



Designation: E 140 – 02

# Standard Hardness Conversion Tables for Metals Relationship Among Brinell Hardness, Vickers Hardness, Rockwell Hardness, Superficial Hardness, Knoop Hardness, and Scleroscope Hardness<sup>1</sup>

This standard is issued under the fixed designation E 140; 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 ( $\epsilon$ ) indicates an editorial change since the last revision or reapproval.

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

## 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 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. Since all converted hardness values must be considered approximate, however, all converted Rockwell hardness numbers shall be rounded to the nearest whole number in accordance with Practice **E 29**.

1.11 **Appendix X1-Appendix X9** contain equations developed from the data in **Tables 1-9**, respectively, to convert from one hardness scale to another. Since all converted hardness values must be considered approximate, however, all converted hardness numbers shall be rounded in accordance with Practice **E 29**.

1.12 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 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.

## 2. Referenced Documents

### 2.1 *ASTM Standards:*

<sup>1</sup> 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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- E 10 Test Method for Brinell Hardness of Metallic Materials<sup>2</sup>
- E 18 Test Method for Rockwell Hardness and Rockwell Superficial Hardness of Metallic Materials<sup>2</sup>
- E 29 Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications<sup>3</sup>
- E 92 Test Method for Vickers Hardness of Metallic Materials<sup>2</sup>
- E 384 Test Method for Microhardness of Materials<sup>2</sup>
- E 448 Practice for Scleroscope Hardness Testing of Metallic Materials<sup>2</sup>

### 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 *Vickers Hardness*—Test Method E 92.
- 3.1.2 *Brinell Hardness*—Test Method E 10.
- 3.1.3 *Rockwell Hardness*—Test Method E 18 Scales A, B, C, D, E, F, G, H, K, 15-N, 30-N, 45-N, 15-T, 30-T, 45-T, 15-W.
- 3.1.4 *Knoop Hardness*—Test Method E 384.
- 3.1.5 *Scleroscope<sup>4</sup> Hardness*—Practice E 448.

### 4. Apparatus and Reference Standards

4.1 The apparatus and reference standards shall conform to the description in Test Methods E 92, E 10, E 18, E 384, and Practice E 448.

### 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 1—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 (see Appendix X1).

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.

### 7. Reporting of Hardness Numbers

7.1 When reporting converted hardness numbers the measured hardness and test scale shall be indicated in parentheses as in the following example:

353 HBW (38 HRC)

(1)

### 8. Keywords

8.1 conversion; hardness scale; metallic

<sup>2</sup> Annual Book of ASTM Standards, Vol 03.01.

<sup>3</sup> Annual Book of ASTM Standards, Vol 14.02.

<sup>4</sup> Registered trademark of the Shore Instrument and Manufacturing Co., Inc.



**TABLE 1 Approximate Hardness Conversion Numbers for Non-Austenitic Steels (Rockwell C Hardness Range)<sup>A, B</sup>**

Rockwell C Hardness Number 150 kgf (HRC)	Vickers Hardness Number (HV)	Brinell Hardness Number <sup>C</sup>		Knoop Hardness, Number 500-gf and Over (HK)	Rockwell Hardness Number		Rockwell Superficial Hardness Number			Scleroscope Hardness Number <sup>D</sup>	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)	15-N Scale, 15-kgf (HR 15-N)	30-N Scale, 30-kgf (HR 30-N)	45-N Scale, 45-kgf (HR 45-N)		
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

<sup>A</sup> In the table headings, *force* refers to total test forces.

<sup>B</sup> Appendix X1 contains equations converting determined hardness scale numbers to Rockwell C hardness numbers for non-austenitic steels. Refer to 1.11 before using conversion equations.

<sup>C</sup> The Brinell hardness numbers in parentheses are outside the range recommended for Brinell hardness testing in 8.1 of Test Method E 10.

<sup>D</sup> 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.



