MATERION

DESIGN GUIDE

PREVIEW:

GUIDE TO HIGH PERFORMANCE ALLOYS

This is Materion's comprehensive guide with information to select and work with our high-performance alloys. The guide includes material chemistry, physical properties and testing data on many of our primary materials.

Table of Contents

Alloy Guide

Product Guide

Materion Value-Added Services

Processing and Fabrication Guide

Other Attributes and Application Engineering Data

Your Supplier

Typical Physical Properties

	Density[1]	Elastic Modulus	Thermal Expansion Coefficient	Thermal Conductivity		Melting Range[2]	Specific Heat Capacity	
				70°F / 20°C	200°F / 100°C		70°F / 20°C	200°F / 100°C
Materion Alloy	lb/in^3	10^6 psi	µin/in/°F, 70 °F to 400 °F	BTU/ft hr °F	BTU/ft hr °F	°F	BTU/lb °F	BTU/lb °F
	g/cm^3	GPa	µm/m/°C, 20 °C to 200 °C	W/m K	W/m K	°C	J/kg K	J/kg K
25, 190, 290	0.302	19	9.7	60	75	1600 - 1800	0.086	0.097
	8.36	131	17.5	105	130	870 - 980	360	406
M25	0.302	19	9.7	60	75	1600 - 1800	0.086	0.097
	8.36	131	17.5	105	130	870 - 980	360	406
165	0.304	19	9.7	60	75	1600 - 1800	0.086	0.097
	8.41	131	17.5	105	130	870 - 980	360	406
3	0.319	20	9.8	140	-	1900 - 1980	0.08	0.091
	8.83	138	17.6	240	-	1040 - 1080	335	381
10, 10X	0.319	20	9.8	115	-	1850 - 1930	0.08	0.091
	8.83	138	17.6	200	-	1010 - 1050	335	381
Brush 60®	0.318	20	9.8	128	-	1880 - 1960	0.08	0.091
	8.80	138	17.6	225	-	1030 - 1070	335	381
174	0.318	20	9.8	135	-	1880 - 1960	0.08	0.091
	8.80	138	17.6	235	-	1030 - 1070	335	381
Alloy 390®	0.318	20	9.8	128	-	1880 - 1960	0.08	0.091
	8.80	138	17.6	222	-	1030 - 1070	335	381
Alloy 390E	0.319	20	9.8	120	-	1850 - 1930	0.1	-
	8.83	138	17.6	208	-	1010 - 1050	419	-
360	0.299	28 - 30	8.0	28	-	2185 - 2420	0.11	-
	8.28	193 - 207	14.4	48	-	1200 - 1330	461	-
BrushForm® 158	0.325	18.5 - 21.0	9.1	22	27	1740 - 2040	0.09	0.10
	9.00	127 - 144	16.4	38	47	950 - 1115	377	419
BrushForm® 96	0.322	20	9.0	30	-	2012 - 1695	0.09	0.093
	8.91	140	16.2	52	-	1100 - 925	377	389
ToughMet® 3	0.325	21	9.1	22	27	1740 - 2040	0.09	0.10
	9.00	144	16.4	38	47	950 - 1115	377	419
ToughMet® 2	0.322	17	9.0	30	-	2012 - 1695	0.09	0.093
	8.91	117	16.2	52	-	1100 - 925	.381	391
Brush 1915®, 1916	0.320	18	9.8	120	-	1980	0.092	-
	8.86	124	17.6	210	-	1080	385	-
PerforMet™	0.314	18	9.7	100	110	1800	0.097	0.1
	8.69	124	17.5	175	210	980	405	425
MoldMAX HH®	0.302	19	9.7	-	75	1600 - 1800	0.086	0.097
	8.36	131	17.5	-	130	870 - 980	360	406
MoldMAX LH®	0.302	19	9.7	-	90	1600 - 1800	0.086	0.097
	8.36	131	17.5	-	155	870 - 980	360	406
PROtherm®	0.319	20	9.8	-	145	1900 - 1980	0.08	0.091
	8.83	138	17.6	-	250	1040 - 1080	335	381
MoldMAX XL®	0.322	17	9.0	-	40	1695	0.09	0.093
	8.91	117	16.2	-	70	925	377	389
MoldMAX V®	0.314	18	9.7	-	92	1800	0.095	0.098
	8.69	124	17.5	-	160	980	400	410

NOTE: 1) Tabulated properties apply to age hardened products. Before age hardening the density is: 0.300 lbs/in^3 for Alloys 25 and M25; 0.302 lbs/in^3 for Alloy 165; 0.316 lbs/in^3 for Alloys 3 and 10. 2) Melting Range is expressed as solidus - liquidus.

