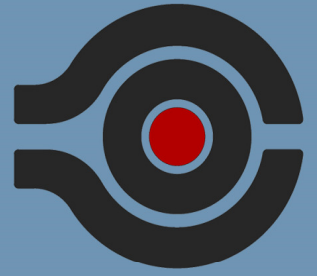


مرکز پژوهش متالورژی رازی



BUEHLER®
Hardness
Conversion
Charts



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Introduction

The requirement to convert from one hardness test scale to another is quite common and as such is covered by various International Standards (ASTM E140, ISO 18265). These standards point out that, due to the differences in the various types of hardness test methods, it is not possible to show a constant conversion relationship across all materials. As such, the standards provide approximate conversions only with defined hardness ranges and test loads for specific materials. Thus there are a number of conversion tables according to material type and it is essential to use the correct one. The following conversion charts have been constructed according to the hardness test scale conversion algorithms provided within ASTM E140. Please treat all converted values as approximations only.

The table below lists the scales present in the following tables and any restrictions on the load ranges valid for the conversions.

Scale	Symbol	Indenter and Load force
Vickers	HV	Vickers diamond, nickel alloys (1, 5, 10 or 30-kgf), copper (100-gf), aluminum (15-kgf)
Knoop	HK	Knoop diamond, 500-gf and over
Rockwell A	HRA	Diamond, 60-kgf
Rockwell B	HRB	Steel ball $\frac{1}{16}$ ", 100-kgf
Rockwell C	HRC	Diamond, 150-kgf
Rockwell D	HRD	Diamond, 100-kgf
Rockwell E	HRE	Steel ball $\frac{1}{8}$ ", 100-kgf
Rockwell F	HRF	Steel ball $\frac{1}{16}$ ", 60-kgf
Rockwell G	HRG	Steel ball $\frac{1}{16}$ ", 150-kgf
Rockwell H	HRH	Steel ball $\frac{1}{8}$ ", 60-kgf
Rockwell K	HRK	Steel ball $\frac{1}{8}$ ", 150-kgf
Superficial Rockwell 15N	HR15N	Diamond, 15-kgf
Superficial Rockwell 30N	HR30N	Diamond, 30-kgf
Superficial Rockwell 45N	HR45N	Diamond, 45-kgf
Superficial Rockwell 15T	HR15T	Steel ball $\frac{1}{16}$ ", 15-kgf
Superficial Rockwell 30T	HR30T	Steel ball $\frac{1}{16}$ ", 30-kgf
Superficial Rockwell 45T	HR45T	Steel ball $\frac{1}{16}$ ", 45-kgf
Superficial Rockwell 15W	HR15W	Steel ball $\frac{1}{8}$ ", 15-kgf
Brinell	HBW	Tungsten carbide 10mm ball, 3000-kgf
Brinell	HBS	Steel 10mm ball, steel and nickel (3000-kgf), brass and aluminum (500-kgf)

A commonly asked question is **"How come my results and those from another facility are different?"** The first step is to use statistical analysis to see if the difference is significant. Next, determine any differences in the test method. The two most common problems relate to either a different load being applied or a converted value being compared with an actual measurement. For this reason, it is recommended that the measured value is included in parenthesis following the conversion when reporting a converted hardness number.

In addition to steel balls, tungsten carbide balls have been introduced for Rockwell and Rockwell Superficial scales. However, all of the equations applied to create values for the tables in this document are based on empirical test accomplished with steel indenters. A Rockwell hardness test done with a tungsten carbide ball may yield slightly different results.

