm (3/16 in) diameter.

5.6.2 In the case of the T scale test, a similar spot anvil shall be used for tests on materials (including test blocks) having a thickness and hardness greater than that stated in the Annex, Table 4. For thinner or softer materials the use of a diamond anvil of approximately 4,5 mm (3/16 in) diameter is recommended. When such an anvil is used it shall be noted in the report of the hardness value.

6 TEST REQUIREMENTS

6.1 The test is normally made at room temperature. When it is considered necessary to make the test under controlled temperature, this shall be 20 ± 2 °C in temperate climates and 27 ± 2 °C in tropical climates.

6.2 The test shall be made on a surface which is smooth and even, and free from oxide scale and foreign matter. Care shall be taken in preparing the surface to avoid any change in condition, for example, due to heating or cold working.

6.3 Bring the indenter into contact with the test surface, and apply the preliminary load F_0 = 29,42 ± 0,588 N (3 ± 0,06 kgf) in a direction normal to the test surface, without shock or vibration. Care shall be taken that this load is not exceeded.

6.4 Set the dial of the indicator at the initial position and increase the load, without shock or vibration, within a period of 4 to 8 s by the value of the additional load F_1, thus obtaining a total load :

$F = F_0 + F_1 =$ 147,1 ± 0,98 N (15 ± 0,1 kgf) for the 15 N and 15 T scales;

294,2 ± 1,96 N (30 ± 0,2 kgf) for the 30 N and 30 T scales;

441,3 ± 2,94 N (45 ± 0,3 kgf) for the 45 N and 45 T scales.

6.5 While maintaining the preliminary load, F_0, remove the additional load, F_1, according to the following :

a) for materials which, under the conditions of the test, show no time dependent plasticity, remove F_1 within 2 s after the indicator comes to rest;

b) in special cases where the material, under the conditions of the test, shows time dependent plasticity, remove F_1 20 to 25 s after the indicator commences to record.

1) This tolerance corresponds to Grade 6 of ISO/R 286. Balls for ball bearings normally satisfy this tolerance.

2) Alternatively, a tungsten carbide ball may be used; if so this shall be stated in the test report.

6.6 The Rockwell superficial hardness number is derived from the permanent depth of indentation, e, as $100 - e$, and is usually read directly from the dial. The derivation of the Rockwell superficial hardness number is illustrated in Figures 1 and 2.

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

7 GENERAL REQUIREMENTS

7.1 The limiting thicknesses of the test piece or of the layer under test are given in Tables 1 and 2, in the Annex. No deformation shall be visible at the back of the test piece after the test. However, by agreement between the interested parties, hardness readings obtained on some materials which show deformation may be accepted.

The ball indenter, however, shall not be used for tests of material of hardness greater than HRB 100.

7.2 The distance between the centres of two adjacent indentations shall be at least three times the diameter of the indentation, and 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, unless otherwise agreed.

7.3 For tests on cylindrical surfaces the corrections given in Tables 3 or 4 shall be applied. In the absence of corrections for tests on spherical and concave surfaces, tests on such surfaces shall be the subject of special agreement.

7.4 The satisfactory condition of the indenter must be verified frequently. Any irregularities in the shape of the indentation may indicate poor condition of the indenter. If the examination of the indenter confirms this, then the test shall be rejected and the indenter renewed.

7.5 After each change, or removal and replacement, of the indenter or the support, it shall be ascertained that the new indenter (or the new support) is correctly mounted in its housing.

7.6 A new ball for an indenter shall be selected from a batch which has been verified to the tolerance given in 5.4. It is advisable to ensure that the ball is representative of the batch. The nominal diameter of the ball, therefore, shall be checked as being within a tolerance of ± 0,01 mm.

NOTES

1 The form of the point and the size of the radius of the conical indenter have an important effect on the Rockwell superficial hardness number obtained. The anisotropy of diamonds makes difficult the machining of the indenter to a precise symmetrical form. For this reason it is necessary to compare the performance of the indenter with that of an accepted indenter at more than one level of hardness by means of standardized blocks.

