

ISO 6508-1 Rockwell Hardness Test -- Test Method
 ISO 6507-1 Vickers Hardness Test -- Test Method
 ISO 6506-1 Brinell Hardness Test -- Test Method

Rockwell Hardness Test ISO6508-1 JIS Z 2245

Calculation Formulae

Rockwell scales A/C/D $HR = 100 - \frac{h}{0.002}$

Rockwell scales B/E/F/G/H/K $HR = 130 - \frac{h}{0.002}$

Rockwell Superficial scales N/T $HR = 100 - \frac{h}{0.001}$

h = Permanent indentation depth (mm).
 h1 = Indentation depth produced by the preliminary test force.
 h2 = Indentation depth produced by the test force.
 h3 = Depth of indentation after unloading the test force.
 d = Indentation diameter.

Indentation Shape

Notation Method

64 HRB W

- Ball material identifier (when a ball indenter is used).
- Steel ball indenter: S / Tungsten carbide indenter: W
- Hardness scale identifier (scale "B" in this case).
- Value of Rockwell hardness.

Rockwell Hardness Scales

Preliminary test force 98.07N

Scale	Indenter	Test force(N)	Application
A	Diamond**	588.4	HRA: Tungsten carbide and thin age-hardening steel or thinner surface layer than is HRC testable. Less stress and damage than with HRC. Tungsten carbide.
D	Diamond**	980.7	
C		1471	HRB: Soft mild steel (sheet metal), non-ferrous metals.
F	Ball with a diameter of 1.5875mm	588.4	
B		980.7	HRC: Tungsten carbide and age-hardening steel (tools, high-strength mild steel).
G	Ball with a diameter of 3.175mm	1471	
H	Ball with a diameter of 588.4	588.4	HRD: Surface-hardened parts of average hardness.
E	Ball with a diameter of 980.7	980.7	
K	Ball with a diameter of 1471	1471	HRE: Cast iron, aluminum alloys, magnesium alloys, bearing metals.
*L	Ball with a diameter of 588.4	588.4	
*M	Ball with a diameter of 980.7	980.7	HRF: Cold rolled sheet metal, annealed bronze and copper.
*P	Ball with a diameter of 1471	1471	
*R	Ball with a diameter of 588.4	588.4	HRG: Phosphor bronze, beryllium copper, soft malleable cast iron.
*S	Ball with a diameter of 980.7	980.7	
*V	Ball with a diameter of 12.7mm	1471	HRK: Bearing metals and similar.

Rockwell Superficial Hardness Scales

Preliminary test force 29.42N

Scale	Indenter	Test force(N)	Application
15N	Diamond**	147.1	HR15N, HR30N, HR45N: Steels according to HRA, HRD and HRC for thin parts or thin hardened layers.
30N	Diamond**	294.2	
45N	Diamond**	441.3	
15T	Ball with a diameter of 1.5875mm	147.1	HR15T, HR30T, HR45T: Soft steel and non-ferrous metals like HRF and HRB, in case of thin parts (e.g. deep-drawn sheet metal)
30T	Ball with a diameter of 3.175mm	294.2	
45T	Ball with a diameter of 4.7625mm	441.3	
*15W	Ball with a diameter of 1.5875mm	147.1	HR15W, HR30W, HR45W: Cast iron, aluminum alloys, magnesium alloys, bearing metals.
*30W	Ball with a diameter of 3.175mm	294.2	
*45W	Ball with a diameter of 4.7625mm	441.3	
*15X	Ball with a diameter of 1.5875mm	147.1	HR15X, HR30X, HR45X: Steel and non-ferrous metals like HRF and HRB, in case of thin parts (e.g. deep-drawn sheet metal)
*30X	Ball with a diameter of 3.175mm	294.2	
*45X	Ball with a diameter of 4.7625mm	441.3	
*15Y	Ball with a diameter of 1.5875mm	147.1	HR15Y, HR30Y, HR45Y: Steel and non-ferrous metals like HRF and HRB, in case of thin parts (e.g. deep-drawn sheet metal)
*30Y	Ball with a diameter of 3.175mm	294.2	
*45Y	Ball with a diameter of 4.7625mm	441.3	