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پایه دانش متاورثی رازی

Hardness Conversion Chart for Non-Austenitic Steels (Rockwell C Range)

<i>HV</i>	<i>HK</i>	<i>HRC</i>	<i>HRA</i>	<i>HRD</i>	<i>HR15N</i>	<i>HR30N</i>	<i>HR45N</i>	<i>HBW</i>
950	917	68.0	85.7	76.9	93.4	84.7	75.9	
940	912	67.8	85.6	76.7	93.3	84.5	75.7	
930	907	67.6	85.5	76.6	93.2	84.3	75.4	
920	902	67.4	85.3	76.4	93.1	84.1	75.2	
910	897	67.2	85.2	76.2	93.0	83.9	74.9	
900	891	66.9	85.1	76.1	92.9	83.7	74.6	
890	885	66.7	84.9	75.9	92.8	83.5	74.3	
880	880	66.4	84.8	75.7	92.7	83.3	74.0	
870	874	66.2	84.6	75.5	92.6	83.0	73.7	
860	867	65.9	84.5	75.3	92.5	82.8	73.4	
850	860	65.6	84.3	75.0	92.4	82.5	73.1	
840	854	65.3	84.2	74.8	92.3	82.3	72.7	
830	847	65.0	84.0	74.6	92.2	82.0	72.4	
820	840	64.7	83.8	74.3	92.1	81.7	72.0	
810	833	64.4	83.6	74.1	91.9	81.4	71.7	
800	825	64.1	83.4	73.9	91.8	81.1	71.3	
790	817	63.7	83.3	73.6	91.7	80.8	70.9	
780	809	63.4	83.1	73.3	91.5	80.5	70.5	
770	801	63.0	82.9	73.0	91.4	80.2	70.1	
760	793	62.7	82.7	72.8	91.2	79.9	69.6	
750	784	62.3	82.5	72.5	91.1	79.5	69.2	
740	776	61.9	82.2	72.2	90.9	79.2	68.7	
730	767	61.5	82.0	71.9	90.7	78.8	68.3	
720	758	61.1	81.8	71.6	90.6	78.4	67.8	
710	749	60.7	81.6	71.2	90.4	78.1	67.3	
700	739	60.2	81.3	70.9	90.2	77.7	66.8	
690	730	59.8	81.1	70.6	90.0	77.3	66.3	
680	720	59.3	80.8	70.2	89.8	76.9	65.7	645
670	710	58.9	80.6	69.9	89.6	76.4	65.2	634
660	700	58.4	80.3	69.5	89.4	76.0	64.6	623
650	690	57.9	80.0	69.1	89.2	75.6	64.1	613
640	679	57.4	79.8	68.7	89.0	75.1	63.5	603
630	669	56.9	79.5	68.3	88.7	74.7	62.9	593
620	658	56.4	79.2	67.9	88.5	74.2	62.3	583
610	647	55.8	78.9	67.5	88.3	73.7	61.6	573
600	637	55.3	78.6	67.1	88.0	73.2	61.0	563
590	626	54.7	78.3	66.7	87.8	72.7	60.3	554
580	614	54.1	78.0	66.2	87.5	72.2	59.7	544
570	603	53.5	77.6	65.8	87.2	71.7	59.0	535
560	592	52.9	77.3	65.3	86.9	71.1	58.2	525
550	581	52.3	77.0	64.8	86.6	70.5	57.5	516
540	570	51.7	76.6	64.3	86.3	70.0	56.8	507
530	558	51.0	76.3	63.8	86.0	69.4	56.0	497

Hardness Conversion Chart for Non-Austenitic Steels (Rockwell C Range)