**TABLE 2 Approximate Hardness Conversion Numbers for Non-Austenitic Steels (Rockwell B Hardness Range)<sup>A, B</sup>**

Rockwell B Hardness Number, 100-kgf (HRB)	Vickers Hardness Number (HV)	Brinell Hardness Number, 3000-kgf, (HBS)	Knoop Hardness Number, 500-gf, and Over (HK)	Rockwell A Hardness Number, 60-kgf, (HRA)	Rockwell F Hardness Number, 60-kgf, (HRF)	Rockwell Superficial Hardness Number			Rockwell B Hardness Number, 100-kgf, (HRB)
						15-T Scale, 15-kgf, (HR 15-T)	30-T Scale, 30-kgf, (HR 30-T)	45-T Scale, 45-kgf, (HR 45-T)	
100	240	240	251	61.5	...	93.1	83.1	72.9	100
99	234	234	246	60.9	...	92.8	82.5	71.9	99
98	228	228	241	60.2	...	92.5	81.8	70.9	98
97	222	222	236	59.5	...	92.1	81.1	69.9	97
96	216	216	231	58.9	...	91.8	80.4	68.9	96
95	210	210	226	58.3	...	91.5	79.8	67.9	95
94	205	205	221	57.6	...	91.2	79.1	66.9	94
93	200	200	216	57.0	...	90.8	78.4	65.9	93
92	195	195	211	56.4	...	90.5	77.8	64.8	92
91	190	190	206	55.8	...	90.2	77.1	63.8	91
90	185	185	201	55.2	...	89.9	76.4	62.8	90
89	180	180	196	54.6	...	89.5	75.8	61.8	89
88	176	176	192	54.0	...	89.2	75.1	60.8	88
87	172	172	188	53.4	...	88.9	74.4	59.8	87
86	169	169	184	52.8	...	88.6	73.8	58.8	86
85	165	165	180	52.3	...	88.2	73.1	57.8	85
84	162	162	176	51.7	...	87.9	72.4	56.8	84
83	159	159	173	51.1	...	87.6	71.8	55.8	83
82	156	156	170	50.6	...	87.3	71.1	54.8	82
81	153	153	167	50.0	...	86.9	70.4	53.8	81
80	150	150	164	49.5	...	86.6	69.7	52.8	80
79	147	147	161	48.9	...	86.3	69.1	51.8	79
78	144	144	158	48.4	...	86.0	68.4	50.8	78
77	141	141	155	47.9	...	85.6	67.7	49.8	77
76	139	139	152	47.3	...	85.3	67.1	48.8	76
75	137	137	150	46.8	99.6	85.0	66.4	47.8	75
74	135	135	147	46.3	99.1	84.7	65.7	46.8	74
73	132	132	145	45.8	98.5	84.3	65.1	45.8	73
72	130	130	143	45.3	98.0	84.0	64.4	44.8	72
71	127	127	141	44.8	97.4	83.7	63.7	43.8	71
70	125	125	139	44.3	96.8	83.4	63.1	42.8	70
69	123	123	137	43.8	96.2	83.0	62.4	41.8	69
68	121	121	135	43.3	95.6	82.7	61.7	40.8	68
67	119	119	133	42.8	95.1	82.4	61.0	39.8	67
66	117	117	131	42.3	94.5	82.1	60.4	38.7	66
65	116	116	129	41.8	93.9	81.8	59.7	37.7	65
64	114	114	127	41.4	93.4	81.4	59.0	36.7	64
63	112	112	125	40.9	92.8	81.1	58.4	35.7	63
62	110	110	124	40.4	92.2	80.8	57.7	34.7	62
61	108	108	122	40.0	91.7	80.5	57.0	33.7	61
60	107	107	120	39.5	91.1	80.1	56.4	32.7	60

