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Standard Hardness Conversion Tables for Metals Relationship Among Brinell Hardness, Vickers Hardness, Rockwell Hardness, Superficial Hardness, Knoop Hardness, Scleroscope Hardness, and Leeb Hardness[1]

This standard is issued under the fixed designation E140; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

This standard has been approved for use by agencies of the U.S. Department of Defense.

ε1 NOTE—Editorial changes were made throughout in May 2019.

1. Scope*

1.1 Conversion Table 1 presents data in the Rockwell C hardness range on the relationship among Brinell hardness, Vickers hardness, Rockwell hardness, Rockwell superficial hardness, Knoop hardness, and Scleroscope hardness of non-austenitic steels including carbon, alloy, and tool steels in the as-forged, annealed, normalized, and quenched and tempered conditions provided that they are homogeneous.

1.2 Conversion Table 2 presents data in the Rockwell B hardness range on the relationship among Brinell hardness, Vickers hardness, Rockwell hardness, Rockwell superficial hardness, Knoop hardness, and Scleroscope hardness of non-austenitic steels including carbon, alloy, and tool steels in the as-forged, annealed, normalized, and quenched and tempered conditions provided that they are homogeneous.

1.3 Conversion Table 3 presents data on the relationship among Brinell hardness, Vickers hardness, Rockwell hardness, Rockwell superficial hardness, and Knoop hardness of nickel and high-nickel alloys (nickel content over 50 %). These hardness conversion relationships are intended to apply particularly to the following: nickel-aluminum-silicon specimens finished to commercial mill standards for hardness testing, covering the entire range of these alloys from their annealed to their heavily cold-worked or age-hardened conditions, including their intermediate conditions.

1.4 Conversion Table 4 presents data on the relationship among Brinell hardness, Vickers hardness, Rockwell hardness, and Rockwell superficial hardness of cartridge brass.

1.5 Conversion Table 5 presents data on the relationship between Brinell hardness and Rockwell B hardness of austenitic stainless steel plate in the annealed condition.

1.6 Conversion Table 6 presents data on the relationship between Rockwell hardness and Rockwell superficial hardness of austenitic stainless steel sheet.

1.7 Conversion Table 7 presents data on the relationship among Brinell hardness, Vickers hardness, Rockwell hardness, Rockwell superficial hardness, and Knoop hardness of copper.

1.8 Conversion Table 8 presents data on the relationship among Brinell hardness, Rockwell hardness, and Vickers hardness of alloyed white iron.

1.9 Conversion Table 9 presents data on the relationship among Brinell hardness, Vickers hardness, Rockwell hardness, and Rockwell superficial hardness of wrought aluminum products.

1.10 Conversion Table 10 presents data in the Rockwell C hardness range on the relationship among Leeb (Type D) hardness, Brinell hardness, Vickers hardness, and Rockwell hardness of non-austenitic steels including carbon, alloy, and tool steels in the as-forged, annealed, normalized, and quenched and tempered conditions provided that they are homogeneous.

1.11 Many of the conversion values presented herein were obtained from computer-generated curves of actual test data. Most Rockwell hardness numbers are presented to the nearest 0.1 or 0.5 hardness number to permit accurate reproduction of these curves.

1.12 Annex A1 – Annex A10 contain equations to convert from one hardness scale to another. The equations given in Annex A1 – Annex A9 were developed from the data in Tables 1 to 9, respectively. The equations given in Annex A10 were developed at the time the Leeb hardness test was invented (see Appendix X2). The data in Table 10 was calculated from the Annex A10 equations.

1.13 Conversion of hardness values should be used only when it is impossible to test the material under the conditions specified, and when conversion is made it should be done with discretion and under controlled conditions. Each type of

[1] These conversion tables are under the jurisdiction of ASTM Committee E28 on Mechanical Testing and are the direct responsibility of Subcommittee E28.06 on Indentation Hardness Testing.

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***A Summary of Changes section appears at the end of this standard**

hardness test is subject to certain errors, but if precautions are carefully observed, the reliability of hardness readings made on instruments of the indentation type will be found comparable. Differences in sensitivity within the range of a given hardness scale (for example, Rockwell B) may be greater than between two different scales or types of instruments. The conversion values, whether from the tables or calculated from the equations, are only approximate and may be inaccurate for specific application.

1.14 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

A956 Test Method for Leeb Hardness Testing of Steel Products

E10 Test Method for Brinell Hardness of Metallic Materials

E18 Test Methods for Rockwell Hardness of Metallic Materials

E29 Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications

E92 Test Methods for Vickers Hardness and Knoop Hardness of Metallic Materials

E384 Test Method for Microindentation Hardness of Materials

E448 Practice for Scleroscope Hardness Testing of Metallic Materials (Withdrawn 2017)[3]

3. Methods for Hardness Determinations

3.1 The hardness readings used with these conversion tables shall be determined in accordance with one of the following ASTM test methods:

3.1.1 *Brinell Hardness*—Test Method E10.

