MATERION

GUIDE TO CLAD METALS

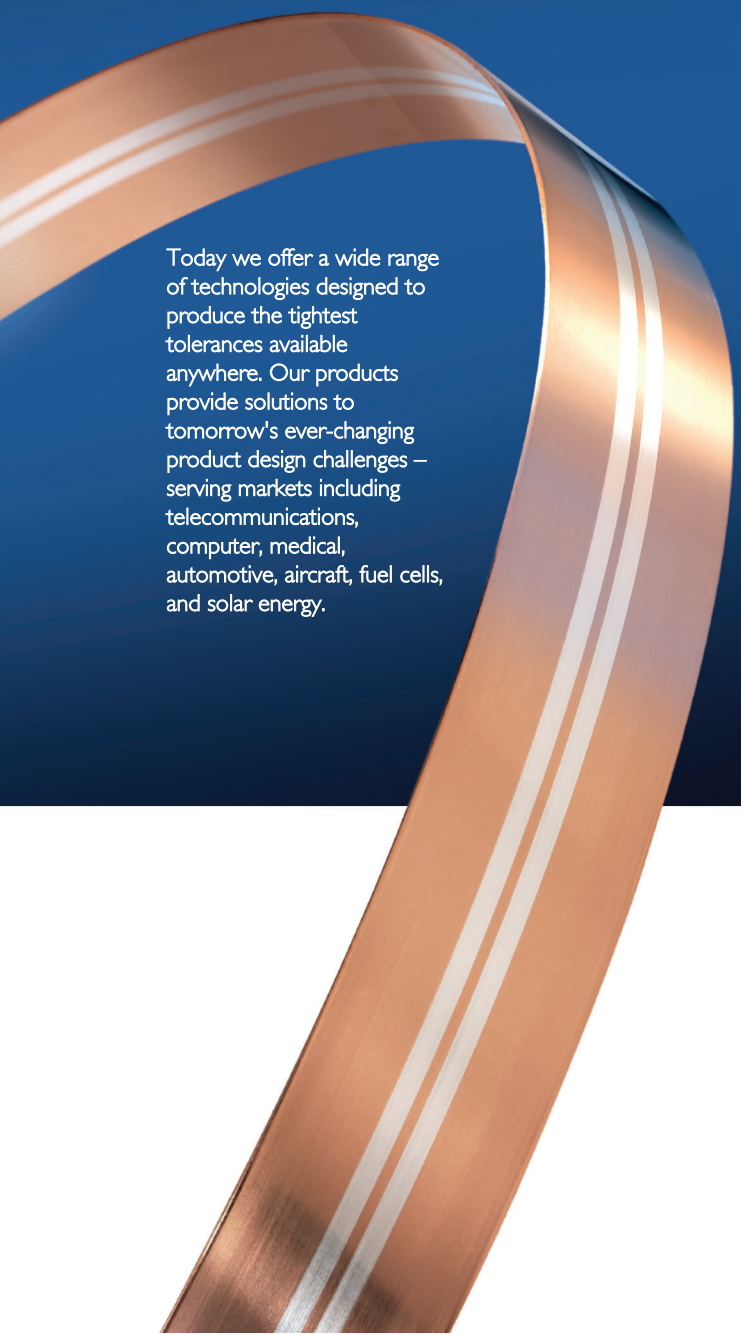
www.materion.com/cladding

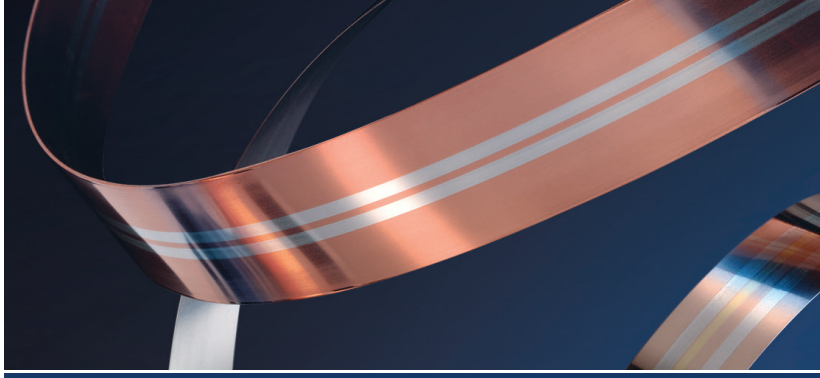
HIGH-PERFORMANCE MATERIALS

Materion is the world's leading resource for cladding, electroplating, solder coating, and other specialty strip products.

Since 1968, our cladding business has continued to pioneer state-of-the-art metal processing of more than 200 alloys – including ferrous, non-ferrous, refractory, and precious metals.

Today we offer a wide range of technologies designed to produce the tightest tolerances available anywhere. Our products provide solutions to tomorrow's ever-changing product design challenges – serving markets including telecommunications, computer, medical, automotive, aircraft, fuel cells, and solar energy.





CONTENTS

CHART FOOTNOTES

1 Lbs. per cubic inch @ 68° F (annealed)

2 Elastic modulus in tension x 10^6 P.S.I.

3 % IACS at 68°F (annealed)

4 BTU per foot per hour per °F at 68°F (annealed)

5 Inches per inch x 10-6 from 68°F to 572°F

6 Reference specification for strip

7 Ultimate tensile strength x 1000 P.S.I.

8 0.2% offset yield strength x 1000 P.S.I. Yield strengths are not used or accepted as specifications by brass mills; but, because of their usefulness, values are given here for design purpose.

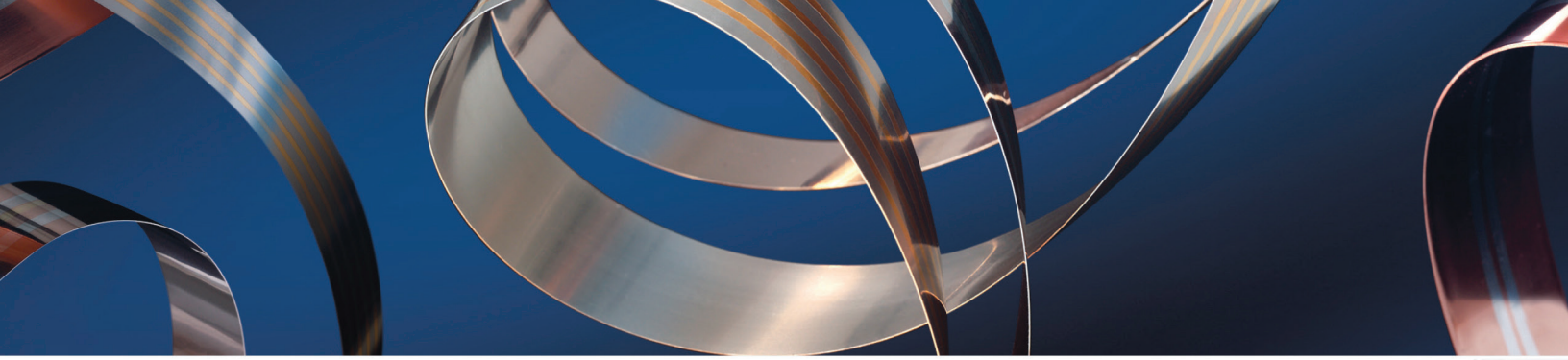
9 % elongation in 2". Elongation values vary considerably with thickness. The rolled temper data given are base on thicknesses ranging from .010" to .035" strip.

10 Approximate Vickers hardness - HV unless otherwise specified.

11 Standard heat treatment 2 hrs. at 600°F (3 hrs. @ 600°F for annealed temper)

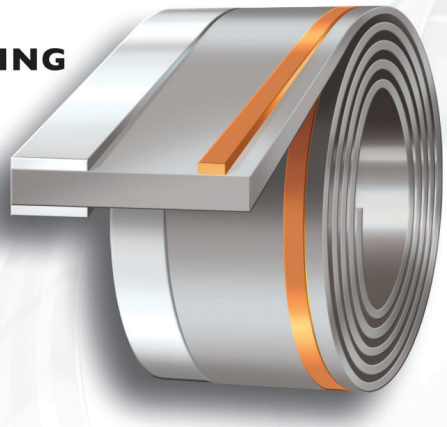
12 Standard heat treatment 2 hrs. at 700°F (2 hrs. @675°F for TS04)

NOTE: The properties on these charts are provided for reference only.