HV	HK	HRC	HRA	HRD	HR15N	HR30N	HR45N	HBW
520	547	50.4	75.9	63.3	85.7	68.8	55.2	488
510	535	49.7	75.6	62.8	85.4	68.2	54.4	479
500	524	49.0	75.2	62.3	85.0	67.5	53.6	470
490	513	48.3	74.8	61.7	84.7	66.9	52.8	460
480	501	47.5	74.4	61.1	84.3	66.2	51.9	451
470	490	46.8	74.0	60.6	83.9	65.6	51.0	442
460	479	46.0	73.6	60.0	83.5	64.8	50.1	433
450	467	45.2	73.2	59.4	83.1	64.1	49.2	424
440	456	44.4	72.7	58.7	82.7	63.4	48.2	415
430	445	43.5	72.3	58.1	82.3	62.6	47.2	406
420	434	42.7	71.8	57.4	81.8	61.9	46.2	396
410	423	41.8	71.4	56.7	81.4	61.0	45.2	387
400	412	40.9	70.9	56.0	80.9	60.2	44.1	378
390	402	39.9	70.4	55.3	80.4	59.4	43.0	369
380	391	38.9	69.9	54.5	79.9	58.5	41.8	360
370	380	37.9	69.4	53.8	79.3	57.6	40.7	351
360	370	36.9	68.8	53.0	78.8	56.6	39.4	341
350	359	35.8	68.3	52.1	78.2	55.7	38.2	332
340	349	34.7	67.7	51.3	77.5	54.7	36.9	323
330	339	33.5	67.1	50.4	76.9	53.6	35.5	314
320	329	32.3	66.5	49.5	76.3	52.5	34.1	304
310	319	31.1	65.9	48.5	75.5	51.4	32.6	295
300	309	29.8	65.2	47.5	74.8	50.2	31.1	285
290	300	28.4	64.6	46.5	74.1	49.0	29.5	276
280	290	27.0	63.9	45.4	73.3	47.7	27.9	266
270	281	25.5	63.1	44.2	72.5	46.4	26.1	257
260	271	23.9	62.3	43.0	71.6	45.0	24.3	247
250	262	22.3	61.5	41.8	70.7	43.5	22.3	237
240	253	20.5	60.7	40.4	69.7	41.9	20.3	228

The non-austenitic steels included carbon, alloy and tool steels in the as-forged, annealed, normalized, and quenched and tempered conditions.

Hardness Conversion Chart for Non-Austenitic Steels (Rockwell B Range)

<i>HV</i>	<i>HK</i>	<i>HRB</i>	<i>HRA</i>	<i>HRF</i>	<i>HR15T</i>	<i>HR30T</i>	<i>HR45T</i>	<i>HBS</i>
240	252	99.8	61.4		93.0	83.0	72.7	240
235	248	99.1	60.9		92.8	82.5	72.0	235
230	243	98.4	60.4		92.6	82.0	71.2	230
225	239	97.6	59.9		92.3	81.5	70.5	225
220	235	96.8	59.4		92.1	81.0	69.7	220
215	230	95.9	58.8		91.8	80.4	68.8	215
210	225	95.1	58.3		91.5	79.8	67.9	210
205	221	94.1	57.7		91.2	79.2	67.0	205
200	216	93.2	57.1		90.9	78.6	66.0	200
195	211	92.2	56.5		90.6	77.9	65.0	195
190	205	91.1	55.8		90.2	77.1	63.9	190
185	200	90.0	55.1		89.8	76.4	62.8	185
180	195	88.8	54.4		89.4	75.6	61.6	180
175	190	87.5	53.7		89.1	74.8	60.4	175
170	185	86.2	52.9		88.6	73.9	59.0	170
165	180	84.8	52.2		88.2	72.9	57.6	165
160	174	83.3	51.3		87.7	72.0	56.1	160
155	169	81.7	50.5		87.2	70.9	54.6	155
150	164	80.1	49.5		86.6	69.8	52.9	150
145	159	78.3	48.6		86.1	68.6	51.1	145
140	154	76.4	47.6		85.5	67.4	49.2	140
135	149	74.4	46.5	99.3	84.8	66.0	47.2	135
130	143	72.2	45.4	98.1	84.1	64.6	45.0	130
125	138	69.9	44.3	96.7	83.3	63.0	42.7	125
120	133	67.4	43.0	95.3	82.5	61.3	40.2	120
115	128	64.7	41.7	93.8	81.7	59.5	37.5	115
110	123	61.8	40.3	92.1	80.7	57.6	34.5	110
105	118	58.6	38.8	90.3	79.7	55.4	31.3	105
100	113	55.1	37.3	88.3	78.5	53.1	27.8	100
95	109	51.3	35.5	86.1	77.3	50.5	24.0	95
90	104	47.1	33.7	83.7	75.9	47.7	19.7	90
85	99	42.4	31.7	81.1	74.4	44.6	15.0	85
80	94	37.1	29.5	78.1	72.7	41.1	9.8	80
75	89	31.2	27.2	74.7	70.8	37.1		75

The non-austenitic steels included carbon, alloy and tool steels in the as-forged, annealed, normalized, and quenched and tempered conditions.