Rockwell B Hardness Number, 100-kgf, (HRB)	Vickers Hardness Number (HV)	Brinell Hardness Number, 3000-kgf, 10-mm Ball	Knoop Hardness Number, 500-gf and Over	Rockwell A Hardness Number, 60-kgf, Diamond Penetrator	Rockwell F Hardness Number, 60-kgf, 1/16-in. (1.588-mm) Ball	Rockwell Superficial Hardness Number			Rockwell B Hardness Number, 100-kgf, 1/16-in. (1.588-mm) Ball
						15-T Scale, 15-kgf, 1/16-in. (1.588-mm) Ball	30-T Scale, 30-kgf, 1/16-in. (1.588-mm) Ball	45-T Scale, 45-kgf, 1/16-in. (1.588-mm) Ball	
59	106	106	118	39.0	90.5	79.8	55.7	31.7	59
58	104	104	117	38.6	90.0	79.5	55.0	30.7	58
57	103	103	115	38.1	89.4	79.2	54.4	29.7	57
56	101	101	114	37.7	88.8	78.8	53.7	28.7	56
55	100	100	112	37.2	88.2	78.5	53.0	27.7	55
54	...	...	111	36.8	87.7	78.2	52.4	26.7	54
53	...	...	110	36.3	87.1	77.9	51.7	25.7	53
52	...	...	109	35.9	86.5	77.5	51.0	24.7	52
51	...	...	108	35.5	86.0	77.2	50.3	23.7	51
50	...	...	107	35.0	85.4	76.9	49.7	22.7	50
49	...	...	106	34.6	84.8	76.6	49.0	21.7	49
48	...	...	105	34.1	84.3	76.2	48.3	20.7	48
47	...	...	104	33.7	83.7	75.9	47.7	19.7	47
46	...	...	103	33.3	83.1	75.6	47.0	18.7	46
45	...	...	102	32.9	82.6	75.3	46.3	17.7	45
44	...	...	101	32.4	82.0	74.9	45.7	16.7	44
43	...	...	100	32.0	81.4	74.6	45.0	15.7	43
42	...	...	99	31.6	80.8	74.3	44.3	14.7	42
41	...	...	98	31.2	80.3	74.0	43.7	13.6	41
40	...	...	97	30.7	79.7	73.6	43.0	12.6	40



**TABLE 2** *Continued*

Rockwell B Hardness Number, 100-kgf, (HRB)	Vickers Hardness Number (HV)	Brinell Hardness Number, 3000-kgf, 10-mm Ball	Knoop Hardness Number, 500-gf and Over	Rockwell A Hardness Number, 60-kgf, Diamond Penetrator	Rockwell F Hardness Number, 60-kgf, 1/16-in. (1.588-mm) Ball	Rockwell Superficial Hardness Number			Rockwell B Hardness Number, 100-kgf, 1/16-in. (1.588-mm) Ball
						15-T Scale, 15-kgf, 1/16-in. (1.588-mm) Ball	30-T Scale, 30-kgf, 1/16-in. (1.588-mm) Ball	45-T Scale, 45-kgf, 1/16-in. (1.588-mm) Ball	
39	...	...	96	30.3	79.1	73.3	42.3	11.6	39
38	...	...	95	29.9	78.6	73.0	41.6	10.6	38
37	...	...	94	29.5	78.0	72.7	41.0	9.6	37
36	...	...	93	29.1	77.4	72.3	40.3	8.6	36
35	...	...	92	28.7	76.9	72.0	39.6	7.6	35
34	...	...	91	28.2	76.3	71.7	39.0	6.6	34
33	...	...	90	27.8	75.7	71.4	38.3	5.6	33
32	...	...	89	27.4	75.2	71.0	37.6	4.6	32
31	...	...	88	27.0	74.6	70.7	37.0	3.6	31
30	...	...	87	26.6	74.0	70.4	36.3	2.6	30

<sup>A</sup> In table headings, kgf refers to total test force.

<sup>B</sup> **Appendix X2** contains equations converting determined hardness numbers to Rockwell B hardness numbers for non-austenitic steels. Refer to **1.11** before using conversion equations.

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TABLE 3 Approximate Hardness Conversion Numbers for Nickel and High-Nickel Alloys<sup>A, B, C</sup>

NOTE 1—See Supplement to Table 3.

NOTE 2—The use of hardness scales for hardness values shown in parentheses is not recommended since they are beyond the ranges recommended for accuracy. Such values are shown for comparative purposes only, where comparisons may be desired and the recommended machine and scale are not available.

