Designation: E140 – 07

StandardHardness Conversion Tables for Metals Relationship Among Brinell Hardness, Vickers Hardness, Rockwell Hardness, Superficial Hardness, Knoop Hardness, and Scleroscope 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 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 5presents 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 7presents 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 E29.

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 E29.

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

[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**

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)	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

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

[B] 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.

[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.

TABLE 2 Approximate Hardness Conversion Numbers for Non-Austenitic Steels (Rockwell B Hardness Range)[A, B]

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

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:*[2]

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 Method for Vickers Hardness of Metallic Materials (Withdrawn 2010)[3]

E384 Test Method for Knoop and Vickers Hardness of Materials

E448 Practice for Scleroscope Hardness Testing of Metallic Materials

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 E92.

3.1.2 *Brinell Hardness*—Test Method E10.

3.1.3 *Rockwell Hardness*—Test Method E18 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 E384.

3.1.5 *Scleroscope* [4] *Hardness*—Practice E448.

NOTE 1—The comparative hardness test done to generate the conversion tables in this standard were preformed 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 MethodE10 and E18, respectively) allow or require the use of tungsten carbide ball

[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.

[4] Registered trademark of the Shore Instrument and Manufacturing Co., Inc.

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	
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
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

[A] In table headings, kgf refers to total test force.
[B] 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.

indenters; however, all of the ball scale Rockwell hardness tests (HRB, HR30T, etc.) and most of the Brinell hardness tests preformed 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 E92, E10, E18, 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

TABLE 3 Approximate Hardness Conversion Numbers for Nickel and High-Nickel Alloys[A, B, C]

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	Brinell Hardness Number	Rockwell Hardness Number								Rockwell Superficial 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
Vickers Indenter 1, 5, 10, 30-kgf (HV)	10-mm Standard Ball, 3000-kgf (HBS)	60-kgf Diamond Penetrator (HRA)	100-kgf 1⁄16-in. (1.588-mm) Ball (HRB)	150-kgf Diamond Penetrator (HRC)	100-kgf Diamond Penetrator (HRD)	100-kgf 1⁄8-in. (3.175-mm) Ball (HRE)	60-kgf 1⁄16-in. (1.588-mm) Ball (HRF)	150-kgf 1⁄16-in. (1.588-mm) Ball (HRG)	150-kgf 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 1⁄16-in. (1.588-mm) Ball (HR 15-T)	30-kgf 1⁄16-in. (1.588-mm) Ball (HR 30-T)	45-kgf 1⁄16-in. (1.588-mm) Ball (HR 45-T)
513	(479)	75.5	...	50.0	63.0	...	...	...	...	85.5	68.0	54.5	...	...	...
481	450	74.5	...	48.0	61.5	...	...	...	...	84.5	66.5	52.5	...	...	...
452	425	73.5	...	46.0	60.0	...	...	...	...	83.5	64.5	50.0	...	...	...
427	403	72.5	...	44.0	58.5	...	...	...	...	82.5	63.0	47.5	...	...	...
404	382	71.5	...	42.0	57.0	...	...	...	...	81.5	61.0	45.5	...	...	...
382	363	70.5	...	40.0	55.5	...	...	...	...	80.5	59.5	43.0	...	...	...
362	346	69.5	...	38.0	54.0	...	...	...	...	79.5	58.0	41.0	...	...	...
344	329	68.5	...	36.0	52.5	...	...	...	...	78.5	56.0	38.5	...	...	...
326	313	67.5	...	34.0	50.5	...	...	...	...	77.5	54.5	36.0	...	...	...
309	298	66.5	(106)	32.0	49.5	...	(116.5)	94.0	...	76.5	52.5	34.0	94.5	85.5	77.0
285	275	64.5	(104)	28.5	46.5	...	(115.5)	91.0	...	75.0	49.5	30.0	94.0	84.5	75.0
266	258	63.0	(102)	25.5	44.5	...	(114.5)	87.5	...	73.5	47.0	26.5	93.0	83.0	73.0
248	241	61.5	100	22.5	42.0	...	(113.0)	84.5	...	72.0	44.5	23.0	92.5	81.5	71.0
234	228	60.5	98	20.0	40.0	...	(112.0)	81.5	...	70.5	42.0	20.0	92.0	80.5	69.0
220	215	59.0	96	(17.0)	38.0	...	(111.0)	78.5	100.0	69.0	39.5	17.0	91.0	79.0	67.0
209	204	57.5	94	(14.5)	36.0	...	(110.0)	75.5	98.0	68.0	37.5	14.0	90.5	77.5	65.0
198	194	56.5	92	(12.0)	34.0	...	(108.5)	72.0	96.5	66.5	35.5	11.0	89.5	76.0	63.0
188	184	55.0	90	(9.0)	32.0	(108.5)	(107.5)	69.0	94.5	65.0	32.5	7.5	89.0	75.0	61.0
179	176	53.5	88	(6.5)	30.0	(107.0)	(106.5)	65.5	93.0	64.0	30.5	5.0	88.0	73.5	59.5
171	168	52.5	86	(4.0)	28.0	(106.0)	(105.0)	62.5	91.0	62.5	28.5	2.0	87.5	72.0	57.5
164	161	51.5	84	(2.0)	26.5	(104.5)	(104.0)	59.5	89.0	61.5	26.5	(−0.5)	87.0	70.5	55.5
157	155	50.0	82	...	24.5	(103.0)	(103.0)	56.5	87.5	...	...	...	86.0	69.5	53.5
151	149	49.0	80	...	22.5	(102.0)	(101.5)	53.0	85.5	...	...	...	85.5	68.0	51.5
145	144	47.5	78	...	21.0	(100.5)	(100.5)	50.0	83.5	...	...	...	84.5	66.5	49.5
140	139	46.5	76	...	(19.0)	99.5	99.5	47.0	82.0	...	...	...	84.0	65.5	47.5
135	134	45.5	74	...	(17.5)	98.0	98.5	43.5	80.0	...	...	...	83.0	64.0	45.5
130	129	44.0	72	...	(16.0)	97.0	97.0	40.5	78.0	...	...	...	82.5	62.5	43.5
126	125	43.0	70	...	(14.5)	95.5	96.0	37.5	76.5	...	...	...	82.0	61.0	41.5
122	121	42.0	68	...	(13.0)	94.5	95.0	34.5	74.5	...	...	...	81.0	60.0	39.5
119	118	41.0	66	...	(11.5)	93.0	93.5	31.0	72.5	...	...	...	80.5	58.5	37.5
115	114	40.0	64	...	(10.0)	91.5	92.5	...	71.0		...	...	79.5	57.0	35.5
112	111	39.0	62	...	(8.0)	90.5	91.5	...	69.0	...	...	...	79.0	56.0	33.5
108	108	...	60	...	...	89.0	90.0	...	67.5	...	...	...	78.5	54.5	31.5
106	106	...	58	...	...	88.0	89.0	...	65.5	...	...	...	77.5	53.0	29.5
103	103	...	56	...	...	86.5	88.0	...	63.5	...	...	...	77.0	51.5	27.5
100	100	...	54	...	...	85.5	87.0	...	62.0	...	...	...	76.0	50.5	25.5
98	98	...	52	...	...	84.0	85.5	...	60.0	...	...	...	75.5	49.0	23.5
95	95	...	50	...	...	83.0	84.5	...	58.0	...	...	...	74.5	47.5	21.5
93	93	...	48	...	...	81.5	83.5	...	56.5	...	...	...	74.0	46.5	19.5