Hardness Conversion Chart for Austenitic Stainless Steel Sheet (Rockwell C Range)

HRC	HRA	HR15N	HR30N	HR45N
48	74.4	84.1	66.2	52.1
47	73.9	83.6	65.3	51.0
46	73.4	83.1	64.5	49.8
45	72.9	82.6	63.6	48.7
44	72.4	82.1	62.8	47.5
43	71.9	81.6	61.8	46.5
42	71.4	81.1	61.0	45.3
41	70.9	80.5	60.1	44.2
40	70.4	80.0	59.2	43.0
39	69.9	79.5	58.4	41.9
38	69.4	79.0	57.5	40.7
37	68.8	78.5	56.6	39.6
36	68.3	78.0	55.7	38.4
35	67.8	77.5	54.9	37.3
34	67.3	77.0	54.0	36.1
33	66.8	76.5	53.1	35.0
32	66.3	75.9	52.3	33.9
31	65.8	75.4	51.4	32.7
30	65.3	74.9	50.5	31.6
29	64.8	74.4	49.6	30.5
28	64.3	73.9	48.8	29.3
27	63.8	73.4	47.9	28.2
26	63.3	72.9	47.0	27.0
25	62.8	72.4	46.2	25.9
24	62.3	71.9	45.3	24.8
23	61.8	71.3	44.4	23.6
22	61.3	70.8	43.5	22.5
21	60.8	70.3	42.7	21.3
20	60.3	69.8	41.8	20.2

The austenitic stainless steel sheet included in the original testing was as follows: Types 201, 202, 301, 302, 304, 304L, 305, 316, 316L, 321 and 347.

Hardness Conversion Chart for Austenitic Stainless Steel Sheet (Rockwell B Range)

HRB	HRA	HRF	HR15T	HR30T	HR45T
100	61.5		91.5	80.4	70.2
99	60.9		91.2	79.8	69.2
98	60.3		90.8	79.1	68.2
97	59.7		90.4	78.4	67.2
96	59.1		90.1	77.7	66.1
95	58.6		89.7	77.0	65.1
94	58.0		89.3	76.3	64.1
93	57.4		88.9	75.6	63.1
92	56.8		88.6	74.9	62.1
91	56.2		88.2	74.2	61.1
90	55.6		87.8	73.5	60.1
89	55.0		87.5	72.8	59.0
88	54.5		87.1	72.1	58.0
87	53.9		86.7	71.4	57.0
86	53.3		86.4	70.7	56.0
85	52.7		86.0	70.0	55.0
84	52.1		85.6	69.3	54.0
83	51.5		85.2	68.6	52.9
82	50.9		84.9	67.9	51.9
81	50.4		84.5	67.2	50.9
80	49.8		84.1	66.5	49.9
79	49.2	99.6	83.8	65.8	48.9
78	48.6	99.0	83.4	65.1	47.9
77	48.0	98.3	83.0	64.5	46.8
76	47.4	97.6	82.6	63.7	45.8
75	46.9	96.9	82.3	63.1	44.8
74	46.3	96.2	81.9	62.4	43.8
73	45.7	95.6	81.5	61.7	42.8
72	45.1	94.9	81.2	61.0	41.8
71	44.5	94.2	80.8	60.3	40.7
70	43.9	93.5	80.4	59.6	39.7
69	43.4	92.9	80.1	58.9	38.7
68	42.8	92.2	79.7	58.2	37.7
67	42.2	91.5	79.3	57.5	36.7
66	41.6	90.8	78.9	56.8	35.7
65	41.0	90.1	78.6	56.1	34.7
64	40.4	89.5	78.2	55.4	33.6
63	39.8	88.8	77.8	54.7	32.6
62	39.3	88.1	77.5	54.0	31.6
61	38.7	87.4	77.1	53.3	30.6
60	38.1	86.8	76.7	52.6	29.6

The austenitic stainless steel sheet included in the original testing was as follows: Types 201, 202, 301, 302, 304, 304L, 305, 316, 316L, 321 and 347.