Vickers Hardness Number	Rockwell Hardness Number										Rockwell Superficial Hardness Number				
	A Scale 60-kgf Dia- mond Penetrator (HRA)	B Scale 100-kgf 1/16-in. (1.588- mm) Ball (HRB)	C Scale 150-kgf Dia- mond Penetrator (HRC)	D Scale 100-kgf Dia- mond Penetrator (HRD)	E Scale 100-kgf 1/16-in. (1.588- mm) Ball (HRE)	F Scale 60-kgf 1/16-in. (1.588- mm) Ball (HRF)	G Scale 150-kgf 1/16-in. (1.588- mm) Ball (HRG)	K Scale 150-kgf 1/8-in. (3.175- mm) Ball (HRK)	15-N Scale 15-kgf Superficial Dia- mond Penetrator (HR 15-N)	30-N Scale 30-kgf Superficial Dia- mond Penetrator (HR 30-N)	45-N Scale 45-kgf Superficial Diamond Penetrator (HR 45-N)	15-T Scale 15-kgf 1/16-in. (1.588- mm) Ball (HR 15-T)	30-T Scale 30-kgf 1/16-in. (1.588- mm) Ball (HR 30-T)	45-T Scale 45-kgf 1/16-in. (1.588- mm) Ball (HR 45-T)	
513	75.5	...	50.0	63.0	...	...	...	85.5	68.0	54.5	...	...	...	...	
481	74.5	...	48.0	61.5	...	...	...	84.5	66.5	52.5	...	...	...	...	
452	73.5	...	46.0	60.0	...	...	...	83.5	64.5	50.0	...	...	...	...	
427	72.5	...	44.0	58.5	...	...	...	82.5	63.0	47.5	...	...	...	...	
404	71.5	...	42.0	57.0	...	...	...	81.5	61.0	45.5	...	...	...	...	
382	70.5	...	40.0	55.5	...	...	...	80.5	59.5	43.0	...	...	...	...	
362	69.5	...	38.0	54.0	...	...	...	79.5	58.0	41.0	...	...	...	...	
344	68.5	...	36.0	52.5	...	...	...	78.5	56.0	38.5	...	...	...	...	
326	67.5	...	34.0	50.5	...	...	...	77.5	54.5	36.0	...	...	...	...	
309	66.5	(106)	32.0	49.5	...	(116.5)	94.0	76.5	52.5	34.0	94.5	85.5	77.0	77.0	
285	64.5	(104)	28.5	46.5	...	(115.5)	91.0	75.0	49.5	30.0	94.0	84.5	75.0	75.0	
266	63.0	(102)	25.5	44.5	...	(114.5)	87.5	73.5	47.0	26.5	93.0	83.0	73.0	73.0	
248	61.5	100	22.5	42.0	...	(113.0)	84.5	72.0	44.5	23.0	92.5	81.5	71.0	71.0	
234	60.5	98	20.0	40.0	...	(112.0)	81.5	70.5	42.0	20.0	92.0	80.5	69.0	69.0	
220	59.0	96	(17.0)	38.0	...	(111.0)	78.5	69.0	39.5	17.0	91.0	79.0	67.0	67.0	
204	57.5	94	(14.5)	36.0	...	(110.0)	75.5	68.0	37.5	14.0	90.5	77.5	65.0	65.0	
198	56.5	92	(12.0)	34.0	...	(108.5)	72.0	66.5	35.5	11.0	89.5	76.0	63.0	63.0	
188	55.0	90	(9.0)	32.0	...	(107.5)	69.0	65.0	32.5	7.5	89.0	75.0	61.0	61.0	
179	53.5	88	(6.5)	30.0	...	(106.5)	65.5	64.0	30.5	5.0	88.0	73.5	59.5	59.5	
171	52.5	86	(4.0)	28.0	...	(105.0)	62.5	62.5	28.5	2.0	87.5	72.0	57.5	57.5	
164	51.5	84	(2.0)	26.5	...	(104.5)	59.5	61.5	26.5	(-0.5)	87.0	70.5	55.5	55.5	
157	50.0	82	...	24.5	...	(103.0)	56.5	...	...	...	86.0	69.5	53.5	53.5	
151	49.0	80	...	22.5	...	(102.0)	53.0	...	...	...	85.5	68.0	51.5	51.5	
145	47.5	78	...	21.0	...	(100.5)	50.0	...	...	...	84.5	66.5	49.5	49.5	
140	46.5	76	...	(19.0)	...	(99.5)	47.0	...	...	...	84.0	65.5	47.5	47.5	
135	45.5	74	...	(17.5)	...	98.0	43.5	...	...	...	83.0	64.0	45.5	45.5	
130	44.0	72	...	(16.0)	...	97.0	40.5	...	...	...	82.5	62.5	43.5	43.5	
126	43.0	70	...	(14.5)	...	96.0	37.5	...	...	...	82.0	61.0	41.5	41.5	
122	42.0	68	...	(13.0)	...	95.0	34.5	...	...	...	81.0	60.0	39.5	39.5	
119	41.0	66	...	(11.5)	...	94.0	31.0	...	...	...	80.5	58.5	37.5	37.5	
115	40.0	64	...	(10.0)	...	93.5	...	...	...	...	80.0	57.0	35.5	35.5	
112	39.0	62	...	(8.0)	...	93.0	...	...	...	...	79.5	56.0	33.5	33.5	
108	...	60	...	...	...	92.5	...	...	...	...	79.0	54.5	31.5	31.5	
106	...	58	...	...	...	92.0	...	...	...	...	78.5	53.0	29.5	29.5	
103	...	56	...	...	...	91.5	...	...	...	...	78.0	51.5	27.5	27.5	
100	...	54	...	...	...	91.0	...	...	...	...	77.5	50.0	25.5	25.5	
98	...	52	...	...	...	90.5	...	...	...	...	77.0	49.0	23.5	23.5	
95	...	50	...	...	...	90.0	...	...	...	...	76.5	47.5	21.5	21.5	