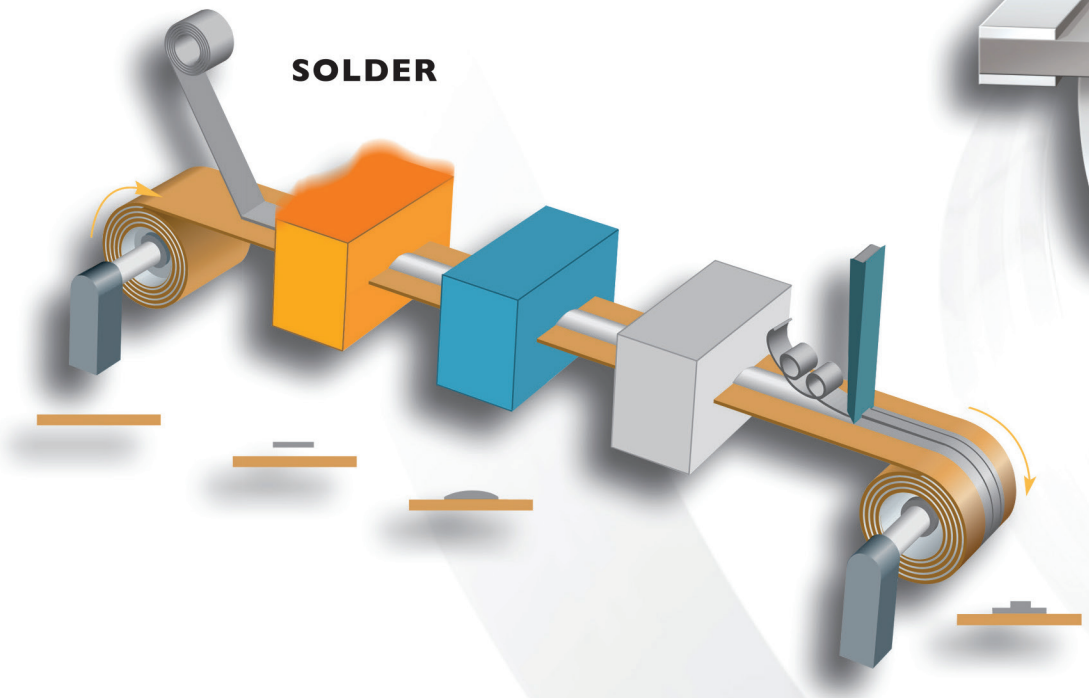


CAPABILITIES

ELECTROPLATING

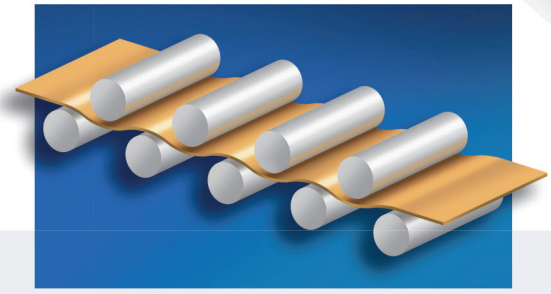


SOLDER

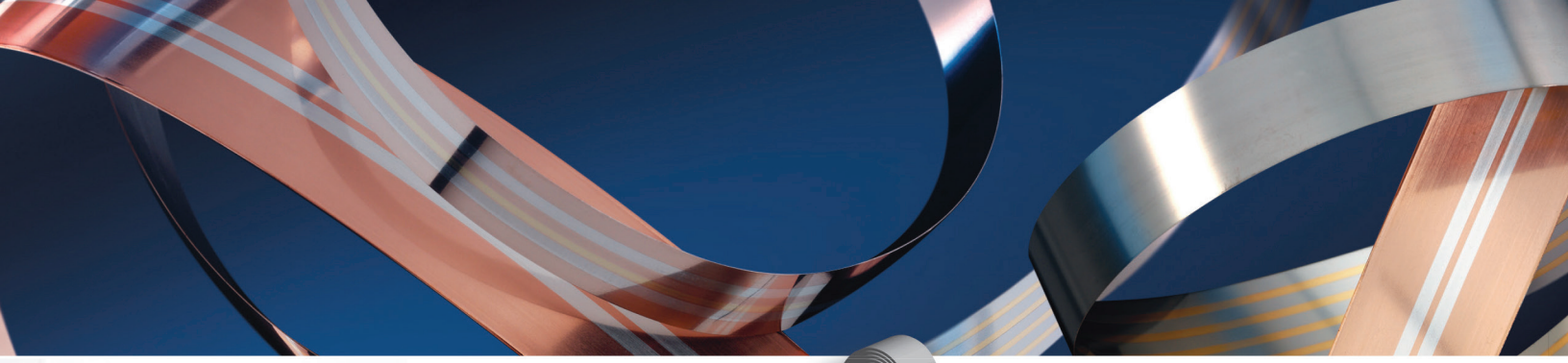


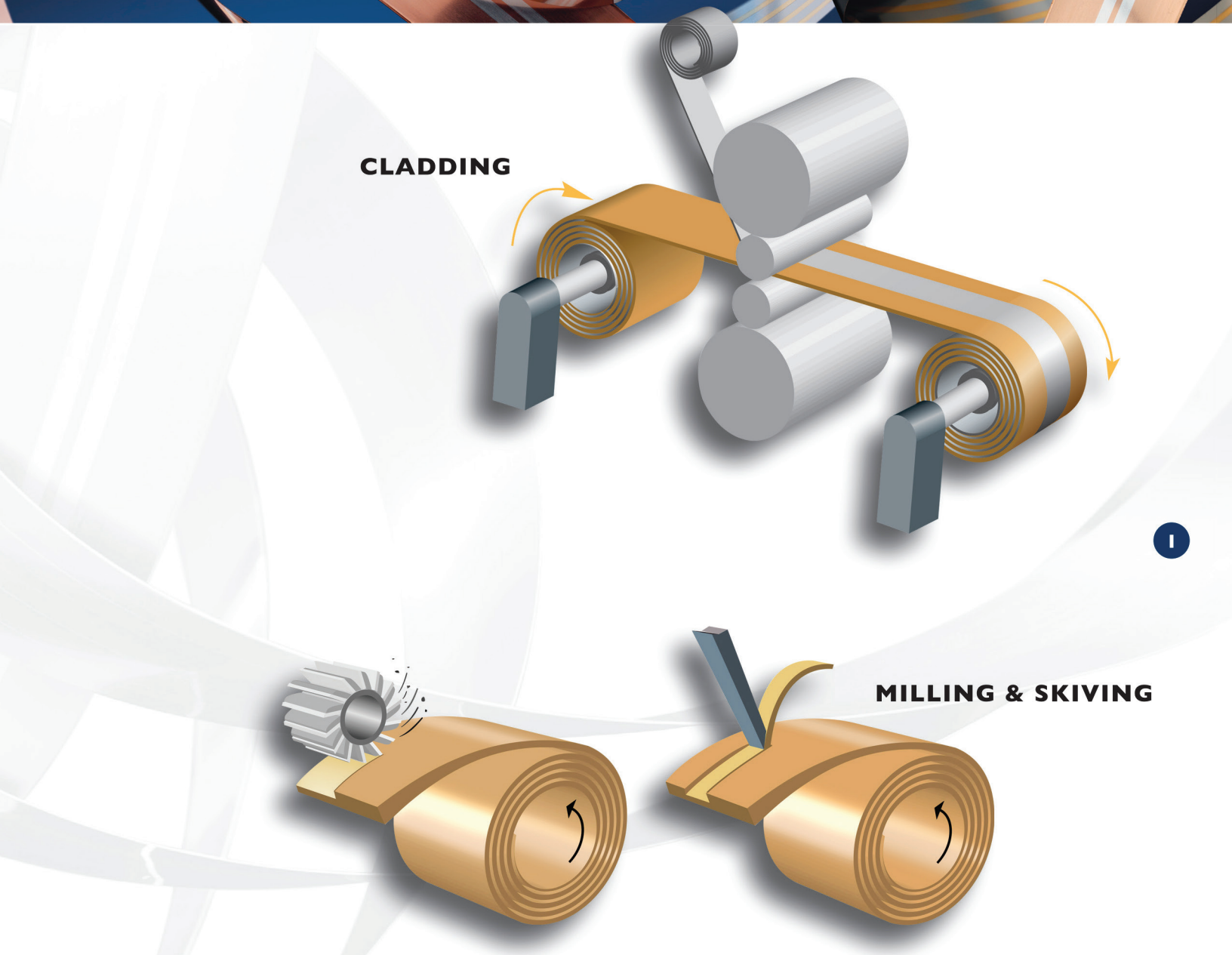
STRIP PROCESSING

- Precision Tolerancing
- Special Tempers
- Stretch Bend Leveling



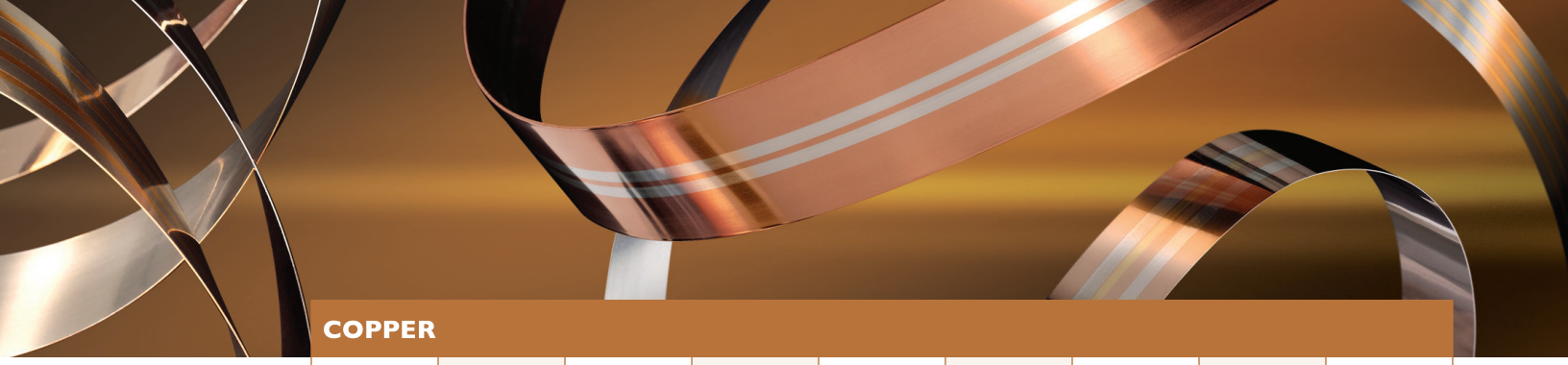
EB WELDING





CUSTOM-ENGINEERED METAL SOLUTIONS

The high-performance demands of today's markets require custom-engineered solutions. We match our leading technologies to your challenges – delivering a high-performance, cost-effective metal system. As your full-service supplier, we thrive on enhancing your product's performance while lowering your total cost.



COPPER

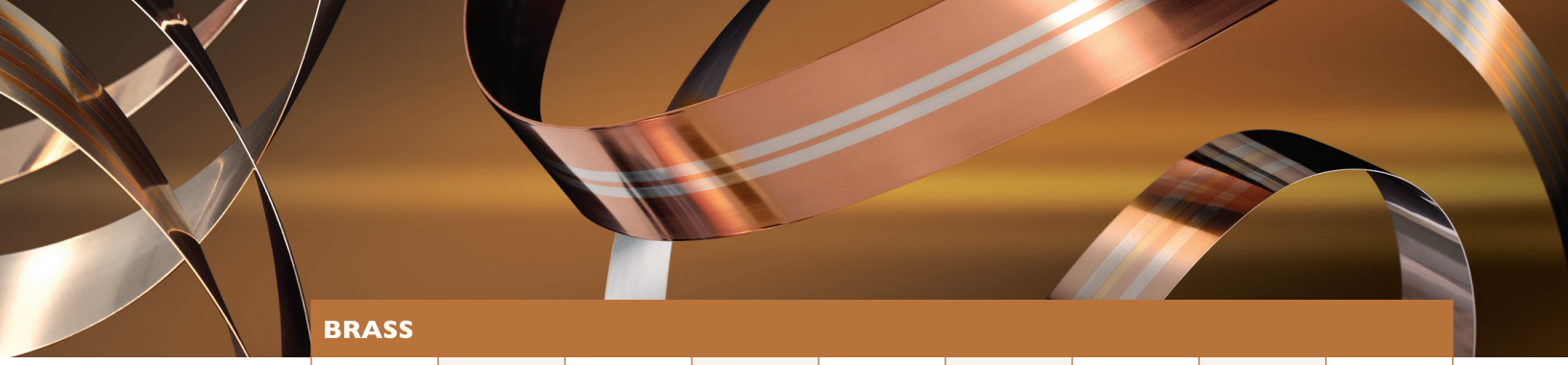
	C10200 OFHC copper 99.95 Cu 10 ppm 0 max	C10700 OFS copper 99.9Cu .085 min. Ag	C11000 ETP copper 99.9Cu	C12200 DHP copper 99.9Cu .025P	C14415 CuSn 0.15 99.85Cu .12Sn	C14530 99.95Cu .013Te .013Sn	C15100 ZHC copper 99.8Cu .15Zr	C15500 99.75Cu .11Mg .06Ag .06P	C18080 K88 99Cu .5Cr .2Ag .1Fe .1Ti .05Si
Density[1]	.323	.323	.322	.323	.321	.323	.323	.322	.320
Modulus[2]	17	17	17	17	18.5	17.4	17.5	17	19.5
Elect. Cond.[3]	101	100	100	85	86	95	95	86	80
Therm. Cond.[4]	226	224	224	196	208	208	208	200	185
Therm. Exp.[5]	9.8	9.4	9.8	9.8	9.8	9.8	9.8	9.8	9.8
ASTM[6]	B152	B152	B152	B152	B747	B888	B888	B888	
Annealed									
UTS[7]	26-38	26-38	26-38	26-38	32 nom.	34 nom.	37-42	34-43	
YS[8]	6-13	6-13	6-13	6-13	11 nom.	12 nom.	9-20	15-22	
EL[9]	20-42	20-42	20-42	20-42	40 nom.	40 nom.	35 nom.	30-42	
HV[10]	40-75	40-75	40-75	40-75	60 nom.	60 nom.	55 nom.	65 nom.	
1/4 Hard								42-50	
UTS	34-42	34-42	34-42	34-42	36-46	35-45	40-45		
YS	26-39	26-39	26-39	26-39	28 min.	26-37	26-40	33-40	
EL	13-33	13-33	13-33	13-33	9 min.	7 min.	11-25	20-28	
HV	70-95	70-95	70-95	70-95	60-90	85-105	90 nom.	95 nom.	
1/2 Hard									
UTS	37-46	37-46	37-46	37-46	43-53	40-50	43-51	45-55	
YS	30-44	30-44	30-44	30-44	36 min.	38-48	35-48	38-48	
EL	8-32	8-32	8-32	8-32	3 nom.	5 min.	3-13	13-22	
HV	85-105	85-105	85-105	85-105	85-110	95-120	105 nom.	113 nom.	
3/4 Hard									
UTS	41-50	41-50	41-50	41-50		44-54	47-56	48-58	
YS	39-48	39-48	39-48	39-48		39-51	45-55	45-54	
EL	5-24	5-24	5-24	5-24		3 min.	1-7	7-13	
HV	90-110	90-110	90-110	90-110		100-125	115 nom.	118 nom.	
Hard									TM04
UTS	43-52	43-52	43-52	43-52	52-62	47-57	53-62	56-64	71-81
YS	41-50	41-50	41-50	41-50	43 min.	43-56	51-61	50-60	65 min.
EL	3-16	3-16	3-16	3-16	3 min.	2 min.	1-5	6-12	8 nom.
HV	95-115	95-115	95-115	95-115	105-130	108-128	122 nom.	126 nom.	140-170
Extra Hard									TM08
UTS	47-56	47-56	47-56	47-56		50-60	59-65	63-72	77-87
YS	46-55	46-55	46-55	46-55		47-59	57-64	58-64	85 min.
EL	3-5	3-5	3-5	3-5		1 min.	1-3	3-7	4 nom.
HV	103-120	103-120	103-120	103-120		108-128	129 nom.	130 nom.	150-180
Spring									TR08
UTS	50-58	50-58	50-58	50-58	61-71	54-64	64-71	65-73	75-90
YS	48-57	48-57	48-57	48-57	51 min.	51-63	62-70	60-74	72 min.
EL	2-4	2-4	2-4	2-4	2 min.	1 min.	1-2	1-5	4 nom.
HV	110-126	110-126	110-126	110-126	120-140	112-130	126 nom.	135 nom.	160-190
Ex. Spring									
UTS	52 min.	52 min.	52 min.	52 min.		58 min.		68-75	
YS	51 min.	51 min.	51 min.	51 min.		56 min.		63-78	
EL	1-3	1-3	1-3	1-3		115 min.		1-4	
HV	115 min.	115 min.	115 min.	115 min.					

