MATERION

TECH BRIEFS

Hardness Testing Copper Alloy Products

Indention hardness tests are the most common procedures for evaluation of the mechanical properties of copper alloy components. The tests are inexpensive, quick, easily performed and require little test material. Hardness testing is used to monitor processing operations such as cold working, solution annealing, quenching, and age hardening.

HARDNESS TEST SELECTION FOR STRIP AND THIN PRODUCTS

A number of hardness tests (Table 1) are appropriate for copper beryllium, copper nickel tin, and other high performance copper alloys, depending upon the alloy, temper (hardness), and part thickness. Refer to the appropriate ASTM standard for detailed information on test procedures and equipment calibration.

Hardness Test	ASTM Standard
Rockwell	E18
Vickers	E92
Knoop	E 384
Brinell	E10

Table 1. Hardness tests for copper alloy products

Rockwell Test

The Rockwell hardness test procedure covers thirty different tests (scales) with various loads and indenter configurations. The most common Rockwell scales, B and C, are not used for copper alloys unless the part thickness is greater than 0.04 inch (1 mm). Hardness on the B and C scales can be used as a reference, but specification of material and testing for thin product should be done on the appropriate superficial scales (N and T), or microhardness scales.

Superficial Rockwell testing on the N and T scales is done with either a 15 or 30 gram load. The minimum allowable thickness for the superficial scale depends upon the hardness; consult ASTM E18. As an approximation, use a 30 gram load for thickness greater than 0.025 inch (0.6 mm) and a 15 gram load above 0.015 inch (0.4 mm). Microindentation hardness tests (Vickers and Knoop) are used for thinner material.

Vickers and Knoop Tests

The standard Vickers test, also referred to as Diamond Pyramid Hardness (DPH) test, uses test loads between 1 and 120 kg. Loads less than 1000 grams are considered a Vickers microhardness test. The load should be selected so that the diagonal of the Vickers indentation is less than 20% of the thickness of the part.

The Knoop test is exclusively a microindentation hardness test using an elongated indenter (compared to the square Vickers indenter), which has a long diagonal seven times the short diagonal. Because of directionality of the test indenter and anisotropic properties in cold worked parts, multiple orientations of Knoop readings are usually required to obtain accurate test data. Where possible, two Knoop readings at 90° to each other should be averaged for each test. The Knoop test load is between 1 and 1000 grams. As with the Vickers microindentation hardness test for thin materials, testing should be done on a cross sectioned, metallographically polished sample at least 0.002 inch (0.05 mm) thick.

Brinell Test

The Brinell test is a large indentation test. It is **not** suitable for thin strip or wire, but is suitable for large plate, bars, rods, forgings, etc. The indenter is a ball made from either hardened steel (results designated by HBS) or tungsten carbide (results designated by HBW). Since this test produces large indentations, it is much less sensitive to local microstructural variations. This makes it ideal for materials with large particles in the microstructure, such as those found in copper nickel silicon chromium alloys. However, Brinell tests may only be run on materials thicker than 0.125 inches (3.2 mm).

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INTERPRETATION OF TEST RESULTS

Because of the relatively small volume of material affected by the hardness test, care must be taken to obtain representative test data. Several measurements should be taken to avoid a false reading caused by microstructural inconsistencies such as hard beryllide particles or grain boundaries. Hardness should be checked on cross sections when nonuniform cold work causes high surface hardness. The depth of penetration of the indenter must be less than 10% of the metal thickness, and the reading must be taken at least two indenter diameters from an edge.

The parts to be tested should be securely fixtured on the anvil. Any movement of the sample can affect the test result. For microindentation hardness testing, best results are obtained when the samples are metallographically mounted and polished.

Hardness tests are most accurate when conducted on smooth, flat surfaces. Testing on curved surfaces should be avoided if possible. For example, cylindrical objects may be tested in cross section or on a flat surface. If a test must be performed on a curved surface, use the appropriate ASTM standard to correct for the curvature. Rockwell tests will read low on convex surfaces and high on concave surfaces. The reverse is true for Vickers, Knoop, and Brinell.

Hardness readings are most accurate when taken near the center of the scale. If a reading falls near or beyond the end of the range of the scale, the measurement should be re-done using a different scale.