**TABLE 3** Continued

Vickers Hardness Number	Rockwell Hardness Number													
	A Scale	B Scale	C Scale	D Scale	E Scale	F Scale	G Scale	K Scale	15-N Scale	30-N Scale	45-N Scale	15-T Scale	30-T Scale	45-T Scale
10-mm Standard Ball, 3000-kgf (HBS)	60-kgf Diamond Penetrator (HRA)	100-kgf $\frac{1}{16}$ -in. (1.588-mm) Ball (HRB)	150-kgf Diamond Penetrator (HRC)	100-kgf Diamond Penetrator (HRD)	100-kgf $\frac{1}{8}$ -in. (3.175-mm) Ball (HRE)	60-kgf $\frac{1}{16}$ -in. (1.588-mm) Ball (HRF)	150-kgf $\frac{1}{16}$ -in. (1.588-mm) Ball (HRG)	150-kgf $\frac{1}{8}$ -in. (3.175-mm) Ball (HRK)	15-kgf Superficial Diamond Penetrator (HR 15-N)	30-kgf Superficial Diamond Penetrator (HR 30-N)	45-kgf Superficial Diamond Penetrator (HR 45-N)	15-kgf $\frac{1}{16}$ -in. (1.588-mm) Ball (HR 15-T)	30-kgf $\frac{1}{16}$ -in. (1.588-mm) Ball (HR 30-T)	45-kgf $\frac{1}{16}$ -in. (1.588-mm) Ball (HR 45-T)
93	...	48	...	...	81.5	83.5	...	56.5	...	...	...	74.0	46.5	19.5
91	...	46	...	...	80.5	82.0	...	54.5	...	...	...	73.5	45.0	17.0
89	...	44	...	...	79.0	81.0	...	52.5	...	...	...	72.5	43.5	14.5
87	...	42	...	...	78.0	80.0	...	51.0	...	...	...	72.0	42.0	12.5
85	...	40	...	...	76.5	79.0	...	49.0	...	...	...	71.0	41.0	10.0
83	...	38	...	...	75.0	77.5	...	47.0	...	...	...	70.5	39.5	7.5
81	...	36	...	...	74.0	76.5	...	45.5	...	...	...	70.0	38.0	5.5
79	...	34	...	...	72.5	75.5	...	43.5	...	...	...	69.0	36.5	3.0
78	...	32	...	...	71.5	74.0	...	42.0	...	...	...	68.5	35.5	1.0
77	...	30	...	...	70.0	73.0	...	40.0	...	...	...	67.5	34.0	(-1.5)