HIGH COPPER

	C19025	C19210	C19400	C19500	C19700
	NB109	XP10		97Cu 1.5Fe .8Co .6Sn .2P	99Cu .6Fe .2P .05Mg
	98Cu 1.0Ni \0.9Sn	99.85Cu .1Fe .03P	97.4Cu 2.35Fe .03P		
Density[1]	.322	.323	.321	.322	.321
Modulus[2]	18.8	17.2	17.5	17.3	17.2
Elect. Cond.[3]	40	91	60	50	80
Therm. Cond.[4]	100	201	150	115	185
Therm. Exp.[5]	9.7	9.7	9.7	9.6	9.6
ASTM[6]	B422		B465	B465	B465
Annealed					
UTS[7]		34-49	40-50	50-60	43-53
YS[8]		17-32	20-40	21-35	16 min.
EL[9]		25 min.	15-35	22-31	20 min.
HV[10]		70 nom.	80 nom.		
1/4 Hard					
UTS	47-69	40-55	45-60	60-72	
YS	53 nom.	20-35	40-56	45-79	
EL	15-35	15 min.	6-20	5-23	
HV	120-155	95 nom.	95-120	112-145	
1/2 Hard	HR02				
UTS	63-76	47-60	53-63	68-78	53-63
YS	66 nom.	44-59	36-58	66-76	36-60
EL	9-25	5 min.	6-15	3-9	6-29
HV	135-170	105 nom.	100-125	140-155	122-144
3/4 Hard					
UTS		52-62		75-85	
YS		60-62		72-82	
EL		4 min.		2-5	
HV		115 nom.		150-160	
Hard	HR04				
UTS	72-83	56-66	60-70	82-90	60-70
YS	76 nom.	54-66	53-65	79-87	53-68
EL	5-14	3 min.	3-8	2-3	2-12
HV	155-180	120 nom.	120-140	55-165	132-153
Extra Hard	HR06				
UTS	78-89	60-70	67-73		67-73
YS	80 nom.	58-70	64-72		64-71
EL	4 min.	2 min.	2 min.		2-10
HV	160-195	133 nom.	25-145		144-158
Spring					
UTS	84-95	64 min.	70-76	88-97	70-76
YS	87 nom.	62 min.	67-75	85-92	67-74
EL		1 nom.	1 min.	1-2	2-8
HV	175-210	150 nom.	130-150	165-175	148-164
Ex. Spring					
UTS	91-106	66 min.	73-80	97 min.	73-80
YS	97 nom.	64 min.	70-79	94 min.	70-78
EL				1-2	1 min.
HV	190 min.			180 min.	153-174

BERYLLIUM COPPER

	C17200	C17200	C17200	C17410	C17460	C17510
	Alloy 25 as rolled	Alloy 25 age hard[11]	Alloy 190 Mill Hard	Alloy 174 Mill Hard	Alloy 60 Mill Hard	Alloy 3 Mill Hard
	98Cu 1.9Be	98Cu 1.9Be	98Cu 1.9Be	99Cu 0.3Be 0.5Co	98Cu 1.2Ni 0.3Be	97.8Cu 1.8Ni .4Be
Density[1]	.298	.302	.302	.318	.318	.319
Modulus[2]	19	19	19	20	20	20
Elect. Cond.[3]	15	22	17	50	50	45 (HT)
Therm. Cond.[4]	60	60	60	135	128	140
Therm. Exp.[5]	9.9	9.7	9.7	9.8	9.8	9.8
ASTM[6]	B194	B194	B194	B768	B768	
Annealed		AT	AM			A
UTS[7]	60-78	165-195	100-110			35-55
YS[8]	30-55	140-175	70-95			20-45
EL[9]	35 min.	3-15	16-30			20-40
HV[10]	90-145	353-413	210-251			65-125
1/4 Hard		1/4 HT	1/4 HM			HTC
UTS	75-88	175-205	110-120			75-85
YS	60-80	150-185	80-110			50-75
EL	20-45	3-10	15-25			8-20
HV	121-185	353-424	230-271			147-176
1/2 Hard		1/2 HT	1/2 HM	1/2 HT		
UTS	85-100	185-215	120-135	95-115		
YS	75-95	160-195	95-125	80-100		
EL	12-30	1-8	12-22	10 Min.		
HV	176-216	373-435	250-301	180-240		
3/4 Hard					3/4 HT	AT
UTS	90-110				115-135	100-130
YS					95-115	80-100
EL	3-15				11 Min.	10-25
HV						195-275
Hard		HT	HM	HT	HT	H
UTS	100-120	190-220	135-150	110-130	120-140	70-85
YS	90-112	165-205	110-135	100-120	105-125	55-80
EL	2-18	1-6	9-20	7 min.	10 Min.	2-10
HV	216-287	385-445	285-343	210-280		144-176
Extra Hard			SHM			HT
UTS			150-160			110-135
YS			125-140			95-120
EL			9-18			8-20
HV			309-363			216-287
Spring			XHM			
UTS	—	—	155-175	—		
YS	—	—	135-170	—		
EL	—	—	4-15	—		
HV	—	—	317-378	—		
Ex. Spring			XHMS			HTR
UTS	—	—	175-190	—		120-150
YS	—	—	150-180	—		110-140
EL	—	—	3-12	—		1-5
HV	—	—	325-413	—		

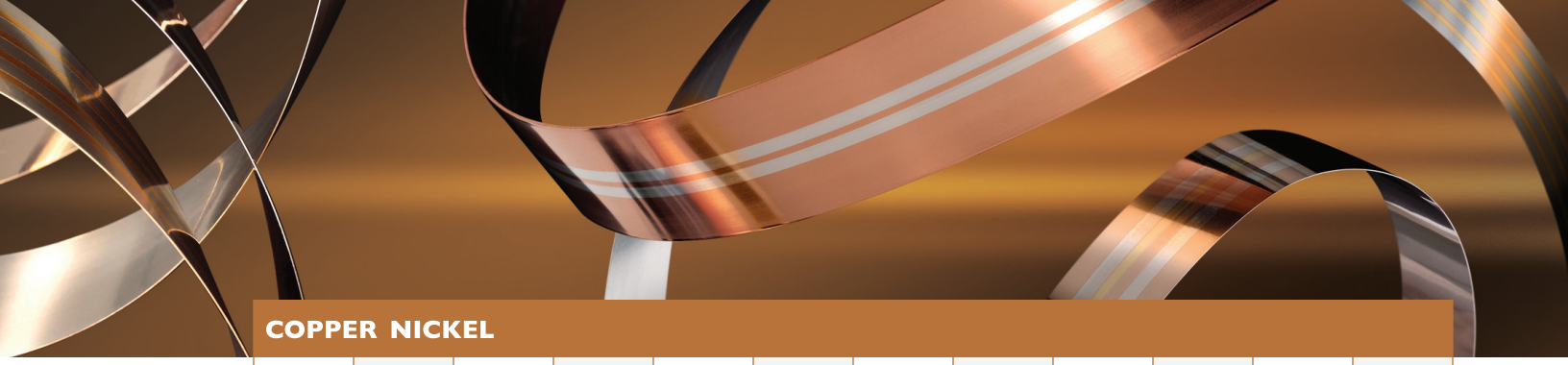


BRASS

	C21000 Gilding Metal 95 Cu 5 Zn	C22000 Commercial Bronze 90 Cu 10 Zn	C23000 Red Brass 85 Cu 15 Zn	C24000 Low Brass 80 Cu 20 Zn	C26000 Cartridge Brass 70 Cu 30 Zn	C26800 Yellow Brass 66 Cu 34 Zn	C42200 Lubronze 90 Cu 9 Zn 1 Sn	C42500 Lubaloy X 88 Cu 10 Zn 2 Sn	C42520 Olin 4252 88 Cu 10 Zn 2 Sn .1 Fe, .1 Ni
Density[1]	.320	.318	.316	.313	.308	.306	.318	.317	.318
Modulus[2]	17	17	17	16	16	15	16	18	16
Elect. Cond.[3]	56	44	37	32	28	27	31	28	30
Therm. Cond.[4]	135	109	92	81	70		75	69	75
Therm. Exp.[5]	10.0	10.2	10.4	10.6	11.1	11.3	10.2	10.2	10.2
ASTM[6]	B36	B36	B36	B36	B36	B36	B591	B591	
Annealed									
UTS[7]	34-40	36-42	39-47	44-54	45-61	41-61	40-50	40-50	
YS[8]	5-15	8-17	8-19	12-29	10-33	23 nom.	19 nom.	13-25	
EL[9]	42-48	46-49	43-48	43-58	40-67	50-52 nom.	45 nom.	30-50	
HV[10]	50-57	55-75	60-85	65-95	70-115			70-90	
1/4 Hard									
UTS	37-47	40-50	44-54	48-58	49-59	49-59	47-57	49-59	
YS	20-40	22-42	24-44	24-45	22-46	34 nom.	38 nom.	20-54	
EL	15-45	15-40	15-39	18-35	34-59	40 nom.	29 nom.	24-47	
HV	67-97	72-102	76-110	81-116	82-117		87-130	90-135	
1/2 Hard									
UTS	42-52	47-57	51-61	55-65	57-67	55-65	54-65	57-69	58-73
YS	33-48	39-52	40-54	39-58	42-61	44 nom.	50-60	51-66	47-68
EL	5-29	5-20	8-21	12-25	19-42	25 nom.	17-27	13-27	20 nom.
HV	82-106	93-118	100-130	105-135	107-142		115-140	120-160	130-165
3/4 Hard									
UTS	46-56	52-62	57-67	61-71	64-74	62-72	62-72	62-74	68-80
YS	40-52	44-57	49-63	48-65	55-69	53 nom.	64 nom.	58-70	61-75
EL	2-17	3-10	4-12	6-15	8-29	17 nom.	7 nom.	10-21	15 nom.
HV	93-117	105-128	118-143	124-149	130-160		130-160	135-171	150-180
Hard									
UTS	50-59	57-66	63-72	68-77	71-81	68-78	67-79	70-82	76-91
YS	45-57	50-63	52-68	57-73	67-78	57 nom.	63-76	66-79	74-88
EL	2-8	2-6	5-9	4-8	6-14	8 nom.	4-9	6-13	10 nom.
HV	102-104	116-138	130-150	140-161	148-173		140-170	153-190	175-205
Extra Hard									
UTS	56-64	64-72	72-80	78-87	83-92	79-89	75-85	76-88	88-103
YS	50-63	58-68	64-76	66-84	79-90	67 nom.	73-83	73-85	85-102
EL	2 Max.	1-3	3-5	2-3	2-5	4 nom.	2-7	4-8	6 nom.
HV	114-134	130-150	146-166	158-180	164-189		150-180	165-210	195-225
Spring									
UTS	60-68	69-77	78-86	85-93	91-100	86-95	82-92	84-94	95-110
YS	54-66	63-75	66-88	75-90	82-98	71 nom.	80-90	81-92	92-108
EL	2 Max.	1-2	3-4	1-2	1-2	2 nom.	1-5	2-5	4 nom.
HV	122-142	140-160	156-176	170-190	178-203		160-190	175-220	205-235
Ex. Spring									
UTS	61-69	72-80	82-90	89-97	95-104	90-99	88 min.	92 min.	100-114
YS	57-68	69-79	75-88	78-95	86-102	75 nom.	86 min.	87 min.	98-110
EL	2 Max.	1 Max.	2 Min.	1 Max.	1-2		1-3	1-3	3 nom.
HV	124-144	140-166	162-182	174-194	184-209		170 min.	190 min.	215-245