3.1.2 *Rockwell Hardness*—Test Method E18 Scales A, B, C, D, E, F, G, H, K, 15N, 30N, 45N, 15T, 30T, 45T, 15W.

3.1.3 *Vickers Hardness and Knoop Hardness*—Test Methods E92.

3.1.4 *Microindentation Hardness (Vickers Hardness and Knoop Hardness)*—Test Method E384.

3.1.5 *Scleroscope Hardness*—Practice E448.

3.1.6 *Leeb Hardness*—Test Method A956.

NOTE 1—The comparative hardness test done to generate the conversion tables in this standard were performed in past years using ASTM test methods in effect at the time of testing. In some cases, the standards have changed in ways that could affect the final results. For example, currently both the Rockwell and Brinell hardness standards (Test Method E10 and E18, respectively) allow or require the use of tungsten carbide ball indenters; however, all of the ball scale Rockwell hardness tests (HRB, HR30T, etc.) and most of the Brinell hardness tests performed to develop these tables used hardened steel ball indenters. The use of tungsten carbide balls will produce slightly different hardness results than steel balls. Therefore, the user is cautioned to consider these differences and to keep in mind the approximate nature of these conversions when applying them to the results of tests using tungsten carbide balls.

4. Apparatus and Reference Standards

4.1 The apparatus and reference standards shall conform to the description in Test Methods A956, E10, E18, E92, E384, and Practice E448.

5. Principle of Method of Conversion

5.1 Tests have proved that even the most reliable data cannot be fitted to a single conversion relationship for all metals. Indentation hardness is not a single fundamental property but a combination of properties, and the contribution of each to the hardness number varies with the type of test. The modulus of elasticity has been shown to influence conversions at high hardness levels; and at low hardness levels conversions between hardness scales measuring depth and those measuring diameter are likewise influenced by differences in the modulus of elasticity. Therefore separate conversion tables are necessary for different materials.

NOTE 2—Hardness conversion values for other metals based on comparative test on similar materials having similar mechanical properties will be added to this standard as the need arises.

6. Significance and Use

6.1 The conversion values given in the tables, or calculated by the equations given in the appendixes, should only be considered valid for the specific materials indicated. This is because conversions can be affected by several factors, including the material alloy, grain structure, heat treatment, etc.

6.2 Since the various types of hardness tests do not all measure the same combination of material properties, conversion from one hardness scale to another is only an approximate process. Because of the wide range of variation among different materials, it is not possible to state confidence limits for the errors in using a conversion chart. Even in the case of a table established for a single material, such as the table for cartridge brass, some error is involved depending on composition and methods of processing.

6.3 Because of their approximate nature, conversion tables must be regarded as only an estimate of comparative values. It is recommended that hardness conversions be applied primarily to values such as specification limits, which are established by agreement or mandate, and that the conversion of test data be avoided whenever possible (see Note 1).

7. Reporting of Hardness Numbers

7.1 Historically when reporting converted hardness numbers, the measured hardness and test scale were also reported in parentheses. This is still an acceptable practice as in the following:

$$353\ \text{HBW}\ (38\ \text{HRC}) \quad (1)$$

where 353 HBW is the converted hardness value and 38 HRC is the original measurement value and test scale.

[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

[3] The last approved version of this historical standard is referenced on www.astm.org.

7.2 Other formats for reporting converted hardness values, such as data tables, may be used; however, the original measurement value and test scale shall also be reported and clearly identified.

7.3 Since all converted hardness values must be considered approximate, all converted hardness numbers shall be rounded in accordance with Practice E29 and should have no more significant digits than is given for the data in the applicable table.

8. Keywords

8.1 conversion; hardness scale; metallic

TABLE 1 Approximate Hardness Conversion Numbers for Non-Austenitic Steels (Rockwell C Hardness Range)[A, B]