Hardness Conversion Chart for Nickel and High-Nickel Alloys

HV	HK	HRA	HRB	HRC	HRD	HRE	HRF	HRG	HRK	HR15N	HR30N	HR45N	HR15T	HR30T	HR45T	HBS
520		75.4		50.0	63.1					85.5	68.2	54.7				
500		74.8		48.9	62.2					84.9	67.1	53.3				
480		74.2		47.6	61.2					84.3	66.0	51.9				449
460		73.6		46.3	60.2					83.6	64.9	50.3				432
440		72.9		44.8	59.1					82.9	63.6	48.6				414
420		72.1		43.3	57.9					82.1	62.3	46.8				397
400		71.3		41.6	56.6					81.3	60.8	44.9				379
380	433	70.4		39.8	55.2					80.4	59.3	42.8				361
360	411	69.4		37.8	53.7					79.5	57.6	40.6				343
340	388	68.3		37.8	53.7					78.4	55.7	38.1				325
320	365	67.2		33.3	50.3					77.2	53.7	35.4	94.9	86.3	77.4	307
300	342	65.9		30.7	48.4					76.0	51.5	32.5	94.4	85.2	75.9	289
280	320	64.5		27.9	46.2			90.0		74.5	49.0	29.2	93.7	84.0	74.2	271
260	297	62.8		24.6	43.7			86.7		72.9	46.3	25.5	93.0	82.6	72.2	252
240	274	61.0	99.0	21.0	41.0			82.9		71.2	43.1	21.5	92.1	80.9	69.9	234
220	251	59.0	96.1		37.9			78.3		69.1	39.6	16.8	91.0	78.9	67.1	215
200	228	56.6	92.5		34.3			72.8	96.9	66.8	35.6	11.4	89.8	76.5	63.8	196
195	223	55.9	91.5		33.4			71.2	96.0	66.1	34.4	10.0	89.5	75.8	62.8	191
190	217	55.3	90.5		32.3			69.6	95.0	65.4	33.3	8.4	89.1	75.1	61.8	187
185	211	54.5	89.4		31.3			67.9	94.0	64.7	32.1	6.8	88.7	74.4	60.8	182
180	206	53.8	88.2		30.2			66.1	93.0	64.0	30.8	5.2	88.3	73.6	59.7	177
175	200	53.0	87.0		29.0			64.2	91.9	63.2	29.5		87.9	72.8	58.5	172
170	194	52.2	85.7		27.8			62.1	90.7	62.4	28.1		87.4	71.9	57.2	167
165	189	51.4	84.3		26.6			60.0	89.4	61.6	26.7		86.9	71.0	55.9	163
160	183	50.5	82.9		25.3			57.7	88.1				86.4	70.0	54.4	158
155	177	49.6	81.3		23.9			55.2	86.7				85.8	68.9	52.9	153
150	171	48.6	79.6		22.4			52.7	85.2				85.2	67.8	51.3	148
145	166	47.6	77.9		20.9			49.9	83.5				84.6	66.6	49.5	143
140	160	46.5	75.9			99.4	99.5	46.9	81.8				83.9	65.3	47.6	139
135	154	45.3	73.9			98.1	98.3	43.7	79.9				83.2	63.9	45.6	134
130	149	44.1	71.7			96.7	97.0	40.3	77.9				82.4	62.4	43.4	129
125	143	42.8	69.3			95.2	95.7	36.5	75.8				81.6	60.8	41.0	124
120	137	41.4	66.7			93.5	94.2	32.5	73.4				80.7	59.1	38.4	119
115	132	40.0	63.9			91.8	92.5		70.9				79.7	57.1	35.5	114
110	126		60.9			89.8	90.8		68.1				78.6	55.1	32.4	110
105	120		57.5			87.7	88.8		65.0				77.4	52.8	28.9	105
100	115		53.8			85.3	86.7		61.7				76.1	50.3	25.0	100
95	109		49.8			82.7	84.4		58.0				74.7	47.5	20.7	95
90	103		45.2			79.8	81.8		53.8				73.1	44.4	15.9	90
85	97		40.2			76.5	78.8		49.2				71.2	40.9	10.4	85
80	92		34.5			72.9	75.6		44.0				69.2	37.0		80
75	86		28.0			68.8	71.8		38.2				66.9	32.6		75