* Not part of ISO6508-1

** Cone angle of the tip: 120°, Radius of curvature of the tip: 0.2mm

Hardness Test Methods and Applications

Hardness Test Method

Often-used range

Special heat treatment, thin coating, surface-modification layer, elastic material, etc. (example: titanium system coating, DLC treatment, semiconductor-field material)

Instrumented Indentation Test (IIT)
 (Commonly known as "Nanoindentation" - specimen thickness: approx. 10µm or less)
 A relatively new method based on recording indenter force against penetration depth throughout the load-dwell-unload cycle, and calculating hardness and stiffness directly from this data. Distances and forces are very small and resolutions are in the nanometer and micronewton ranges.

Standardized evaluation method of heat treatment including carburizing, decarburizing and nitriding.
 Frequently used for various applications including small parts and topical assessment.

Integrity assessment of high-frequency quenching, flame quenching and welded parts.

Macroscopic assessment from material to deeply-heat-treated objects
 Frequently used for various applications.

Intensity assessment of metallic casting and foundry pieces.

Brinell Hardness Test ISO6506-1 JIS Z 2243

Calculation Formulae

$$HBW = k \frac{F}{S} = 0.102 \frac{2F}{\pi D(D - \sqrt{D^2 - d^2})}$$

k = Constant. F = Test force (N). S = Surface area of indentation.
 D = Diameter of the ball (mm).
 d = Arithmetic mean (mm) of the indentation diameters measured at 90° (d1, d2).
 h = Depth of indentation.

Indentation Shape

Minimum Allowable Indentation Spacing

Indentation center-to-center distance: 3d or more
 Specimen-edge to indentation-center distance: 2.5d or more

Thickness of Specimen or Plating

Thickness: 8h or more

Notation Method

600 HBW 1 / 30 / 20

- Dwell time of the test force (20s). If not within the specified range (10s to 15s) Approximate kgf equivalent value of applied test force where (30 kgf = 294.2N).
- Diameter of the ball (mm).
- Referring to the material of the indenter. Steel indenter: S / Tungsten carbide indenter: W
- Hardness scale identifier (scale "B" in this case).
- Value of Brinell hardness.