Rockwell C Hardness Number 150 kgf (HRC)	Vickers Hardness Number (HV)	Brinell Hardness Number[C]		Knoop Hardness, Number 500-gf and Over (HK)	Rockwell Hardness Number		Rockwell Superficial Hardness Number			Scleroscope Hardness Number[D]	Rockwell C Hardness Number 150 kgf (HRC)
		10-mm Standard Ball, 3000-kgf (HBS)	10-mm Carbide Ball, 3000-kgf (HBW)		A Scale, 60-kgf (HRA)	D Scale, 100-kgf (HRD)	15N Scale, 15-kgf (HR15N)	30N Scale, 30-kgf (HR30N)	45N Scale, 45-kgf (HR45N)		
68	940	...	...	920	85.6	76.9	93.2	84.4	75.4	97.3	68
67	900	...	...	895	85.0	76.1	92.9	83.6	74.2	95.0	67
66	865	...	...	870	84.5	75.4	92.5	82.8	73.3	92.7	66
65	832	...	(739)	846	83.9	74.5	92.2	81.9	72.0	90.6	65
64	800	...	(722)	822	83.4	73.8	91.8	81.1	71.0	88.5	64
63	772	...	(705)	799	82.8	73.0	91.4	80.1	69.9	86.5	63
62	746	...	(688)	776	82.3	72.2	91.1	79.3	68.8	84.5	62
61	720	...	(670)	754	81.8	71.5	90.7	78.4	67.7	82.6	61
60	697	...	(654)	732	81.2	70.7	90.2	77.5	66.6	80.8	60
59	674	...	634	710	80.7	69.9	89.8	76.6	65.5	79.0	59
58	653	...	615	690	80.1	69.2	89.3	75.7	64.3	77.3	58
57	633	...	595	670	79.6	68.5	88.9	74.8	63.2	75.6	57
56	613	...	577	650	79.0	67.7	88.3	73.9	62.0	74.0	56
55	595	...	560	630	78.5	66.9	87.9	73.0	60.9	72.4	55
54	577	...	543	612	78.0	66.1	87.4	72.0	59.8	70.9	54
53	560	...	525	594	77.4	65.4	86.9	71.2	58.6	69.4	53
52	544	(500)	512	576	76.8	64.6	86.4	70.2	57.4	67.9	52
51	528	(487)	496	558	76.3	63.8	85.9	69.4	56.1	66.5	51
50	513	(475)	481	542	75.9	63.1	85.5	68.5	55.0	65.1	50
49	498	(464)	469	526	75.2	62.1	85.0	67.6	53.8	63.7	49
48	484	451	455	510	74.7	61.4	84.5	66.7	52.5	62.4	48
47	471	442	443	495	74.1	60.8	83.9	65.8	51.4	61.1	47
46	458	432	432	480	73.6	60.0	83.5	64.8	50.3	59.8	46
45	446	421	421	466	73.1	59.2	83.0	64.0	49.0	58.5	45
44	434	409	409	452	72.5	58.5	82.5	63.1	47.8	57.3	44
43	423	400	400	438	72.0	57.7	82.0	62.2	46.7	56.1	43
42	412	390	390	426	71.5	56.9	81.5	61.3	45.5	54.9	42
41	402	381	381	414	70.9	56.2	80.9	60.4	44.3	53.7	41
40	392	371	371	402	70.4	55.4	80.4	59.5	43.1	52.6	40
39	382	362	362	391	69.9	54.6	79.9	58.6	41.9	51.5	39
38	372	353	353	380	69.4	53.8	79.4	57.7	40.8	50.4	38
37	363	344	344	370	68.9	53.1	78.8	56.8	39.6	49.3	37
36	354	336	336	360	68.4	52.3	78.3	55.9	38.4	48.2	36
35	345	327	327	351	67.9	51.5	77.7	55.0	37.2	47.1	35
34	336	319	319	342	67.4	50.8	77.2	54.2	36.1	46.1	34
33	327	311	311	334	66.8	50.0	76.6	53.3	34.9	45.1	33
32	318	301	301	326	66.3	49.2	76.1	52.1	33.7	44.1	32
31	310	294	294	318	65.8	48.4	75.6	51.3	32.5	43.1	31
30	302	286	286	311	65.3	47.7	75.0	50.4	31.3	42.2	30
29	294	279	279	304	64.8	47.0	74.5	49.5	30.1	41.3	29
28	286	271	271	297	64.3	46.1	73.9	48.6	28.9	40.4	28
27	279	264	264	290	63.8	45.2	73.3	47.7	27.8	39.5	27
26	272	258	258	284	63.3	44.6	72.8	46.8	26.7	38.7	26
25	266	253	253	278	62.8	43.8	72.2	45.9	25.5	37.8	25
24	260	247	247	272	62.4	43.1	71.6	45.0	24.3	37.0	24
23	254	243	243	266	62.0	42.1	71.0	44.0	23.1	36.3	23
22	248	237	237	261	61.5	41.6	70.5	43.2	22.0	35.5	22
21	243	231	231	256	61.0	40.9	69.9	42.3	20.7	34.8	21
20	238	226	226	251	60.5	40.1	69.4	41.5	19.6	34.2	20

[A] In the table headings, *force* refers to total test forces.

[B] Annex A1 contains equations converting determined hardness scale numbers to Rockwell C hardness numbers for non-austenitic steels. Refer to 1.12 before using conversion equations.

[C] The Brinell hardness numbers in parentheses are outside the range recommended for Brinell hardness testing in 8.1 of Test Method E10.

[D] These Scleroscope hardness conversions are based on Vickers—Scleroscope hardness relationships developed from Vickers hardness data provided by the National Bureau of Standards for 13 steel reference blocks, Scleroscope hardness values obtained on these blocks by the Shore Instrument and Mfg. Co., Inc., the Roll Manufacturers Institute, and members of this institute, and also on hardness conversions previously published by the American Society for Metals and the Roll Manufacturers Institute.