TABLE 3 Continued

Vickers Hardness Number		Knoop Hardness Number
Vickers Indenter 1,5,10,30-kgf (HV)		Knoop Indenter: 500 and 1000-gf (HK)
382		436
362		413
344		392
326		372
309		352
285		325
266		304
248		283
234		267
220		251
209		239
198		226
188		215
179		204
171		195
164		187
157		179
151		173
145		166
140		160
135		154
130		149
126		144
122		140
119		136

<sup>A</sup> In table headings, kgf or gf refers to total test force.

<sup>B</sup> Appendix X3 contains equations converting determined hardness scale numbers to Vickers hardness numbers for nickel and high-nickel alloys. Refer to 1.11 before using conversion equations.

<sup>C</sup> Note that in Table 5 of Test Method E 10 (appears in the *Annual Book of ASTM Standards*, Vol 03.01), the use of a 3000-kgf force is recommended (but not mandatory) for material in the hardness range from 96 to 600 HV, and a 1500-kgf force is recommended (but not mandatory) for material in the hardness range from 48 to 300 HV. These recommendations are designed to limit impression diameters to the range from 2.50 to 6.0 mm. The Brinell hardness numbers in this conversion table are based on tests using a 3000-kgf force. When the 1500-kgf force is used for the softer nickel and high-nickel alloys, these conversion relationships do not apply.