BRONZE

	C51000 Phos. Bronze A 94.9 Cu 5 Sn .1 P	C51100 Phos. Bronze 4% 95.9 Cu 4 Sn, .1P, .1 Ni, .1 Fe	C51180 Mod. Phos. Bronze 95.5 Cu 4.2 Sn .03P	C51900 Phos. Bronze 6% 93.9 Cu 6 Sn .1 P	C52100 Phos. Bronze C 91.9 Cu 8 Sn .1 P	C52180 Mod. Phos. Bronze 91.8 Cu 8 Sn, .03 P, .1 Ni, 1.Fe	C50725 95.6 Cu 2.2 Zn 2.0 Sn	C63800 638 95 Cu 2.8 Al 1.8 Si, .4 Co	C65500 Silicon Bronze A 97 Cu 3 Si	C66300 86 Cu 9.9 Zn 2.2 Sn 1.9 Fe	C68800 688 73.5 Cu 22.7 Zn 3.4 Al .4 Co
Density[1]	.320	.320	.320	.319	.318	.318	.322	.299	.308	.317	.296
Modulus[2]	16	16	16	16	16	16	16.4	16.7	15	18	16.8
Elect. Cond.[3]	15	20	20	15	13	13	33	10	7	25	18
Therm. Cond.[4]	40	48	50	39	36	36	87	24	21	62	40
Therm. Exp.[5]	9.9	9.9	9.9	10.0	10.1	10.1	9.7	9.5	18	9.8	10.1
ASTM[6]	B103	B103		B103	B103			B422	B96	B592	B592
Annealed											
UTS[7]	43-58	40-55		48-63	53-67			77-87	56		77-87
YS[8]	19-31	16-28		16-28	23-35			45-67	21		44-61
EL[9]	48-62	45-49		50-65	60-67			27-40	63		30-40
HV[10]	70-115	67-87		70-120	80-140				120 nom.		
1/4 Hard											
UTS	49-61	46-58		60-72	63-75			90-102	68		87-101
YS	22-52	20-50		28-60	35-62			75-90	35		63-89
EL	32-50	25-47		35-55	40-60			12-21	30		10-29
HV	95-135	73-132		110-160	130-170			210 nom.	140 nom.		210 nom.
1/2 Hard											
UTS	58-73	55-70	69-84	64-79	69-84	90-105	68-80	100-112	78	58-73	97-112
YS	47-68	42-70	60-80	49-72	51-75	84-100	73 nom.	87-100	45	56 nom.	82-102
EL	16-38	12-31	22. nom.	20-42	25-49	25 nom.	11 nom.	7-13	17	20 min.	3-15
HV	130-165	97-158		120-175	150-185		170 nom.	225 nom.	175 nom.		240 nom.
3/4 Hard											
UTS	68-80	67-82	80-92	74-90	80-95	97-112		105-117			
YS	61-75	64-80	72-90	64-80	70-85	88-105		93-105			
EL	10-20	6-15	18 nom.	14-26	18-32	20 nom.		5-10			
HV	150-180	135-174		160-195	175-205			240 nom.	190 nom.		
Hard											106-120
UTS	76-91	72-87	85-100	80-96	85-100	105-120	81-93	114-126	94	76-91	95-108
YS	74-88	70-83	77-97	75-92	78-95	95-115	85 nom.	102-115	58	81 nom.	2-7
EL	4-11	2-12	12 nom.	7-16	12-30	18 nom.	9 nom.	3-6	8	17 nom.	258 nom.
HV	175-205	148-180		180-215	190-220		192 nom.	250 nom.			
Extra Hard											
UTS	88-103	84-99	97-112	92-108	97-112	108-125	85-100	118-130	104	88-103	113-127
YS	85-102	81-96	90-110	88-106	92-107	100-120	92 nom.	106-119	60	93 nom.	102-115
EL	2-6	1-6	8 nom.	3-8	6-10	12 nom.	8 nom.	2-5	6	7 nom.	2-3
HV	195-225	168-197		200-235	210-240		206 nom				266 nom.
Spring											
UTS	95-110	91-106	105-119	99-116	105-119	115-132		123-134	110	95-110	123-133
YS	92-108	88-101	97-117	95-110	100-113	105-125		111-121	62	100 nom.	111-117
EL	1-3	1-5	5 nom.	2-6	3-9	8 nom.		2-4	4	5 nom.	1-2
HV	205-235	180-209		210-250	225-255			270 nom.			275 nom.
Ex. Spring											
UTS	100-114	96-108	110-122	105mm	110-122	120-140		130 Min.		100-114	125 min.
YS	98-110	92-104	102-120	100mm.	105-116	110-130		119 Min.		104 nom.	117 min.
EL	1-3	1-4	3 nom.	1-3	2-6	3 nom.		1-2		4 nom.	1-2
HV	215-245	187-218			235-265						280 min.

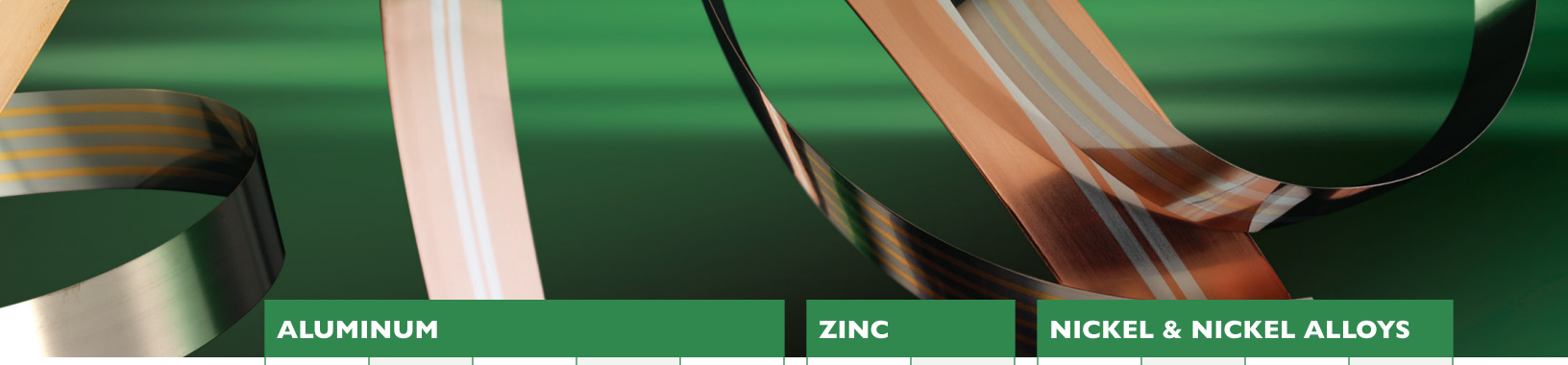


COPPER NICKEL

	C70250	C70260	C70600	C71500	C72500	C72900	C72900	C72900	C73500	C75200	C76200	C77000
	96.2 Cu 3 Ni .6 Si .2 Mg	97.5 Cu 2 Ni .5 Si	Cupro Nickel 88.6 Cu 10 Ni 1.4 Fe	Cupro Nickel 69.4 Cu 30 Ni .6 Fe	88.2 Cu 9.5 Ni 2.3 Sn	as rolled 77 Cu 15 Ni 8 Sn	age hard[12] 77 Cu 15 Ni 8 Sn	mill hard 77 Cu 15 Ni 8 Sn	Nickel Silver 72 Cu 10 Zn 18 Ni	Nickel Silver 65 Cu 17 Zn 18 Ni	Nickel Silver 59 Cu 29 Zn 12 Ni	Nickel Silver 55 Cu 27 Zn 18 Ni
Density[1]	.318	.320	.323	.323	.321	.321	.321	.321	.319	.316	.310	.314
Modulus[2]	19	19	20	22	20	18.5	18.5	19.5	18.000	18	18	18
Elect. Cond.[3]	40	40	9.1	4.6	11	7.8	7.8	7.8	8.000	6	9	5.5
Therm. Cond.[4]	85	90	23	17	31	17	17	17	21.500	19	24	17
Therm. Exp.[5]	10.0		9.5	9.0	9.2	9.1	9.1	9.1	9.000	9.0	8.5	9.3
ASTM[6]	B422	B422	B122	B122	B122	B740	B740	B740	B122	B122	B122	B122
Annealed	TM00	TM00				TB00	TX00	TM00				
UTS[7]	90-110	85-95		50-65	45-65	64-85	120-150	95-115	50-68	53-63	57-75	61-76
YS[8]	65-90	75 min.		20-40	18-25	24-40	100-130	75-95	15-60	18-32	21-52	23-41
EL[9]	10 min.	15 min.		25 Min.	34-36	32 Min.	6 Min.	22 Min.	11-37	29-42	32-49	39-48
HV[10]		190 nom.	65-90	80-110	80-110	100-150	275-350	190-290	89-145	78-120	92-145	83-135
1/4 Hard						TD01	TS01					
UTS			51-67	58-72	55-75	75-100	130-160		56-69	58-72	65-81	69-87
YS				35-69	73 Max.	50-75	115-145		28-59	26-64	36-68	44-83
EL				5-30	5 min.	18 Min.	4 Min.		10-25	14-35	20-50	11-41
HV			95-146	120-155	164 Max	150-235	290-365		119-151	95-138	110-167	126-179
1/2 Hard	TM02	TM02				TD02	T202	TM02				
UTS	95-120	95-105	58-72	66-80	65-80	85-110	145-175	105-125	63-75	66-80	75-91	78-95
YS	85-119	95 min.		60-78	59-78	65-100	135-165	90-110	49-69	48-78	58-82	64-93
EL	7 min.	6 min.		3-10	3-17	8 Min.	3 Min.	15 Min.	3-16	6-22	6-30	5-24
HV		210 nom.	120-160	140-170	132-180	170-275	315-390	215-315	138-164	122-157	145-193	154-198
3/4 Hard	TM03						TS03					
UTS	100-125					95-120	155-185		69-79	74-86	83-98	88-101
YS	95-120					90-115	145-175		59-73	69-82	73-91	84-100
EL	5 min.					3 Min.	2 Min.		2-5	4-12	4-16	3-13
HV						210-290	325-400		142-171	138-175	160-203	171-193
Hard						TD04	T204	TM04				
UTS			71-83	75-88	75-90	100-130	165-195	115-135	73-84	78-91	90-105	92-109
YS				73-84	73-88	85-125	155-185	105-125	67-78	75-90	82-97	90-108
EL				2-4	1-5	1 min.	2 min.	10 min.	1-3	3-7	3-6	3-6
HV			140-174	160-185	135-180	220-300	335-410	245-345	160-180	151-188	188-215	188-220
Extra Hard								TM06				
UTS			73-85	80-92	80-95			130-150	79-90	86-98	99-114	102-115
YS				78-88	78-93			120-145	72-81	85-97	93-103	101-114
EL				1-3	1-3			6 min.	1-2	3-4	1-3	1-2
HV			158-192	165-195	153-218			270-370	170-190	175-209	209-234	214-240
Spring						TD08		TM08				
UTS			78-86	84-94	85-100	122-145		150-178	85-93	90-101	107-122	108-123
YS				81-90	83-97	100-140		140-170	78-84	88-99	101-110	107-118
EL				1-2	1-2			2 min.	1	1-2	1-2	1
HV			164-196	174-200	164-218			305-405	180-200	183-220	228-250	228-250
Ex. Spring												
UTS					90-105				88 Min.	96 Min.	114 Min.	116 Min.
YS					88-102				78 Min.	95 Min.	102 Min.	115 Min.
EL					1				1	1-2	1	1
HV					187-218				185 Min.	198 Min.	235 Min.	235 Min.