Mechanical and Electrical Properties of Plate and Rolled Bar Products

Alloy	Temper[1]	Heat Treatment Specification	Thickness	Tensile Strength	Yield Strength 0.2% Offset	Elongation	Rockwell Hardness	Electrical Conductivity
			in	ksi	ksi	Percent	B or C Scale	Percent IACS
			mm	MPa	MPa			
25 C17200	A (TB00)	3 hr 600-675 °F	0.5 to 8	60 - 85	20 - 35	20 - 75	B45 - 85	15 - 20
		3 hr 316-357 °C	12.7 to 203.2	410 - 590	130 - 250			
	H (TD04)	2 hr 600-675 °F	0.188 to .375	90 - 130	75 - 105	8 - 20	B91 - 103	15 - 20
		2 hr 316-357 °C	4.78 to 9.5	620 - 900	520 - 720			
		2 hr 600-675 °F	Over .375 to 1	90 - 125	75 - 105	8 - 20	B90 - 102	15 - 20
		2 hr 316-357 °C	Over 9.5 to 25.4	620 - 860	520 - 720			
		2 hr 600-675 °F	Over 1 to 2	85 - 120	75 - 105	8 - 20	B88 - 102	15 - 20
		2 hr 316-357 °C	Over 25.4 to 51	590 - 830	520 - 720			
		2 hr 600-675 °F	Over 2 to 3	85 - 120	75 - 105	8 - 20	B88 - 102	15 - 20
		2 hr 316-357 °C	Over 51 to 76	590 - 830	520 - 720			
	AT (TF00)	-	0.5 to 8	165 - 200	140 - 175	3 - 10	C36 - 41	25 - 30
			12.7 to 203.2	1140 - 1380	970 - 1200			
	HT (TH04)	-	0.188 to .375	180 - 215	160 - 200	1 - 5	C38 - 45	25 - 30
			4.78 to 9.5	1240 - 1490	1100 - 1380			
			Over .375 to 1	180 - 220	155 - 200	1 - 5	C38 - 44	25 - 30
			Over 9.5 to 25.4	1240 - 1520	1060 - 1380			
			Over 1 to 2	175 - 215	150 - 200	2 - 5	C37 - 43	25 - 30
			Over 25.4 to 51	1200 - 1490	1030 - 1380			
			Over 2 to 3	165 - 200	130 - 180	2 - 5	C36 - 42	25 - 30
			Over 51 to 76	1140 - 1380	890 - 1250			
165 C17000	A (TB00)	3 hr 600-675 °F	0.5 to 8	60 - 85	20 - 35	20 - 60	B45 - 85	15 - 20
		3 hr 316-357 °C	12.7 to 203.2	410 - 590	130 - 250			
	HT (TH04)	2 hr 600-675 °F	0.188 to .375	90 - 130	75 - 105	8 - 20	B92 - 103	15 - 20
		2 hr 316-357 °C	4.78 to 9.5	620 - 900	520 - 720			
		2 hr 600-675 °F	Over .375 to 1	90 - 125	75 - 105	8 - 20	B91 - 102	15 - 20
		2 hr 316-357 °C	Over 9.5 to 25.4	620 - 860	520 - 720			
		2 hr 600-675 °F	Over 1 to 2	85 - 120	75 - 105	8 - 20	B88 - 101	15 - 20
		2 hr 316-357 °C	Over 25.4 to 51	590 - 830	520 - 720			
		2 hr 600-675 °F	Over 2 to 3	85 - 120	75 - 105	8 - 20	B88 - 101	15 - 20
		2 hr 316-357 °C	Over 51 to 76	590 - 830	520 - 720			
	AT (TF00)	-	0.5 to 8	150 - 190	130 - 155	3 - 10	C33 - 39	25 - 30
			12.7 to 203.2	1030 - 1310	890 - 1070			
	HT (TH04)	-	0.188 to .375	170 - 210	135 - 165	2 - 5	C35 - 41	25 - 30
			4.78 to 9.5	1170 - 1450	930 - 1140			
			Over .375 to 1	170 - 210	135 - 165	2 - 5	C35 - 41	25 - 30
			Over 9.5 to 25.4	1170 - 1450	930 - 1140			
			Over 1 to 2	165 - 200	135 - 165	2 - 5	C34 - 39	25 - 30
			Over 25.4 to 51	1140 - 1380	930 - 1140			
			Over 2 to 3	160 - 190	125 - 165	2 - 5	C34 - 38	25 - 30
			Over 51 to 76	1100 - 1310	860 - 1140			
3 C17510 and 10 C17500	A (TB00)	3 hr 850-900 °F	1.75 to 5	35 - 55	25 - 45	20 - 35	B 20 - 45	20 - 30
		3 hr 454-482 °C	44.5 to 127	240 - 380	170 - 310			
	H (TD04)	2 hr 850-900 °F	0.188 to 3	70 - 85	55 - 80	2 - 8	B78 - 88	20 - 30
		2 hr 454-482 °C	4.78 to 76	480 - 590	380 - 550			
	AT (TF00)	-	1.75 to 5	100 - 130	80 - 100	8 - 20	B92 - 100	45 - 60
			44.5 to 127	690 - 900	550 - 690			
	HT (TH04)	-	0.188 to 3	110 - 140	100 - 120	5 - 15	B95 - 102	48 - 60
			4.78 to 76	760 - 970	690 - 830			
310	(Note 2)	-	(Note 2)	104 - 119	96 - 107	10 - 14	B98 min.[3]	45
			-	720 - 820	660 - 740			
ToughMet® 2 C96970	CX 90	-	2 to 12	105 min.	90 min.	3 min.	C27 min.	13 - 14
			50.8 to 304.8	720 min.	620 min.			
ToughMet® 3 C72900	AT 110	-	0.15 to 4.5	125 min.	110 min.	5 min.	C30 min.	7 - 8
			3.8 to 114.3	860 min.	760 min.			
C18000	TF00	-	0.5 to 8	90 nom	70 nom	14 nom	B90 min.	45 min.
			12.7 - 203.2	620 nom	480 nom			