Hardness Conversion Chart for Cartridge Brass

<i>HV</i>	<i>HRB</i>	<i>HRF</i>	<i>HR15T</i>	<i>HR30T</i>	<i>HR45T</i>	<i>HBS</i>
195	93.4	109.8	89.9	77.0	65.6	169
190	92.2	109.2	89.6	76.3	64.5	164
185	90.9	108.5	89.3	75.6	63.3	160
180	89.6	107.8	89.0	74.9	62.1	156
175	88.2	107.0	88.6	74.1	60.8	152
170	86.7	106.2	88.3	73.3	59.5	148
165	85.2	105.4	87.9	72.4	58.1	143
160	83.6	104.6	87.4	71.5	56.6	139
155	82.0	103.6	87.0	70.5	55.0	135
150	80.2	102.7	86.5	69.5	53.4	131
145	78.3	101.7	85.9	68.4	51.7	127
140	76.4	100.6	85.4	67.2	49.8	122
135	74.3	99.4	84.8	65.9	47.9	118
130	72.1	98.2	84.1	64.5	45.8	114
125	69.8	96.9	83.4	63.0	43.6	110
120	67.3	95.5	82.6	61.4	41.2	106
115	64.6	94.0	81.7	59.6	38.6	101
110	61.7	92.4	80.7	57.7	35.7	97
105	58.5	90.6	79.7	55.6	32.6	93
100	55.1	88.7	78.5	53.2	29.2	89
95	51.4	86.6	77.2	50.7	25.3	85
90	47.3	84.3	75.8	47.8	21.0	80
85	42.7	81.8	74.1	44.6	16.0	76
80	37.6	78.9	72.3	41.1	10.0	72
75	31.9	75.7	70.3	37.0		68
70	25.3	72.1	68.0	32.4		63
65	17.5	67.9	65.4	27.0		59
60		63.0	62.4	20.7		55
55		57.2	59.1	13.3		51
50		50.1	55.4			47
45		41.0				43

Hardness Conversion Chart for Copper

<i>HV</i>	<i>HK</i>	<i>HRB</i>	<i>HRF</i>	<i>HR15T</i>	<i>HR30T</i>	<i>HR45T</i>	<i>HBS</i>
126	133	66.6	97.9	87.1	68.7	48.0	118
124	131	65.2	97.2	86.7	67.7	46.7	116
122	129	63.8	96.4	86.4	66.8	45.3	113
120	127	62.3	95.7	86.0	65.8	43.8	111
118	125	60.7	94.9	85.6	64.8	42.4	109
116	122	59.0	94.0	85.2	63.7	40.9	106
114	120	57.3	93.1	84.8	62.6	39.3	104
112	118	55.4	92.2	84.3	61.4	37.7	102
110	116	53.5	91.2	83.8	60.2	36.0	100
108	114	51.5	90.2	83.3	58.9	34.3	97
106	111	49.4	89.1	82.8	57.6	32.5	95
104	109	47.2	87.9	82.2	56.3	30.6	93
102	107	44.9	86.7	81.5	54.8	28.7	91
100	104	42.5	85.5	80.8	53.4	26.7	88
98	102	39.9	84.1	80.2	51.8	24.6	86
94	100	37.3	82.7	79.4	50.2	22.4	84
96	98	34.5	81.2	78.6	48.5	20.0	82
92	95	31.7	79.7	77.7	46.8	17.6	80
90	93	28.7	78.0	76.7	44.9	15.1	77
88	91	25.6	76.3	75.7	43.0	12.4	75
86	88	22.5	74.5	74.6	41.1		73
84	86	19.2	72.6	73.4	39.0		71
82	83	15.8	70.6	72.1	36.8		69
80	81	12.4	68.5	70.6	34.6		67
78	79	8.8	66.3	69.1	32.3		64
76	76		64.1	67.5	29.8		62
74	74		61.8	65.7	27.3		60
72	71		59.3	63.8	24.7		58
70	69		56.8	61.8	21.9		56
68	66		54.3	59.7	19.0		54
66	64		51.6	57.5	16.0		52
64	61		48.8	55.2	12.9		50
62	59		46.0	52.9	8.2		47
60	56		43.1	50.5			45
58	53		40.1	48.1			43
56	51		36.9	45.6			41
54	48		33.7	43.1			
52	45		30.3	40.6			

The copper included in the original testing was UNS C10200 to C14200 inclusive. The conversions are listed for strip 0.040 in (1.02 mm) or greater in thickness.