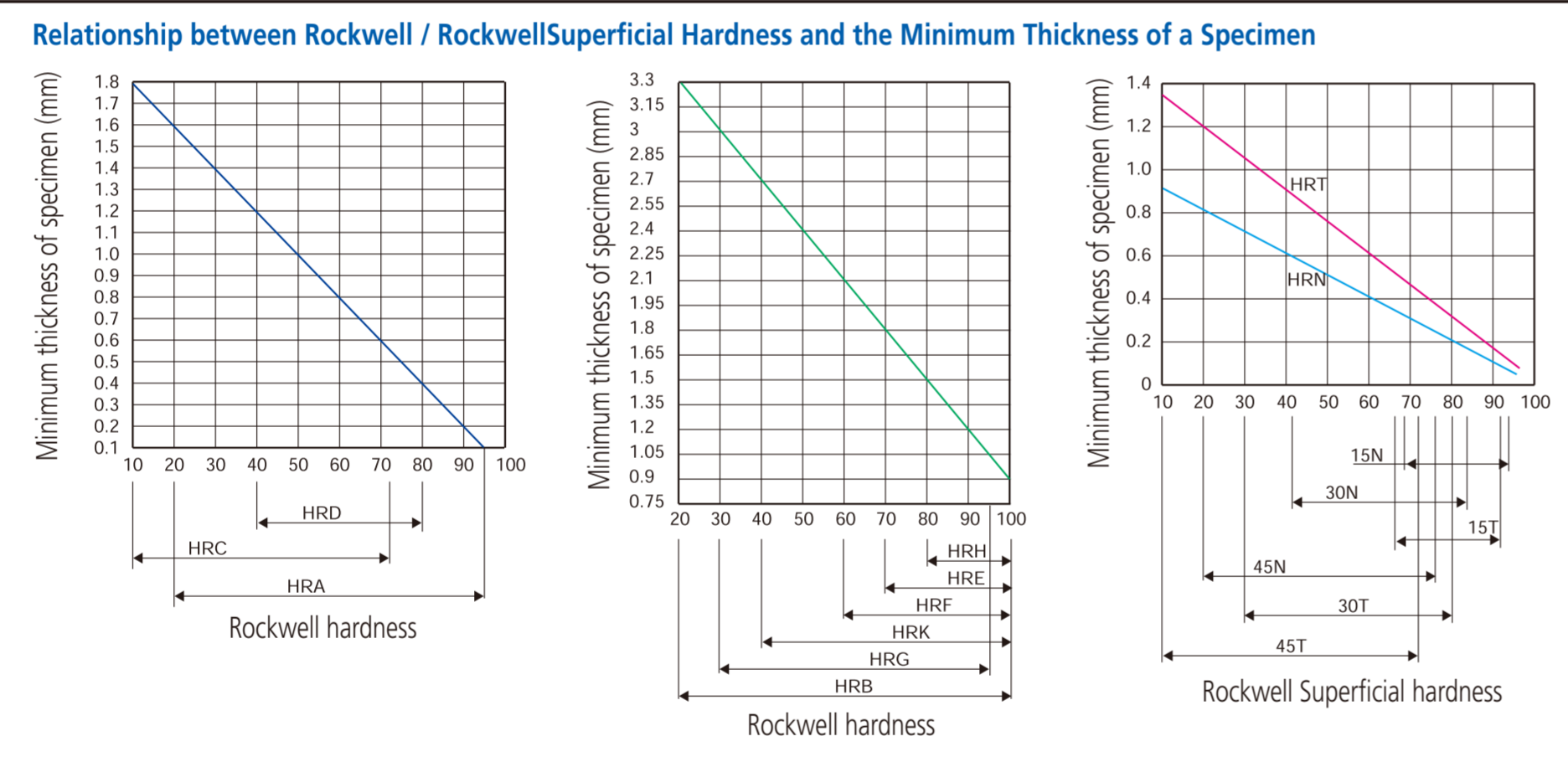
Rockwell Hardness Test ISO6508-1 JIS Z 2245

Indentation Center-to-Center Distance Specimen-Edge to Indentation-Center Distance

Indentation center-to-center distance: 4d or more (has to be 2mm or more)
 Specimen-edge to indentation-center distance: 2.5d or more (has to be 1mm or more)

Thickness of Specimen or Plating

Thickness
 Diamond indenter: 10h or more
 Ball indenter: 15h or more



Hardness Conversion Table ISO18265 (excerpted)