TABLE 3 *Continued*

Vickers Hardness Number	Brinell Hardness Number	Rockwell Hardness Number								Rockwell Superficial Hardness Number					
Vickers Indenter 1, 5, 10, 30-kgf (HV)	10-mm Standard Ball, 3000-kgf (HBS)	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
		60-kgf Diamond Penetrator (HRA)	100-kgf 1/16-in. (1.588-mm) Ball (HRB)	150-kgf Diamond Penetrator (HRC)	100-kgf Diamond Penetrator (HRD)	100-kgf 1/8-in. (3.175-mm) Ball (HRE)	60-kgf 1/16-in. (1.588-mm) Ball (HRF)	150-kgf 1/16-in. (1.588-mm) Ball (HRG)	150-kgf 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 1/16-in. (1.588-mm) Ball (HR 15-T)	30-kgf 1/16-in. (1.588-mm) Ball (HR 30-T)	45-kgf 1/16-in. (1.588-mm) Ball (HR 45-T)
91	91	...	46	...	...	80.5	82.0	...	54.5	...	...	...	73.5	45.0	17.0
89	89	...	44	...	...	79.0	81.0	...	52.5	...	...	...	72.5	43.5	14.5
87	87	...	42	...	...	78.0	80.0	...	51.0	...	...	...	72.0	42.0	12.5
85	85	...	40	...	...	76.5	79.0	...	49.0	...	...	...	71.0	41.0	10.0
83	83	...	38	...	...	75.0	77.5	...	47.0	...	...	...	70.5	39.5	7.5
81	81	...	36	...	...	74.0	76.5	...	45.5	...	...	...	70.0	38.0	5.5
79	79	...	34	...	...	72.5	75.5	...	43.5	...	...	...	69.0	36.5	3.0
78	78	...	32	...	...	71.5	74.0	...	42.0	...	...	...	68.5	35.5	1.0
77	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

[A] In table headings, kgf or gf refers to total test force.

[B] 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.

[C] Note that in Table 5 of Test Method E10 (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)[A,B]

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)	500-kgf, 10-mm Ball (HBS)
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
60	10.0	62.5	62.5	...	...	55

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)	500-kgf, 10-mm Ball (HBS)
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

[A] In table headings, kgf or gf refers to total test force.
[B] Appendix X4 contains equations converting determined hardness scale numbers to Vickers hardness numbers for cartridge brass. Refer to 1.11 before using conversion equations.

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

$$353\ HBW\,(38\ HRC) \quad (1)$$

8. Keywords

8.1 conversion; hardness scale; metallic

TABLE 5 Approximate Brinell-Rockwell B Hardness Conversion Numbers for Austenitic Stainless Steel Plate in Annealed Condition[A,B]

Rockwell Hardness Number, B Scale (100-kgf, 1/16-in. (1.588-mm) ball) (HRB)	Brinell Hardness Number (3000-kgf, 10-mm ball) (HBS)
100	256
99	248
98	240
97	233
96	226
95	219
94	213
93	207
92	202
91	197
90	192
89	187
88	183
87	178
86	174
85	170
84	167
83	163
82	160
81	156
80	153
79	150
78	147
77	144
76	142
75	139
74	137
73	135
72	132
71	130
70	128
69	126
68	124
67	122
66	120
65	118
64	116
63	114
62	113
61	111
60	110

[A] In table headings, kgf or gf refers to total test force.
[B] Appendix X5 contains an equation converting determined Brinell hardness numbers to Rockwell B hardness numbers for austenitic steel plate in the annealed condition. Refer to 1.11 before using this conversion equation.