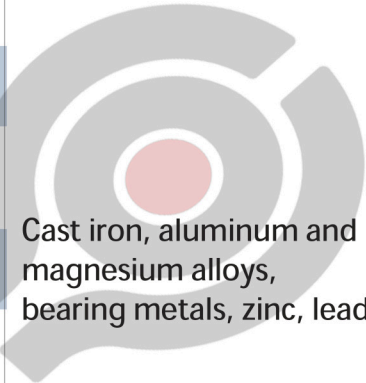
Hardness Conversion Chart for Wrought Aluminum Products

<i>HV</i>	<i>HRB</i>	<i>HRE</i>	<i>HRH</i>	<i>HR15T</i>	<i>HR30T</i>	<i>HR15W</i>	<i>HBS</i>
190	91.8			89.2	77.2	95.1	161
185	90.7			89.0	76.4	94.8	156
180	89.5			88.7	75.5	94.6	152
175	88.2			88.5	74.6	94.2	148
170	86.8			88.2	73.7	94.0	144
165	85.3			87.9	72.6	93.7	140
160	83.7			87.6	71.5	93.3	136
155	81.9			87.2	70.4	93.0	132
150	79.9			86.8	69.1	92.7	128
145	77.8			86.4	67.8	92.4	123
140	75.4			86.0	66.5	92.0	119
135	72.8			85.5	65.0	91.6	115
130	69.9	99.6		84.9	63.5	91.3	111
125	66.7	98.6		84.3	61.9	90.9	107
120	63.3	97.4		83.5	60.2	90.4	103
115	59.6	96.2		82.9	58.4	90.0	99
110	55.6	94.8		82.0	56.6	89.5	95
105	51.3	93.2		81.0	54.7	89.0	90
100	46.9	91.3	107.3	79.9	52.7	88.5	86
95	42.3	89.2	106.3	78.7	50.7	87.9	82
90	37.6	86.7	105.0	77.3	48.5	87.3	78
85	32.8	83.8	103.7	75.8	46.3	86.6	74
80	27.9	80.4	102.0	74.1	44.0	85.9	70
75		76.5	100.2	72.2		85.1	66
70		72.2	98.1	70.3		84.1	62
65		67.5	95.7	68.3		83.1	57
60		62.6	93.0	66.2		81.8	53
55		57.6	90.1	64.0		80.4	49
50		52.6	87.0	61.8		78.7	45
45		47.4	83.7	59.5		76.9	41