Table for unalloyed and low alloy steels and cast iron

Tensile strength MPa	Vickers hardness HV10	Brinell hardness HB	HRB	HRF	HRC	HRA	HRD	HR15N	HR30N	HR45N
575	180	171	87.1	107.2						
610	190	181	89.5	108.7						
640	200	190	91.5	110.1						
675	210	199	93.5	111.3						
705	220	209	95.0	112.4						
740	230	219	96.7	113.4						
770	240	228	98.1	114.3	20.3	60.7	40.3	69.6	41.7	19.9
800	250	238	99.5	115.1	22.2	61.6	41.7	70.6	43.4	22.2
835	260	247	(101)		24.0	62.4	43.1	71.6	45.0	24.3
865	270	257	(102)		25.6	63.1	44.3	72.6	46.4	26.2
900	280	266	(104)		27.1	63.8	45.3	73.4	47.8	27.9
930	290	276	(105)		28.5	64.5	46.5	74.2	49.0	29.5
965	300	285			29.8	65.2	47.5	74.9	50.2	31.1
995	310	295			31.0	65.8	48.4	75.6	51.3	32.5
1 030	320	304			32.2	66.4	49.4	76.2	52.3	33.9
1 060	330	314			33.3	67.0	50.2	76.8	53.6	35.2
1 095	340	323			34.4	67.6	51.1	77.4	54.4	36.5
1 125	350	333			35.5	68.1	51.9	78.0	55.4	37.8
1 155	360	342			36.6	68.7	52.8	78.6	56.4	39.1
1 190	370	352			37.7	69.2	53.6	79.2	57.4	40.4
1 220	380	361			38.8	69.8	54.4	79.8	58.4	41.7
1 255	390	371			39.8	70.3	55.3	80.3	59.3	42.9
1 290	400	380			40.8	70.8	56.0	80.8	60.2	44.1
1 320	410	390			41.8	71.4	56.8	81.4	61.1	45.3
1 350	420	399			42.7	71.8	57.5	81.8	61.9	46.4
1 385	430	409			43.6	72.3	58.2	82.3	62.7	47.4
1 420	440	418			44.5	72.8	58.8	82.8	63.5	48.4
1 455	450	428			45.3	73.3	59.4	83.2	64.3	49.4
1 485	460	437			46.1	73.6	60.1	83.6	64.9	50.4
1 520	470	447			46.9	74.1	60.7	83.9	65.7	51.3
1 555	480	456			47.7	74.5	61.3	84.3	66.4	52.2
1 595	490	466			48.4	74.9	61.6	84.7	67.1	53.1
1 630	500	475			49.1	75.3	62.2	85.0	67.7	53.9
1 665	510	485			49.8	75.7	62.9	85.4	68.3	54.7
1 700	520	494			50.5	76.1	63.5	85.7	69.0	55.6
1 740	530	504			51.1	76.4	63.9	86.0	69.5	56.2
1 775	540	513			51.7	76.7	64.4	86.3	70.0	57.0
1 810	550	523			52.3	77.0	64.8	86.6	70.5	57.8
1 845	560	532			53.0	77.4	65.4	86.9	71.2	58.6
1 880	570	542			53.6	77.8	65.8	87.2	71.7	59.3
1 920	580	551			54.1	78.0	66.2	87.5	72.1	59.9
1 955	590	561			54.7	78.4	66.7	87.8	72.7	60.5
1 995	600	570			55.2	78.6	67.0	88.0	73.2	61.2
2 030	610	580			55.7	78.9	67.5	88.2	73.7	61.7
2 070	620	589			56.3	79.2	67.9	88.5	74.2	62.4
2 105	630	599			56.8	79.5	68.3	88.8	74.6	63.0
2 145	640	608			57.3	79.8	68.7	89.0	75.1	63.5
2 180	650	618			57.8	80.0	69.0	89.2	75.5	64.1
	660				58.3	80.3	69.4	89.5	75.9	64.7
	670				58.8	80.6	69.8	89.7	76.4	65.3
	680				59.2	80.8	70.1	89.8	76.8	65.7
	690				59.7	81.1	70.5	90.1	77.2	66.2
	700				60.1	81.3	70.8	90.3	77.6	66.7
	720				61.0	81.8	71.5	90.7	78.4	67.7
	740				61.8	82.2	72.1	91.0	79.1	68.6
	760				62.5	82.6	72.6	91.2	79.7	69.4
	780				63.3	83.0	73.3	91.5	80.4	70.2
	800				64.0	83.4	73.8	91.8	81.1	71.0
	820				64.7	83.8	74.3	92.1	81.7	71.8
	840				65.3	84.1	74.8	92.3	82.2	72.2
	860				65.9	84.4	75.3	92.5	82.7	73.1
	880				66.4	84.7	75.7	92.7	83.1	73.6
	900				67.0	85.0	76.1	92.9	83.6	74.2
	920				67.5	85.3	76.5	93.0	84.0	74.8
	940				68.0	85.6	76.9	93.2	84.4	75.4

* Brinell hardness values up to 450 HB were determined using a steel ball indenter, those above this value were determined with a hardmetal ball.

Table for Cartridge brass (70 % Copper 30 % Zinc Alloy)

HV 30	HRB	HRF	HR15T	HR30T	HR45T	HB HBS10/500
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	—	74.5	62.0	156
178	89.0	—	—	—	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	55.0	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		