**TABLE 4 Approximate Hardness Conversion Numbers for Cartridge Brass (70 % Copper 30 % Zinc Alloy)<sup>A,B</sup>**

Vickers Hardness Number (HV)	Rockwell Hardness Number		Rockwell Superficial Hardness Number			Brinell Hardness Number
	B Scale, 100-kgf, 1/16-in. (1.588-mm) Ball (HRB)	F Scale, 60-kgf 1/16-in. (1.588-mm) Ball (HRF)	15-T Scale, 15-kgf, 1/16-in. (1.588-mm) Ball (HR 15-T)	30-T Scale, 30-kgf, 1/16-in. (1.588-mm) Ball (HR 30-T)	45-T Scale, 45-kgf, 1/16-in. (1.588-mm) Ball (HR 45-T)	
196	93.5	110.0	90.0	77.5	66.0	169
194	...	109.5	...	...	65.5	167
192	93.0	...	...	77.0	65.0	166
190	92.5	109.0	...	76.5	64.5	164
188	92.0	...	89.5	...	64.0	162
186	91.5	108.5	...	76.0	63.5	161
184	91.0	...	...	75.5	63.0	159
182	90.5	108.0	89.0	...	62.5	157
180	90.0	107.5	...	75.0	62.0	156
178	89.0	...	...	74.5	61.5	154
176	88.5	107.0	...	...	61.0	152
174	88.0	...	88.5	74.0	60.5	150
172	87.5	106.5	...	73.5	60.0	149
170	87.0	...	...	...	59.5	147
168	86.0	106.0	88.0	73.0	59.0	146
166	85.5	...	...	72.5	58.5	144
164	85.0	105.5	...	72.0	58.0	142
162	84.0	105.0	87.5	...	57.5	141
160	83.5	...	...	71.5	56.5	139
158	83.0	104.5	...	71.0	56.0	138
156	82.0	104.0	87.0	70.5	55.5	136
154	81.5	103.5	...	70.0	54.5	135
152	80.5	103.0	...	...	54.0	133
150	80.0	...	86.5	69.5	53.5	131
148	79.0	102.5	...	69.0	53.0	129
146	78.0	102.0	...	68.5	52.5	128
144	77.5	101.5	86.0	68.0	51.5	126
142	77.0	101.0	...	67.5	51.0	124
140	76.0	100.5	85.5	67.0	50.0	122
138	75.0	100.0	...	66.5	49.0	121
136	74.5	99.5	85.0	66.0	48.0	120
134	73.5	99.0	...	65.5	47.5	118
132	73.0	98.5	84.5	65.0	46.5	116
130	72.0	98.0	84.0	64.5	45.5	114
128	71.0	97.5	...	63.5	45.0	113
126	70.0	97.0	83.5	63.0	44.0	112
124	69.0	96.5	...	62.5	43.0	110
122	68.0	96.0	83.0	62.0	42.0	108
120	67.0	95.5	...	61.0	41.0	106
118	66.0	95.0	82.5	60.5	40.0	105
116	65.0	94.5	82.0	60.0	39.0	103
114	64.0	94.0	81.5	59.5	38.0	101
112	63.0	93.0	81.0	58.5	37.0	99
110	62.0	92.6	80.5	58.0	35.5	97
108	61.0	92.0	...	57.0	34.5	95
106	59.5	91.2	80.0	56.0	33.0	94
104	58.0	90.5	79.5	55.0	32.0	92
102	57.0	89.8	79.0	54.5	30.5	90
100	56.0	89.0	78.5	53.5	29.5	88
98	54.0	88.0	78.0	52.5	28.0	86
96	53.0	87.2	77.5	51.5	26.5	85
94	51.0	86.3	77.0	50.5	24.5	83
92	49.5	85.4	76.5	49.0	23.0	82
90	47.5	84.4	75.5	48.0	21.0	80
88	46.0	83.5	75.0	47.0	19.0	79
86	44.0	82.3	74.5	45.5	17.0	77
84	42.0	81.2	73.5	44.0	14.5	76
82	40.0	80.0	73.0	43.0	12.5	74
80	37.5	78.6	72.0	41.0	10.0	72
78	35.0	77.4	71.5	39.5	7.5	70
76	32.5	76.0	70.5	38.0	4.5	68
74	30.0	74.8	70.0	36.0	1.0	66
72	27.5	73.2	69.0	34.0	...	64
70	24.5	71.8	68.0	32.0	...	63
68	21.5	70.0	67.0	30.0	...	62
66	18.5	68.5	66.0	28.0	...	61
64	15.5	66.8	65.0	25.5	...	59
62	12.5	65.0	63.5	23.0	...	57



**TABLE 4** *Continued*

Vickers Hardness Number (HV)	Rockwell Hardness Number		Rockwell Superficial Hardness Number			Brinell Hardness Number
	B Scale, 100-kgf, 1/16-in. (1.588-mm) Ball (HRB)	F Scale, 60-kgf 1/16-in. (1.588-mm) Ball (HRF)	15-T Scale, 15-kgf, 1/16-in. (1.588-mm) Ball (HR 15-T)	30-T Scale, 30-kgf, 1/16-in. (1.588-mm) Ball (HR 30-T)	45-T Scale, 45-kgf, 1/16-in. (1.588-mm) Ball (HR 45-T)	
60	10.0	62.5	62.5	...	...	55
58	...	61.0	61.0	18.0	...	53
56	...	58.8	60.0	15.0	...	52
54	...	56.5	58.5	12.0	...	50
52	...	53.5	57.0	...	...	48
50	...	50.5	55.5	...	...	47
49	...	49.0	54.5	...	...	46
48	...	47.0	53.5	...	...	45
47	...	45.0	...	...	...	44
46	...	43.0	...	...	...	43
45	...	40.0	...	...	...	42

<sup>A</sup> In table headings, kgf or gf refers to total test force.

<sup>B</sup> Appendix X4 contains equations converting determined hardness scale numbers to Vickers hardness numbers for cartridge brass. Refer to 1.11 before using conversion equations.

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