Common Applications and Nomenclature for Hardness Tests

Test	Symbol	Indenter	Test Force (kg)	Indentation depth (mm) *	Application
Rockwell A	HRA	diamond	60	(100 - HRA value) / 500	Very hard materials, cemented carbides
Rockwell B	HRB	$\frac{1}{16}$ " ball	100	(130 - HRB value) / 500	Low strength steel, copper alloys, aluminum alloys, malleable iron
Rockwell C	HRC	diamond	150	(100 - HRC value) / 500	High strength steel, titanium, pearlitic malleable iron
Rockwell D	HRD	diamond	100	(100 - HRD value) / 500	High strength steel, thin steel
Rockwell E	HRE	$\frac{1}{8}$ " ball	100	(130 - HRE value) / 500	Cast iron, aluminum and magnesium alloys
Rockwell F	HRF	$\frac{1}{16}$ " ball	60	(130 - HRF value) / 500	Annealed copper alloys, thin soft metals
Rockwell G	HRG	$\frac{1}{16}$ " ball	150	(130 - HRG value) / 500	Phosphor bronze, beryllium copper, malleable irons**
Rockwell H	HRH	$\frac{1}{8}$ " ball	60	(130 - HRH value) / 500	Aluminum, zinc, lead
Rockwell K	HRK	$\frac{1}{8}$ " ball	150	(130 - HRK value) / 500	Bearing metals and other very soft or thin materials, including plastics. Use smallest ball and heaviest load that do not give anvil effect.
Rockwell L	HRL	$\frac{1}{4}$ " ball	60	(130 - HRL value) / 500	
Rockwell M	HRM	$\frac{1}{4}$ " ball	100	(130 - HRM value) / 500	
Rockwell P	HRP	$\frac{1}{4}$ " ball	150	(130 - HRP value) / 500	
Rockwell R	HRR	$\frac{1}{2}$ " ball	60	(130 - HRR value) / 500	
Rockwell S	HRS	$\frac{1}{2}$ " ball	100	(130 - HRS value) / 500	
Rockwell V	HRV	$\frac{1}{2}$ " ball	150	(130 - HRV value) / 500	
Superficial Rockwell N	HR15N	diamond	15	(100 - HR15N value) / 1000	Cemented carbides, thin steel and case hardened steel, hard cast irons, titanium, and other materials harder than 100HRB
Superficial Rockwell N	HR30N	diamond	30	(100 - HR30N value) / 1000	
Superficial Rockwell N	HR45N	diamond	45	(100 - HR45N value) / 1000	
Superficial Rockwell T	HR15T	$\frac{1}{16}$ " ball	15	(100 - HR15T value) / 1000	Copper alloys, phosphor bronze, soft steels, aluminum alloys, malleable iron, thin soft sheet metals
Superficial Rockwell T	HR30T	$\frac{1}{16}$ " ball	30	(100 - HR30T value) / 1000	
Superficial Rockwell T	HR45T	$\frac{1}{16}$ " ball	45	(100 - HR45T value) / 1000	

Common Applications and Nomenclature for Hardness Tests

Test	Symbol	Indenter	Test Force (kg)	Indentation depth (mm) *	Application
Superficial Rockwell W	HR15W	1/8" ball	15	(100 - HR15W value) / 1000	 Cast iron, aluminum and magnesium alloys, bearing metals, zinc, lead
Superficial Rockwell W	HR30W	1/8" ball	30	(100 - HR30W value) / 1000	
Superficial Rockwell W	HR45W	1/8" ball	45	(100 - HR45W value) / 1000	
Superficial Rockwell X	HR15X	1/4" ball	15	(100 - HR15X value) / 1000	
Superficial Rockwell X	HR30X	1/4" ball	30	(100 - HR30X value) / 1000	
Superficial Rockwell X	HR45X	1/4" ball	45	(100 - HR45X value) / 1000	
Superficial Rockwell Y	HR15Y	1/2" ball	15	(100 - HR15Y value) / 1000	
Superficial Rockwell Y	HR30Y	1/2" ball	30	(100 - HR30Y value) / 1000	
Superficial Rockwell Y	HR45Y	1/2" ball	45	(100 - HR45Y value) / 1000	
Vickers - "Macro"	HV	diamond	1-100	diagonal length in mm / 7	A wide range of materials
Vickers - "Micro"	HV	diamond	.005 to 1	diagonal length in mm / 7	A wide range of materials
Knoop	HK	diamond	.005 to 1	diagonal length in mm/ 30	A wide range of materials, case depth determination

**It is possible to determine the minimum recommended thickness of the test piece using the indentation depth. Rule of thumb is that the thickness should exceed 10 times the depth of the indentation with a diamond indenter and 15 times the depth of the indentation with a ball indenter.*

EXAMPLE: A hardness reading of HRB 43 is observed

$$t = (130 - HRB) / 500$$

$$t = (130 - 43) / 500$$

$$t = 0.174 \text{ mm or } 0.0071 \text{ in}$$

Test Piece thickness should be 15 x t or 2.61 mm (0.1in)

***Upper limit is 92 HRG to avoid possible flattening of the ball.*