STEELS

	S30100	S30200	S30403	S30500	S31008	S31600	S32100	S40900	S43000	G100800	K00100
	301 Fe 17Cr 7Ni	302 Fe 18Cr 9Ni	304L Fe 19Cr 10Ni	305 Fe 18Cr 12Ni	310 S Fe 25Cr 20Ni	316 Fe 17Cr 12Ni 2.5Mo	321 Fe 18Cr 10Ni .4Ti	409 Fe 11Cr	430 Fe 16Cr	1008 Fe .08C	Iron Fe .005C
Density[1]	.285	.285	.284	.29	.29	.29	.29	.28	.28	.283	.278
Modulus[2]	28	28	28	28	28	28	28	29	29	29	
Elect. Cond.[3]	2.5	2.5	2.4	2.4	2.4	2.2	2.3	2.8	2.8		16
Therm. Cond.[4]	9.4	9.4	9.4	9.4	9.4	8.2	9.4	14.4	13.8		
Therm. Exp.[5]	9.5	9.5	9.9	9.9	9.9	9.0	9.0	6.1	6.1	6.7	
ASTM[6]	A666	A666	A666	A240	A240	A666	A240	A240	A176	A109	
Annealed										skin rolled	
UTS[7]	110 Nom.	90 Nom.	84 Nom.	85 Nom.	95 Nom.	84 Nom.	90 Nom.	55-68	65-80	40-55	40-60
YS[8]	40 Nom.	40 Nom.	42 Nom.	38 Nom.	45 Nom.	42 Nom.	35 Nom.	25-41	40-60	25-40	30-45
EL[9]	60 Nom.	50 Nom.	55 Nom.	55 Nom.	45 Nom.	50 Nom.	45 Nom.	20-38	18-30	24 Min.	25 Num.
HV[10]	170 Nom.	170 Nom.	170 Nom.	170 Nom.	170 Nom.	150 Nom.	150 Nom.	123	144-176	125 Max.	115 Num.
1/4 Hard											
UTS	125 Min.	125 Min.	125 Min.	125 Min.	125 Min.	125 Min.	125 Min.	58	78-90	45-65	
YS	75 Min.	75 Min.	75 Min.	75 Min.	75 Min.	75 Min.	75 Min.	25	60-78	--	
EL	25 Min.	25 Min.	25 Min.	25 Min.	25 Min.	25 Min.	25 Min.	25	3-19	13-27	
HV	250 Nom.	250 Nom.	250 Nom.	250 Nom.	250 Nom.	250 Nom.	250 Nom.		172-205	107-137	
1/2 Hard											
UTS	150 Min	140 Min.	140 Min.	130 Min.	130 Min	130 Min	130 Min.	75	90-100	55-75	
YS	110 Min	110 Min.	110 Min.	110 Min.	110 Min	110 Min	110 Min.	74	76-92	--	
EL	15 Min.	15 Min.	15 Min.	10 Min.	15 Min.	10 Min.	8 Min.	16	3-7	4-16	
HV	300 Nom.	300 Nom.	300 Nom.	300 Nom.	300 Nom.	300 Nom.	300 Nom.	172	205-228	125-170	
3/4 Hard											
UTS	175 Min	165 Min.	160 Min.	150 Min.	150 Min.	150 Min	150 Min.	82	98-110		
YS	135 Min	135 Min.	135 Min.	135 Min.	135 Min.	135 Min	135 Min.	81	90-103		
EL	10 Min.	10 Min.	5 Min.	5 Min.	10 Min.	10 Min.	5 Min.	9.5	1-7		
HV	350 Nom.	350 Nom.	350 Nom.	350 Nom.	350 Nom.	350 Nom.	350 Nom.	190	222-242		
Hard											
UTS	185 Min	175 Min	170 Min.			170 Min.		101	107-115	80-100	75-85
YS	140 Min	140 Min	140 Min.			140 Min.		102	100-110	--	65-80
EL	8 Min	8 Min	2 Min.			2 Min.		3	1-2	--	
HV	390 Nom.	390 Nom.	390 Nom.			390 Nom.		222	228-246	185 Min.	150 Num.
	maximum strength and work hardening	standard general purpose stable properties low C	stable properties low C	low work hardening good formability	high temp oxidation resistance good formability	maximum corrosion resistance	excellent resistance to oxidation & corrosion	ferretic economical use for corrosion & oxidation resistance	ferretic general use for corrosion & oxidation resistance		better formability
Magnetic	No	No	No	No	No	No	No	Yes	Yes	Yes	Yes



	ALUMINUM					ZINC		NICKEL & NICKEL ALLOYS			
	A91100	**A91145**	**A93003**	**A95052**	**A96061**	**Z13004**	**Z41321**	**N02201**	**N02270**	**N04400**	**N06600**
	99.0 Al	99.45 Al	98.3Al 1.2Mn .1Cu	97.2Al 2.5Mg .25Cr	97.9Al 1Mg 0.6Si 0.3Cu 0.2Cr	Pure Zinc 99.98 Zn	Zn Cu Ti Alloy 99.2 Zn .6 Cu .15 Ti	201 99.0 Ni .02 Max C	270 99.98N	Monel™* 400 65Ni 35Cu	Inconel™* 600 76 Ni 16 Cr 8 Fe
Density[1]	.098	.0977	.099	.097	.098	0.258	0.259	.321	.321	.319	.305
Modulus[2]	10	10	10.2	10.1	10	9-13	9-13	30	30	26	31
Elect. Cond.[3]	59	61	50	35	45	27	26	18	23	3.4	1.8
Therm. Cond.[4]	128	130	112	79	100	61	61	43	50	12.6	8.6
Therm. Exp.[5]	14.1	13.1	13.9	14.3	13.1	16.7	12.7	8.0	8.6	8.8	7.6
ASTM[6]	B209		B209	B209	B209	B69	B69	B162			B168
Annealed	O	O	O	O	O						
UTS[7]	11-15	8-14	14-19	25-31	18	10-18	21-32	50-65	45-55	70-85	80-100
YS[8]	4 Min.	3 Min.	5 Min.	10 Min.	8			12-28	10-25	25-45	40 Nom.
EL[9]	15 Min.	15 Min.	18 Min.	14 Min.	25	30-75	15-50	30-50	40-55	35-50	35-55
HV[10]	25 Nom.	20 Nom.	30 Nom.	40 Nom.	40 Nom.	25-45	50-75	120 Max.		133 Max.	150 Nom.
1/4 Hard											
UTS								60-75	50-65	75-95	
YS								45-66	20-34	40-80	
EL								17-26	35-48	20-40	
HV								120-150	85-112	133-160	
1/2 Hard	H12	H12	H12	H32							
UTS	14-19	11-16	17-23	31-38				76-92	60-70	80-100	100-125
YS	11 Min.	9 Min.	12 Min.	23 Min.				60-84	32-44	60-90	60-100
EL	4 Min.	6 Min.	3 Min.	4 Min.				8-21	30-45	14-30	10-25
HV	30 Nom.	25 Nom.	42 Nom.	50 Nom.				140-170	108-130	157-188	235 Nom.
3/4 Hard											
UTS								85-100	68-80	90-110	
YS								70-90	42-58	73-102	
EL								3-8	25-37	6-20	
HV								160-190	125-155	183-209	
Hard	H14	H14	H14	H34							
UTS	16-21	12-17	20-26	34-41			27-40	90 Min.	78-90	100-120	120-150
YS	14 Min.	10 Min.	17 Min.	26 Min.				80 Min.	55-70	90-110	90-125
EL	–	–	–	–			10-40	2 Min.	15-28	2-15	2-15
HV	35 Nom.	30 Nom.	50 Nom.	60 Nom.			60-95	180-220	145-175	205-234	275 Nom.
Extra Hard	H16	H16	H16	H36	H16						
UTS	19-24	14-19	24-30	37-44	28-36						
YS	17 Min.	11 Min.	21 Min.	29 Min.	–						
EL	–	–	–	–	–						
HV	40 Nom	35 Nom	55 Nom	65 Nom	70 Nom						
Spring	H18	H18	H18	H38	T4						
UTS	22 Min.	16 Min.	27 Min.	39 Min.	30 Min.			96 Min.		120 Min.	145-170
YS	20 Min.	12 Min.	24 Min.	32 Min.	16 Min.			85 Min.		110 Min.	120-160
EL	–	–	–	–	10 Min.			1 Min.		1-10	2-10
HV	50 Nom.	50 Nom.	50 Nom..	50 Nom.				193 Min.		234 Min.	320 Nom.
Ex. Spring					H18						
UTS					42 Min.						
YS					35 Min.						
EL					–						
HV											

* Monel and Inconel are registered trademarks of Special Metals Corporation.

REFRACTORY METALS

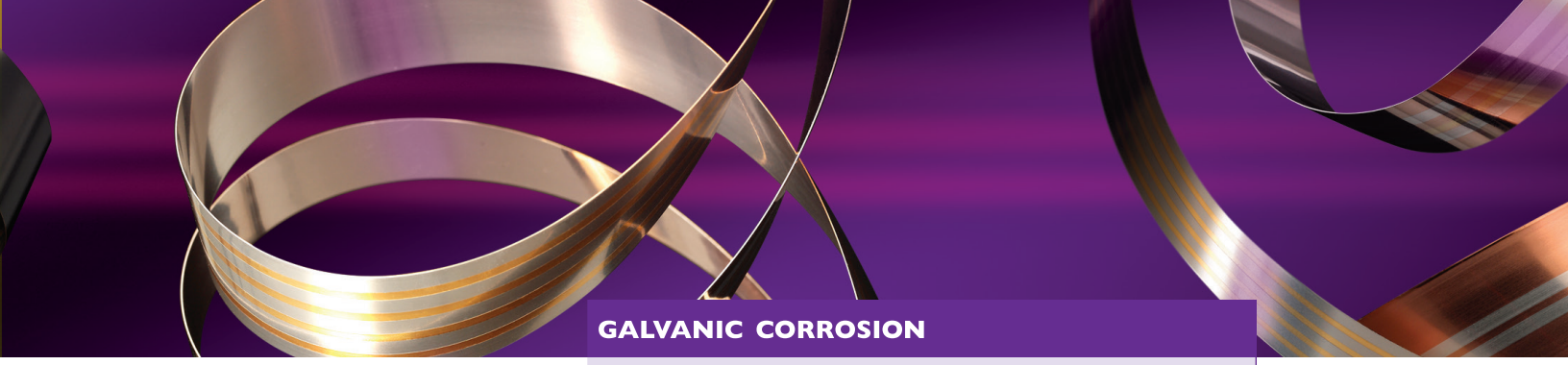
LOW EXPANSION ALLOYS

	R04200	R05200	R50250	R60702	K93600	K94100	K94610
	Reactor Grade Niobium Nb	Unalloyed Tantalum Ta	Grade 1 Titanium Ti	Unalloyed Zirconium 99.2 Zr	Invar 36 64Fe 36Ni	Alloy 42 58Fe 42Ni	Kovar 54Fe 29Ni 17Co
Density[1]	.310	.600	.163	14	0.292	.293	.302
Modulus[2]	15	27	15	4.1	21	21.5	20
Elect. Cond.[3]	11.5	14	3	9	2.1	2.4	3.5
Therm. Cond.[4]	30	34	9.2	3.5	5.8	6.2	10
Therm. Exp.[5]	4.1	3.7	5.1	B551	2.1	6.1	2.9
ASTM[6]	B393	B70	B26		B753	F30	F15
Annealed							
UTS[7]	18-38	30-45	35-60	55-80	65-85	65-85	65-85
YS[8]	10-30	20-40	25-45	30-65	35-75	35-75	35-75
EL[9]	20 Min.	20 Min.	24 Min.	16 Min.	18-32	18-32	18-32
HV[10]	55-95	90-120	120 Nom.	150 Nom.			
1/4 Hard	CW10%	CW10%	CW10%				
UTS	48	40	70		75-90	75-90	75-90
YS	43	35					
EL	25						
HV	90	120	160				
1/2 Hard	CW25%	CW25%	CW25%	CW25%			
UTS	55	45	80		85-100	85-100	85-100
YS	53	42		64			
EL	7			18			
HV	115	125	180				
3/4 Hard	CW50%	CW50%	CW50%	CW50%			
UTS	63	55	100		95-110	95-110	95-110
YS	62	53		71			
EL	2			15			
HV	135	130	210				
Hard	CW70%	CW70%	CW70%	CW70%			
UTS	70	70	115		100 Min.	100 Min.	100 Min.
YS	69	69		84			
EL	1			8			
HV	150	150	230				
Extra Hard							
UTS							
YS							
EL							
HV							
Spring							
UTS							
YS							
EL							
HV							
Ex. Spring							
UTS							
YS							
EL							
HV							