While hardness testing provides an indication of material strength, it is not a substitute for tensile testing. When tensile and hardness test data are both listed, tensile data is precedent and hardness data is reference. Hardness scale conversions are frequently done for convenience, but scale conversions in material properties certifications are not permitted by ASTM. Approximate hardness scale conversions provided in Table 2.

When reporting hardness values, list the hardness test scale and, if it is a variable, the test load, e.g. HR15T, HV500. Brinell tests should also report the ball diameter in mm HBS 5/3000. If a load application time other than the standard 10-15 sec is used, this should also be reported.

SAFE HANDLING OF COPPER BERYLLIUM

Handling copper beryllium in solid form poses no special health risk. Like many industrial materials, beryllium-containing materials may pose a health risk if recommended safe handling practices are not followed. Inhalation of airborne beryllium may cause a serious lung disorder in susceptible individuals. The Occupational Safety and Health Administration (OSHA) has set mandatory limits on occupational respiratory exposures. Read and follow the guidance in the Material Safety Data Sheet (MSDS) before working with this material. For additional information on safe handling practices or technical data on copper beryllium, contact Materion Brush Performance Alloys, Technical Service Department at 1-800-375-4205.

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Hardness Test Conversions								
Vickers	**Rockwell**						**Brinell**	**Knoop**
(DPH)	C	15N	30N	B	15T	30T	3000 kg HBS	
484	48	84.5	66.5				451	510
471	47	84	65.5				442	495
458	46	83.5	64.5				432	480
446	45	83	64				421	468
434	44	82.5	63				409	453
423	43	82	62				400	438
412	42	81.5	61				390	425
402	41	81	60.5				381	413
392	40	80.5	59.5				371	402
382	39	80	58.5				362	391
372	38	79.5	57.5				353	381
363	37	79	57				344	372
354	36	78.5	56				336	361
345	35	78	55				327	351
336	34	77.5	54.5				319	341
327	33	76.5	52.5				311	333
318	32	76	52				301	325
310	31	75.5	51.5				294	318
302	30	75	50.5				286	310
294	29	74.5	49.5				279	304
286	28	74	48.5				271	297
279	27	73.5	47.5				264	290
272	26	73	47				258	284
266	25	72.5	46				253	279
260	24	72	45				247	272
254	23	71.5	44				243	265
248	22	71	43				237	260
243	21	69.5	42.5				231	257
240		68.5	40.5	100	93.1	83.1	240	251
238	20	69	41.5				225	246
234		68	39.5	99	92.8	82.5	234	246
228		67.5	39	98	92.5	81.8	228	241
222		67	38	97	92.1	81.1	222	236
216		66.5	37.5	96	91.8	80.4	216	231
210				95	91.5	79.8	210	226
205				94	91.2	79.1	205	221
200				93	90.8	78.4	200	216
195				92	90.5	77.8	195	211
190				91	90.2	77.1	190	206
185				90	89.9	76.4	185	201
180				89	89.5	75.8	180	196
176				88	89.2	75.1	176	192
172				87	88.9	74.4	172	188
169				86	88.6	73.8	169	184
165				85	88.2	73.1	165	180
152				84	87.9	72.4	152	176
159				83	87.6	71.8	159	173
156				82	87.3	71.1	156	170
153				81	86.9	70.4	153	167
150				80	86.6	69.7	150	164
147				79	86.3	69.1	147	161
144				78	86	68.4	144	158
141				77	85.6	67.7	141	155
139				76	85.3	67.1	139	152
137				75	85	66.4	137	150
135				74	84.7	65.7	135	147
132				73	84.3	65.1	132	145
130				72	84	64.4	130	143
127				71	83.7	63.7	127	141
125				70	83.4	63.1	125	139
123				69	83	62.4	123	137
121				68	82.7	61.7	121	135
119				67	82.4	61	119	133
117				66	82.1	60.4	117	131
116				65	81.8	59.7	116	129
114				64	81.4	59	114	127
112				63	81.1	58.4	112	125
110				62	80.8	57.7	110	124
108				61	80.5	57	108	122
107				60	80.1	56.4	107	120
106				59	79.8	55.7	106	118
104				58	79.5	55	104	117
103				57	79.2	54.4	103	115
101				56	78.8	53.7	101	114
100				66	78.5	53	100	112

Source: ASTM E 140 - Standard Hardness Converstion Tables for Metals - Tables 1 and 2

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