2 There is no general process for accurately converting Rockwell superficial hardness into the other Rockwell scales or into any other scales of hardness, or tensile strength. These conversions therefore should be avoided, except for special cases where a reliable basis for the conversion has been obtained by comparison tests.

ANNEX

TABLE 1 — **Guide for choice of scales using the diamond indenter**

NOTE — The test can be carried out in the scales given below on any test piece of which the thickness and the hardness are greater than those stated.

Thickness of test piece		Rockwell superficial scale					
		15 N		30 N		45 N	
mm	in	Dial reading	Approximate hardness C scale [1]	Dial reading	Approximate hardness C scale [1]	Dial reading	Approximate hardness C scale [1]
0,20	0.008	90	60	....	....	....	....
0,25	0.010	88	55	....	....	....	....
0,30	0.012	83	45	....	....	....	....
0,36	0.014	76	32	78,5	61	....	....
0,41	0.016	68	18	74	56	....	....
0,46	0.018	....	....	66	47	68	61
0,51	0.020	....	....	57	37	63	57
0,56	0 022	....	....	47	26	58	52,5
0,61	0.024	....	....	....	....	51	47
0,66	0 026	....	....	....	....	37	35

1) These approximate hardness numbers are for use in selecting a suitable scale, and should not be used as hardness conversions.

TABLE 2 — **Guide for choice of scales using the 1,587 5 mm (1/16 in) ball indenter**

NOTE — The test can be carried out in the scales given below on any test piece of which the thickness and the hardness are greater than those indicated.

Thickness		Rockwell superficial scale					
		15 T		30 T		45 T	
mm	in	Dial reading	Approximate hardness B scale [1]	Dial reading	Approximate hardness B scale [1]	Dial reading	Approximate hardness B scale [1]
0,25	0.010	91	93	....	....	....	....
0,30	0.012	86	78	....	....	....	....
0,36	0.014	81	62	79	95	....	....
0,41	0.016	75	44	73	84	71	99
0,46	0.018	68	24	64	71	62	90
0,51	0.020	....	....	55	58	53	80
0,56	0.022	....	....	45	43	43	70
0,61	0.024	....	....	34	28	31	58
0,66	0.026	....	....	....	....	18	45

1) These approximate hardness numbers are for use in selecting a suitable scale, and should not be used as hardness conversions.

TABLE 3 – Corrections[1] to be added to Rockwell superficial 15 N, 30 N and 45 N values obtained on cylindrical test pieces[2] of various diameters

Dial reading	Diameter of cylindrical test piece					
	3.2 mm (1/8 in)	6.4 mm (1/4 in)	10 mm (3/8 in)	13 mm (1/2 in)	19 mm (3/4 in)	25 mm (1 in)
20	(6,0)[3]	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

TABLE 4 – Corrections[1] to be added to Rockwell superficial 15 T, 30 T and 45 T values obtained on cylindrical test pieces[2] of various diameters

Dial reading	Diameter of cylindrical test piece						
	3.2 mm (1/8 in)	6.4 mm (1/4 in)	10 mm (3/8 in)	13 mm (1/2 in)	16 mm (5/8 in)	19 mm (3/4 in)	25 mm (1 in)
20	(13,0)[3]	(9,0)	(6,0)	(4,5)	(3,5)	3,0	2,0
30	(11,5)	(7,5)	(5,0)	(4,0)	(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 approximate only and represent the averages, to the nearest 0,5 Rockwell superficial hardness number, of numerous actual observations on test pieces having the inch dimensions given in the Table.

2) When testing cylindrical test pieces, the accuracy of the test will be seriously affected by alignment of the elevating screw, V-anvil, indenter, surface finish, and the straightness of the cylinder.

3) The corrections given in parentheses should not be used except by agreement.

NOTE – For diameters other than those given in the Table, corrections may be derived by linear interpolation.