PRECIOUS METAL ALLOYS

Material	Composition	Densitylbs/in^3	Coating Technology	ASTM Specification	Hardness(HK) Annealed-Spring	Resistivity	Typical Applications
DRY CIRCUIT							
Soft Gold	99.9 Au	0.698	Plated	B-488	40-90	2.4	C, S ,L, R
Hard Au	99.7 Au	0.633	Plated	B-488	130-200	2.9-4.7	C, S ,L, R
Palladium	99.8 Pd	0.434	Plated	B-679	200-300	10.7	C, S ,L, R
Palladium Nickel	80 Pd, 20 Ni	0.405	Plated	B-867	250-500	19	C, S, R
24kt Gold	99.99 Au	0.698	Clad	B-562	40-90	2.4	C, S ,L, R
18 kt Gold	75 Au, 25 Ag	0.577	Clad		65-135		C, S, R
14 kt Gold	58 Au, 42 Ag	0.516	Clad		70-145		C, S, R
WE#1	69 Au, 25 Ag, 6 Pt	0.580	Clad	B-522	90-170	15.4	C, S, R
Palladium	99.9 Pd	0.434	Clad	B-683	80-160	10.7	C, S ,L, R
Palladium Nickel	90 Pd, 10 Ni	0.419	Clad		145-265	16*	C, S, R
Palladium Nickel	80 Pd, 20 Ni	0.405	Clad		180-310	19	C, S, R
Palladium Silver	60 Pd, 40 Ag	0.410	Clad	B-731	120-210	43	C, S, R
Palladium Silver	50 Pd, 50 Ag	0.404	Clad		110-200		C, S, R
	65 Au, 21 Pd, 14 Ag	0.560	Clad		140-250	47	C, S, R
DGR-156	Diffused Au, 60 Pd, 40 Ag	0.439	Clad		140-200		C, S, R
	WE#1 Capped, 60 Pd, 40 Ag	0.460	Clad		110-190		C, S, R
DGPN	Diffused Au, PdNi	.5	Clad		150-280		C, S, R
Paliney 6™	44 Pd, 38 Ag, 16 Cu, 1 Pt, 1 Ni	0.390	Clad	B-563	290-370	25.8	C, S, R
Paliney 7™	35 Pd, 30 Ag, 14 Cu, 10 Au, 10 Pt, 1 Zn	0.426	Clad	B-540	330-400	31.6	C, S, R
Gold Alloys	70 Au, 24 Ag, 6 Cu	0.549	Clad		115-190	23	C, S, R
	70 Au, 20 Ag, 10 Cu	0.543	Clad		140-220	31	C, S, R
	96 Au, 4 Ni	0.667	Clad		110-200	11	C, S, R
	90 Au, 10 Ni	0.625	Clad		205-280	22	C, S, R
Platinum	99.9 Pt	0.775	Clad	B-561	75-140	10.6	R
SWITCHING							
Silver		0.379	Plated	B-700	40-185	1.7	S, L
Silver	99.9 Ag	0.379	Clad	B-742	40-90	1.7	S, L
Silver Nickel	90 Ag, 10 Ni	0.372	Clad	B-693	70-105	2.1	S, R
Coin Silver	90 Ag, 10 Cu	0.373	Clad	B-617	80-120	2.1	S
	75 Ag, 24.5 Cu, 0.5 Ni	0.408	Clad	B-780	95-130	2.4	S
BT	72 Ag, 28 Cu	0.361	Clad	B-628	90-130	2.1	B
Silver Tin Oxide	90 Ag, 10 SnO_2	0.357	Clad	B-844	100-130	2.3	S, R
Silver Cadmium Oxide	90 Ag, 10 CdO	0.368	Clad	B781	95-130	2.2	S, R

Typical Applications Key: C=Connectors, S=Switches, L=Lead Frames, R=Relays, B=Brazing



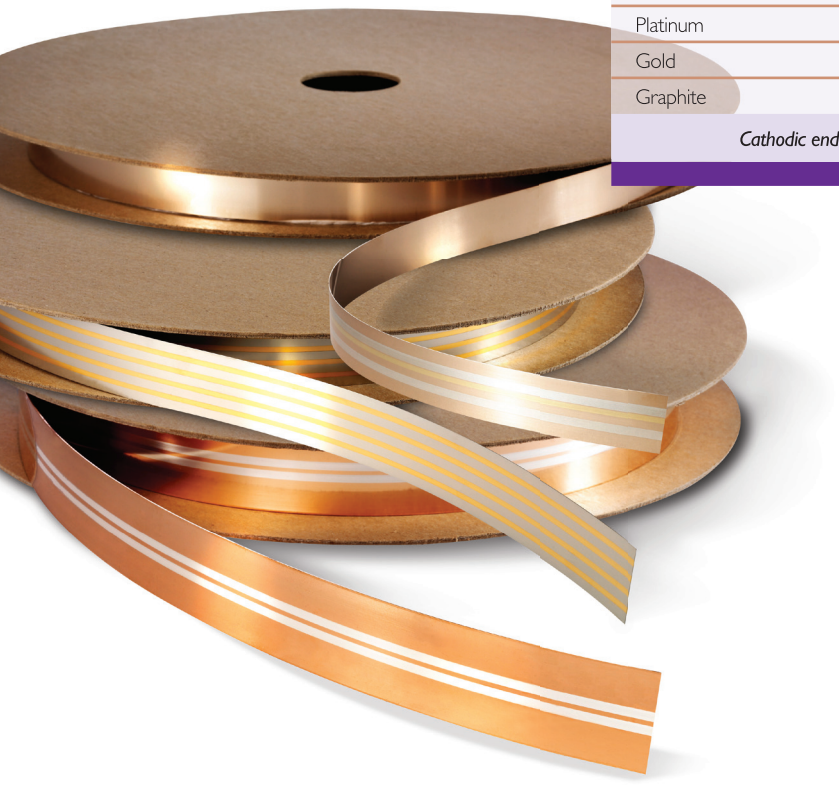
GALVANIC CORROSION

This table lists the potential differences for various metals in water at 77°F (25°C). The order of the series can change for different electrolytes (for example, different pH, ions in solution).

Anodic end: The corrosion occurs here.

ELEMENT	STANDARD ELECTRODE POTENTIAL (VOLTS)
Lithium	-3.045
Potassium	-2.920
Sodium	-2.712
Magnesium	-2.340
Beryllium	-1.700
Aluminum	-1.670
Manganese	-1.050
Zinc	-0.762
Chromium	-0.744
Iron, Mild Steel	-0440
Cadmium	-0.402
Yellow Brass	-0.350
50-50 Tin-Lead Solder	-0.325
Cobalt	-0.277
Nickel	-0.250
Tin	-0.136
Lead	-0.126
Hydrogen Reference Electrode	0.000
Titanium	+0.055
Copper	+0.340
Mercury	+0.789
Silver	+0.799
Carbon	+0.810
Platinum	+1.200
Gold	+1.420
Graphite	+2.250

Cathodic end (passive): The corrosion does not occur here.



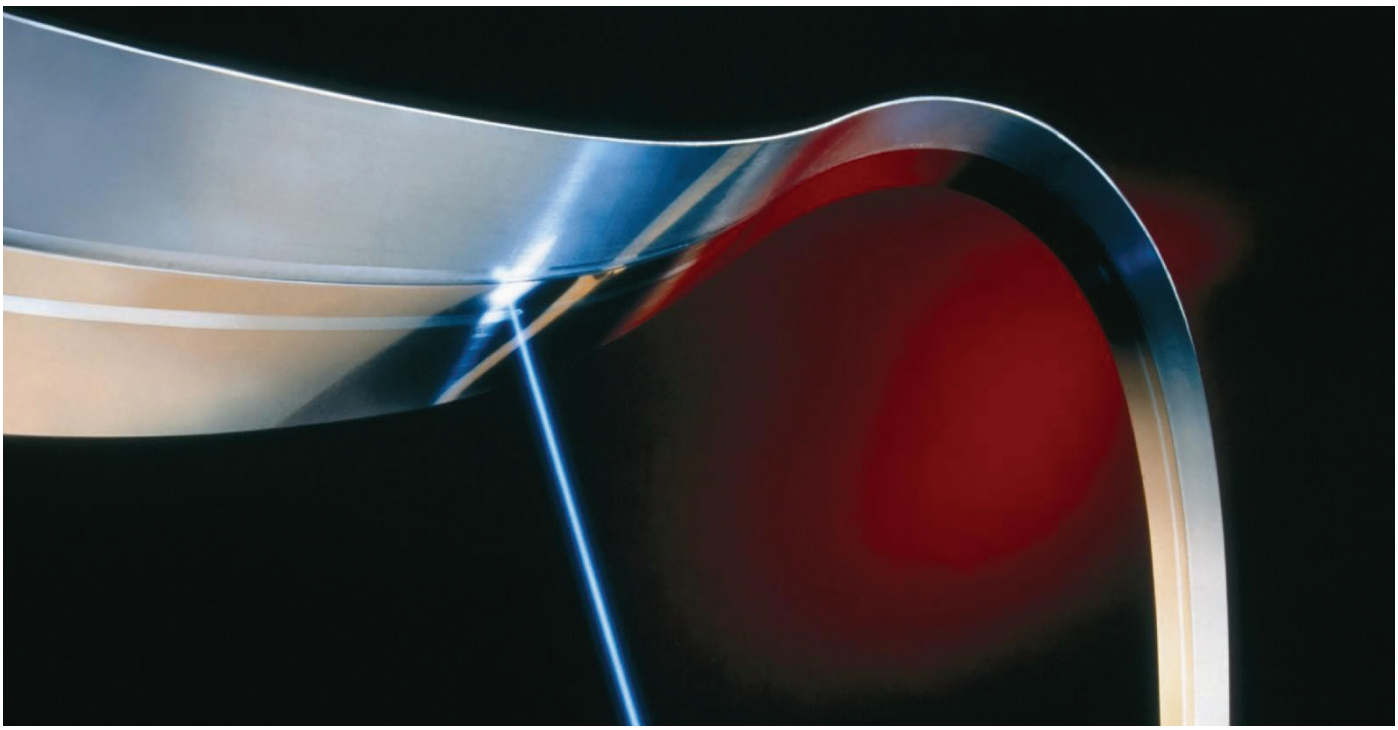
Note: Stainless steel alloys have not been included in the above table. They can significantly change their potential and become much more active if exposed to stagnant or poorly aerated water.

SOLDERS

Fahrenheit		Composition	Centigrade		Density	
Solidus	Liquidus	*(Shaded rows indicate lead-free compositions)*	Solidus	Liquidus	(lb/c.in)	(g/cc)
SOLDERS						
205	205	52 Bi, 30 Pb, 18 Sn	96	96	0.346	9.58
212	212	35.7 Sn, 35.7 Bi, 28.6 Pb	100	100	0.337	9.33
244	244	52 In, 48 Sn	118	118	0.264	7.30
244	257	50 In, 50 Sn	118	125	0.264	7.29
281	281	58 Bi, 42 Sn	138	138	0.309	8.55
281	290	50 Sn, 50 Bi	138	143	0.297	8.22
296	296	97 In, 3 Ag	147	147	0.266	7.37
315	315	100 In	157	157	0.264	7.31
275	333	47 Sn, 40 Pb, 10 Bi, 3 Ag	135	167.2	0.321	8.89
338	338	65.5 Sn, 31.5 Bi, 3.0 Zn	170	170	0.290	8.03
354	354	62 Sn, 36 Pb, 2 Ag	179	179	0.304	8.41
361	361	63 Sn, 37 Pb	183	183	0.301	8.34
361	370	60 Pb, 40 Sn	183	188	0.307	8.49
361	432	95 Sn, 5 Pb	183	222	0.268	7.42
361	376	60 Sn, 40 Pb	183	188	0.307	8.50
361	390	80 Sn, 20 Pb	183	199	0.284	7.85
361	392	55 Sn, 45 Pb	183	200	0.314	8.68
361	401	85 Sn, 15 Pb	183	205	0.278	7.70
363	410	50 Pb, 50 In	184	209	0.320	8.86
361	414	50 Pb, 50 Sn	183	212	0.320	8.87
361	415	90 Sn, 10 Pb	183	213	0.273	7.55
430	430	96.5 Sn, 3.5 Ag	221	221	0.266	7.35
430	450	96 Sn, 4 Ag	221	232	0.267	7.39
430	465	95 Sn, 5 Ag	221	240	0.267	7.39
275	439	62 Pb, 25 Sn, 10 Bi, 3 Ag	135	226	0.354	9.80
407	439	2 Bi, 1.5 Cu, .2 Ag, 96.3 Sn	208	226	0.267	7.39
440	500	95.5 Sn, 4 Cu, 0.5 Ag	226	260	0.267	7.39
440	440	95.6 Sn, 4 Cu, 0.4 Ag	227	227	0.266	7.36
450	450	100 Sn	232	232	0.263	7.28
450	464	95 Sn, 5 Sb	232	240	0.262	7.24
355	487	70 Pb, 27 Sn, 3 Ag	179	253	0.342	9.47
361	495	70 Pb, 30 Sn	183	257	0.349	9.66
520	520	100 Bi	271	271	0.354	9.80
529	553	85 Pb, 15 In	277	290	0.380	10.50
361	536	80 Pb, 20 Sn	183	280	0.363	10.04
361	550	85 Pb, 15 Sn	183	288	0.379	10.48
527	576	90 Pb, 10 Sn	275	302	0.379	10.50
441	590	97 Sn, 3 Cu	227	310	0.265	7.34
590	597	95 Pb, 5 Sn	310	314	0.390	10.80

BRAZING ALLOYS

Fahrenheit		Composition	Centigrade		Density	
Solidus	Liquidus		Solidus	Liquidus	(lb/c.in)	(g/cc)
BRAZING						
1125	1145	BAg-1 (45 Ag, 24 Cd, 16 Zn, 15 Cu)	605	620	0.340	9.41
1160	1175	BAg-1a (50 Ag, 18 Cd, 16.5 Zn, 15.5 Cu)	625	635	0.341	9.45
1145	1205	BAg-7 (56 Ag, 22 Cu, 17 Zn, 5 Sn)	620	650	0.340	9.41
1170	1270	BAg-3 (50 Ag, 16 Cd, 15.5 Cu, 15.5 Zn, 3 Ni)	630	690	0.344	9.53
1125	1295	BAg-2 (35 Ag, 26 Cu, 21 Zn, 18 Cd)	605	700	0.322	9.19
1220	1305	BAg-24 (50 Ag, 20 Cu, 28 Zn, 2 Ni)	660	705	0.324	8.98
1240	1325	BAg-9 (65 Ag, 20 Cu, 15 Zn)	671	718	0.347	9.60
1200	1330	BAg-34 (38 Ag, 32 Cu, 28 Zn, 2 Sn)	650	721	0.327	9.05
1225	1370	BAg-5 (45 Ag, 30 Cu, 25 Zn)	665	745	0.329	9.11
1435	1435	BAg-8 (BT) (72 Ag, 28 Cu)	780	780	0.360	9.96
1742	1742	82 Au, 18 Ni	950	950	0.571	15.81
1761	1761	99.9 Ag	960	960	0.379	10.50
CERAMIC ACTIVE METAL LAMINATES						
1425	1726	TiLam (88 Ag, 9.5 Cu, 2.5 Ti)	774	959	0.359	9.94
1049	1623	TiLam 72 (70 Ag, 27 Cu, 3 Ti)	765	884	0.349	9.67



ALLOY COMPATIBILITY

CLADDING OR PLATING METAL (B)

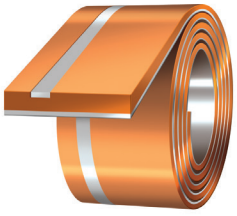
A can be combined with B via:

BASE METAL (A)	Aluminum	Brazing Alloys	Carbon Steel	Copper	Copper Be	Copper Brass	Copper Bronze	Cupro Nickel	Gold	Gold Alloys	Iron	Lead
Aluminum Alloys	C	--	C	C	C	--	C	C	C	C	C	C
Brazing Alloys	--	CE	CE	CEP	CE	C	CE	C	CEP	CE	CE	C[1]
Carbon Steel	C[1]	C	CE	CEP	CE	C	CE	CE	CEP	CE	CE	C[1]
Copper	C	C	CE	CEP	CE	C	CE	CE	CEP	CE	CE	C
Copper Be	--	C	CE	CEP	CE	C	CE	CE	CEP	CE	CE	C[1]
Copper Brass	--	C	C	CP	C	C	C	C	CP	C	C	C[1]
Copper Bronze	C	C	CE	CEP	CE	C	CE	CE	CEP	CE	CE	C[1]
Cupro Nickel	C[1]	C	CE	CEP	CE	C	CE	CE	CEP	CE	CE	C[1]
Gold Alloys	--	C	CE	--	CE	--	CE	CE	CEP	CE	CE	--
Iron	C[1]	C	CE	CEP	CE	C	CE	CE	CEP	CE	CE	C[1]
Lead	C	--	--	C	--	C	C	C	C	C	C	C
Molybdenum[2]	C[1]	--	E	EP	E	--	E	E	EP	--	E	--
Nickel	C	C	CE	CEP	CE	C	CE	CE	EP	CE	CE	C
Fe-Ni CTE Alloy	C[1]	C	CE	CEP	CE	C	CE	CE	EP	CE	CE	C[1]
Niobium	C[1]	C[1]	CE	CEP	CE	C[1]	CE	CE	CEP	CE	CE	C[1]
Palladium Alloys	C[1]	C	CE	CEP	--	--	CE	CE	CEP	CE	CE	--
Platinum	C[1]	C	CE	CEP	--	--	CE	CE	CEP	CE	CE	--
Silver Alloy	C[1]	C	E	CEP	CE	C	CE	CE	CEP	CE	CE	C
SS 300 Series	C[1]	C[1]	CE	CEP	E	C[1]	CE	CE	CEP	CE	CE	C[1]
SS 400 Series	C[1]	C	CE	CEP	CE	C	CE	CE	CEP	CE	CE	C[1]
Tantalum	C[1]	C[1]	C[1]E	C[1]E	C[1]E	C[1]	C[1]E	C[1]E	C[1]E	C[1]E	CE	C[1]
Titanium	C[1]	C	CE	CE	CE	C	CE	CE	CE	CE	CE	C[1]
Zinc	C	--	--	C	--	--	--	--	C	--	--	C

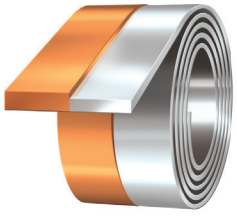
[1] Rolled tempers only.

[2] Normally requires hot bonding. Plating requires Ni interliner.

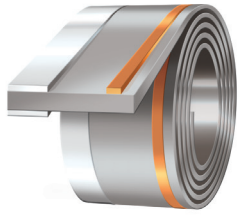
[3] SnPb plating only.



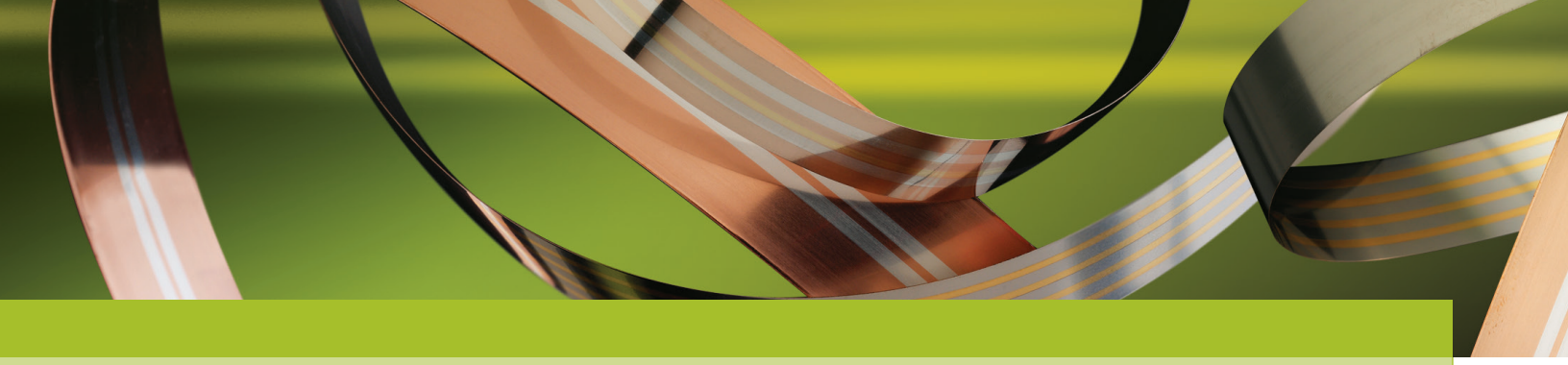
C = CLADDING



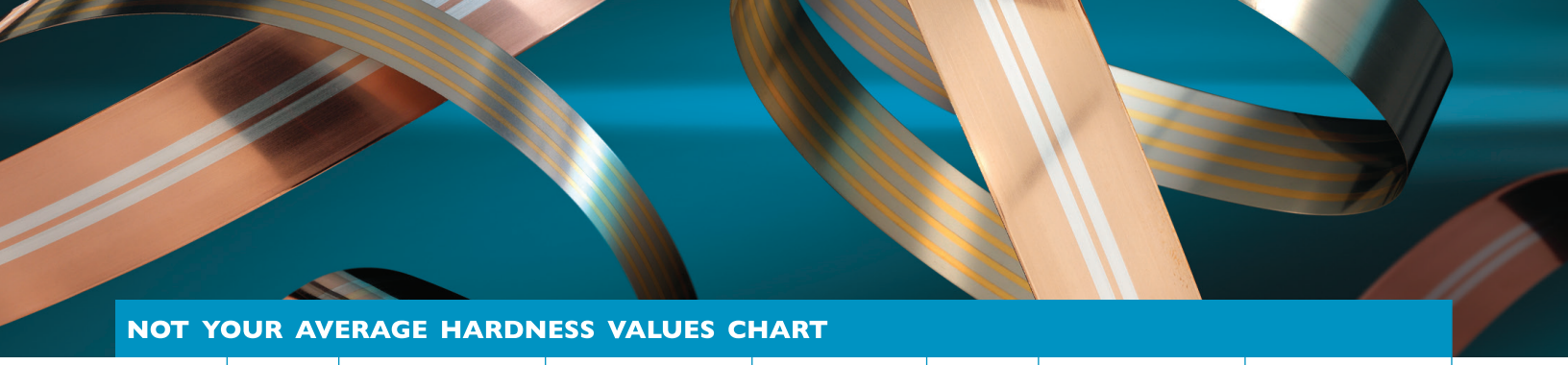
E = ELECTRON BEAM WELDING



P = PLATING



Nickel	Fe-Ni CTE Alloy	Niobium	Palladium	Palladium Alloys	Platinum	Silver	Silver Alloy	Solder Alloys[3]	SS 300 Series	SS 400 Series	Tantalum	Tin	Titanium	Zinc
C	C	C	C	C	C	C	C	C	C	C	C	C	C	C
CE	CE	CE	CEP	CE	CE	CEP	CE	C[I] P	C[I] E	CE	CE	C[I] P	CE	C[I]
CEP	CE	CE	CEP	CE	CE	CEP	CE	C[I] P	CE	CE	CE	C[I] P	CE	C[I]
CEP	CE	CE	CEP	CE	CE	CEP	CE	CP	CE	CE	CE	CP	CE	C
CEP	CE	CE	P	--	CE	CEP	CE	C[I] P	E	CE	CE	C[I] P	CE	C[I]
CP	C	C	CP	C	C	CPC[I]	C	C[I] P	CI	C	C	C[I] P	C	C[I]
CEP	CE	CE	CEP	CE	CE	CEP	CE	C[I] P	C[I] E	CE	CE	C[I] P	CE	C[I]
CEP	CE	CE	CEP	CE	CE	CEP	CE	C[I] P	CE	CE	CE	C[I] P	CE	C[I]
CE	CE	E	CEP	CE	CE	CEP	CE	--	E	E	--	--	--	--
CEP	CE	CE	CEP	CE	CE	CEP	CE	C[I] P	CE	CE	CE	C[I] P	CE	C[I]
C	--	C	C	C	C	C	C	C	--	--	--	C	--	C
E	E	E	EP	E	E	EP	E	P	E	E	E	P	E	C
CEP	CE	CE	CEP	CE	CE	CEP	CE	C[I] P	CE	CE	CE	C[I] P	CE	C
CEP	CE	CE	CEP	CE	CE	CEP	CE	C[I] P	CE	CE	CE	C[I] P	CE	C[I]
CE	CE	CE	CE	CE	CE	CE	CE	C[I]	CE	CE	CE	C[I]	CE	C[I]
CE	CE	CE	CEP	CE	CE	CEP	CE	--	--	--	--	--	--	--
CE	--	--	CEP	CE	CE	CEP	CE	--	--	--	--	--	--	--
CEP	CE	CE	CEP	CE	CE	CEP	CE	CP	--	--	CE	CP	CE	C
CEP	CE	CE	CEP	CE	CE	CEP	CE	C[I] P	CE	CE	CE	C[I] P	CE	C[I]
CEP	CE	CE	CEP	CE	CE	CEP	CE	C[I] P	CE	CE	CE	C[I] P	CE	C[I]
CE	CE	CE	CE	CE	CE	CE	CE	C[I]	CE	CE	CE	C[I]	CE	C[I]
CE	CE	CE	CE	CE	CE	CE	CE	C[I]	CE	CE	CE	C[I]	CE	C[I]
--	--	--	C	--	--	C	C	C	--	--	--	C	--	C

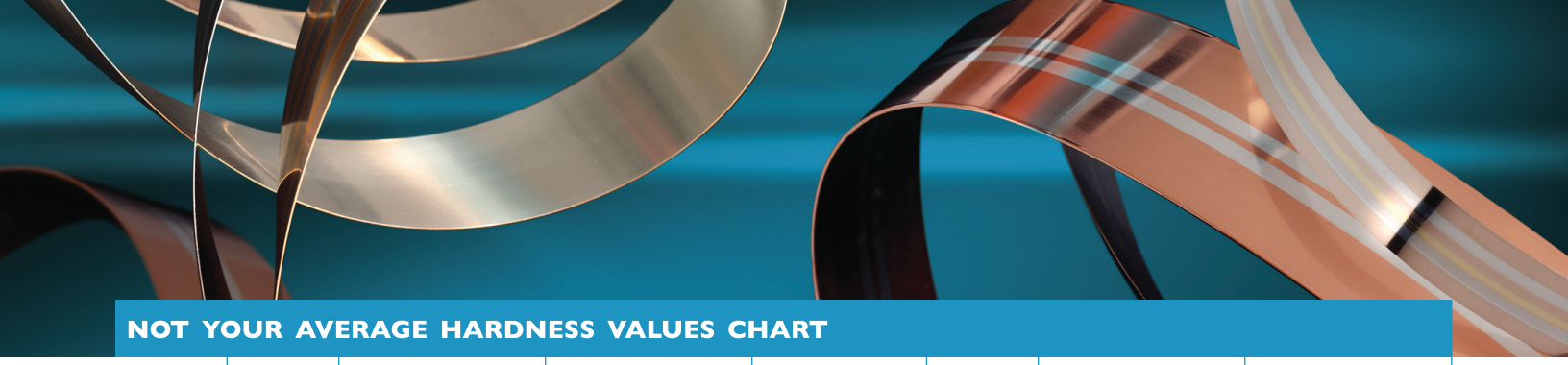


NOT YOUR AVERAGE HARDNESS VALUES CHART

Vickers Hardness	Knoop Hardness	Rockwell Hardness			RockwellSuperficial Hardness		
HV	HK	B	C	F	15-T	30-T	15-N
940	920	-	68	-	-	-	93.2
900	895	-	67	-	-	-	92.9
865	870	-	66	-	-	-	92.5
832	846	-	65	-	-	-	92.2
800	822	-	64	-	-	-	91.8
772	799	-	63	-	-	-	91.4
746	776	-	62	-	-	-	91.1
720	754	-	61	-	-	-	90.7
697	732	-	60	-	-	-	90.2
674	710	-	59	-	-	-	90.8
653	690	-	58	-	-	-	89.3
633	670	-	57	-	-	-	88.9
613	650	-	56	-	-	-	88.3
595	630	-	55	-	-	-	87.9
577	612	-	54	-	-	-	87.4
560	594	-	53	-	-	-	86.9
544	576	-	52	-	-	-	86.4
528	558	-	51	-	-	-	85.9
513	542	-	50	-	-	-	85.5
481	506	-	48	-	-	-	84.5
452	476	-	46	-	-	-	93.5
427	450	-	44	-	-	-	82.5
404	427	-	42	-	-	-	81.5
382	436	-	40	-	-	-	80.5
362	413	-	38	-	-	-	79.5
344	392	-	36	-	-	-	78.5
326	372	-	34	-	-	-	77.5
309	353	-	32	-	94.5	85.5	76.5
295	337	-	30	-	94.0	85.0	75.5
285	325	-	28.5	-	94.0	84.5	75.0

Vickers Hardness	Knoop Hardness	Rockwell Hardness			RockwellSuperficial Hardness		
HV	HK	B	C	F	15-T	30-T	15-N
266	304	-	25.5	-	93.0	83.0	73.5
248	283	100	22.5	-	92.5	81.5	72.0
234	267	98	20.0	-	92.0	80.5	70.5
220	251	96	17.0	-	91.0	79.0	69.0
209	239	94	14.5	-	90.5	77.5	68.0
198	226	92	12.0	-	89.5	76.0	66.5
196	224	94.0	11.4	110.0	90.0	77.5	66.2
194	222	93.5	10.8	109.5	89.8	77.2	65.9
192	219	93.0	10.2	109.2	89.7	77.0	65.6
190	217	92.5	9.6	109.0	89.6	76.6	65.3
188	215	92.0	9.0	108.7	89.5	76.3	65.0
186	212	91.5	8.4	108.5	89.4	76.0	64.7
184	210	91.0	7.8	108.2	89.2	75.7	64.4
182	208	90.5	7.2	108.0	89.1	75.4	64.1
180	205	90.0	6.6	107.5	89.0	75.1	63.8
178	203	89.0	6.0	107.2	88.8	74.7	63.5
176	201	88.5	-	107.0	88.6	74.4	63.2
174	198	88.0	-	106.7	88.5	74.0	62.9
172	196	87.5	-	106.5	88.3	73.6	62.5
170	194	87.0	-	106.2	88.2	73.3	62.0
168	192	86.0	-	106.0	88.0	73.0	61.8
166	190	85.5	-	105.7	87.9	72.5	61.6
164	187	85.0	-	105.5	87.7	72.2	61.4
162	185	84.0	-	105.0	87.6	71.8	-
160	182	83.5	-	104.7	87.4	71.5	-
158	180	83.0	-	104.5	87.2	71.0	-
156	178	82.0	-	104.0	87.0	70.5	-
154	176	81.5	-	103.5	86.8	70.1	-
152	174	80.5	-	103.0	86.6	69.8	-
150	172	80.0	-	102.7	86.4	69.5	-

Blue: STEELS (non-austenitic) (Ref. ASTM E140-06 Hardness Conversion Chart, Table 1)
Black: NICKEL ALLOYS (Ref. ASTM E140-06 Hardness Conversion Chart, Table 2)
Red: BRASS (C260) (Ref. ASTM E140-06 Hardness Conversion Chart, Table 3)
Green: COPPER (Ref. ASTM E140-06 Hardness Conversion Chart, Table 7)



NOT YOUR AVERAGE HARDNESS VALUES CHART

Vickers Hardness	Knoop Hardness	Rockwell Hardness		RockwellSuperficial Hardness	
HV	HK	B	F	15-T	30-T
148	169	79.0	102.5	86.2	69.0
146	167	78.0	102.0	86.0	68.5
144	165	77.5	101.5	85.8	68.0
142	162	77.0	101.0	85.6	67.5
140	160	76.0	100.5	85.4	67.0
138	158	75.0	100.0	85.2	66.5
136	156	74.5	99.5	85.0	66.0
134	153	73.5	99.0	84.7	65.5
132		73.0	98.5	84.5	65.0
130	138.7	72.0	98.0	84.3	64.3
128	136.8	71.0	97.5	84.0	63.6
126	134.9	70.0	97.0	83.7	63.0
124	133.0	69.0	96.5	83.4	62.5
122	131.0	68.0	96.0	83.1	61.8
120	129.0	67.0	95.5	82.7	61.2
118	127.1	66.0	95.0	82.4	60.5
116	125.1	65.0	94.5	82.0	60.0
114	123.2	64.0	94.0	81.5	59.3
112	121.4	63.0	93.0	81.2	58.7
110	119.5	62.0	92.6	80.7	58.0
108	117.5	61.0	92.0	80.3	57.0
106	115.6	59.5	91.2	79.9	56.0
104	113.5	58.0	90.5	79.5	55.2
102	111.5	57.0		79.0	54.5
100	109.4	56.0	87.0	78.5	53.5
98	107.3	54.0	85.5	78.0	52.5
96	105.3	53.0	84.5	77.5	51.5
94	103.2	51.0	83.0	77.0	50.5
92	101.0	49.5	82.0	76.5	49.0
90	98.9	47.5	81.0	75.5	48.0

Vickers Hardness	Knoop Hardness	Rockwell Hardness		RockwellSuperficial Hardness	
HV	HK	B	F	15-T	30-T
88	96.9	46.0	79.5	750	47.0
86	95.5	44.0	78.0	74.5	45.5
84	92.3	42.0	76.5	73.5	44.0
82	90.1	40.0	74.5	73.0	43.0
80	87.9	37.5	73.0		
78	85.7	35.0	71.0	72.5	37.5
76	83.5	32.5	69.0	71.5	36.0
74	81.1	30.0	67.5	70.0	34.0
72	79.9	27.5	66.0	69.0	32.0
70	76.8	24.5	64.0	67.5	30.0
68	74.1	21.5	62.0	66.0	28.0
66	71.9	18.5	60.0	64.5	25.5
64	69.5	15.5	57.7	62.8	23.5
62	67.0	12.5	56.0	61.0	21.0
60	64.6	10.0	54.0	59.0	18.0
58	62.0	-	51.5	57.0	15.5
56	59.8	-	49.0	55.1	13.0
54	57.4	-	47.0	53.2	10.0
52	55.0	-	44.0	51.5	7.5
50	52.8	-	41.5	49.5	4.5
49	51.5	-	40.3	48.5	-
48	50.3	-	39.0	47.4	-
47	49.1	-	37.5	46.2	-
46	48.0	-	36.0	45.0	-
45	46.5	-	34.8	44.0	-
44	45.9	-	33.5	43.0	-
43	44.3	-	32.0	42.0	-
42	42.7	-	30.5	41.0	-
42	42.7	-	30.5	41.0	-
40	40.2	-	28.0	38.5	-

MATERION

MATERION LOCATIONS

Main Office and Manufacturing Facility
Lincoln, Rhode Island

U.S. Sales/Technical Support
Aurora, Illinois
Lincoln, Rhode Island

International Sales/Technical Support

Europe
Stuttgart, Germany

Asia
Seoul, South Korea
Shanghai, China
Singapore
Tokyo, Japan

ABOUT MATERION

Materion is among the world's premier providers of advanced materials solutions and services. We offer a broad scope of products, services and expertise needed to drive our customers' growth and profitability and become a trusted partner. Materion Corporation common stock trades on the New York Stock Exchange under the symbol MTRN.

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