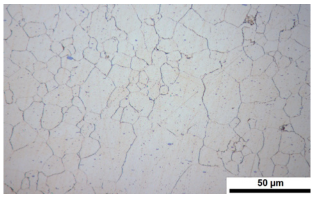
NOTE: 1) ASTM alphanumeric code for tempers. 2) Alloy 310 temper either AT (TF00) or HT (TH04) depending on size and shape. 3) Alloy 310 minimum HRB 98 hardness is a direct conversion from 230 HBS (Brinell test with a steel indenter).

Microstructures

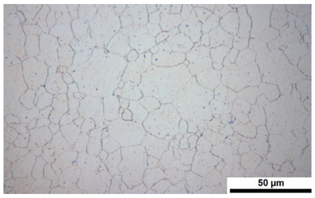
The combined effects of composition, cold work and thermal treatment are portrayed in the microstructure of each material.

Copper Beryllium

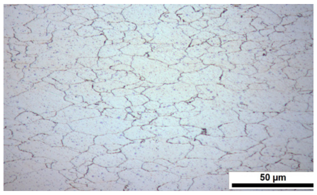
Microstructural features are revealed on a metallographicallyprepared sample by etching with ammonium persulfate/hydroxide or potassium dichromate. The former etchantdelineates grain boundaries in all tempers and displays coldwork effects in age hardened material. The latter etchantenhances the contrast of beryllides beyond the as-polishedcondition. Metallographic examination can thus be tailored to the processing conditions of the material.



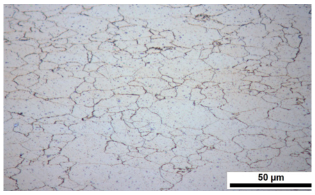
Alloy 25 A Transverse



Alloy 25 A Longitudinal

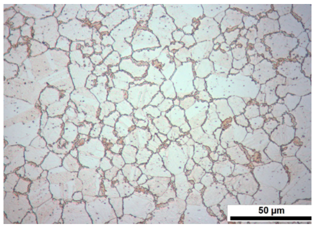


Alloy 25 H Transverse

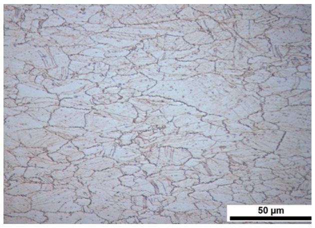


Alloy 25 H Longitudinal

The microstructure of solution annealed Alloy 25 A temper reveals an equiaxed grain structure with uniformly dispersed cobalt beryllides. The H temper microstructure for Alloy 25 shows the effect of a cold rolling reduction of 37% ofthe original thickness on the grain structure. Cold working elongates the grain structure in the working direction as can be seen in the longitudinal micrograph.

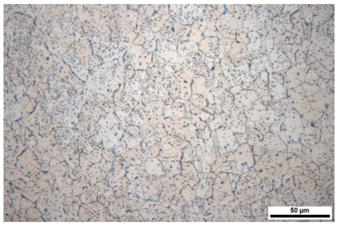


Alloy 25 AT Longitudinal

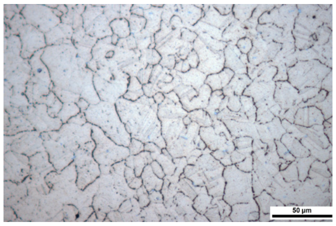


Alloy 25 HT Longitudinal

Alloy 25 is strengthened through the precipitation of gamma phase in the grain boundaries. As can be seen above, this also results in better definition in the grain boundaries in the micrographs. In fact when using micrographs to certify material shipping in either H or A condition, the puck being analyzed is placed in a salt bath to create this effect.

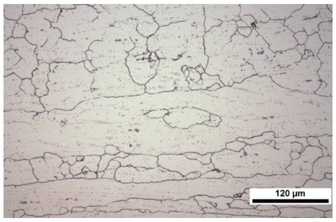


Alloy 3 AT Transverse

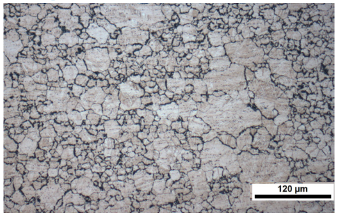


Alloy 3 HT Transverse

The high conductivity alloys are characterized by equiaxed grains with a fine dispersion of nickel or cobalt rich beryllides. The microstructural features, in this case for Alloy 3, are somewhat more difficult to develop by etching.

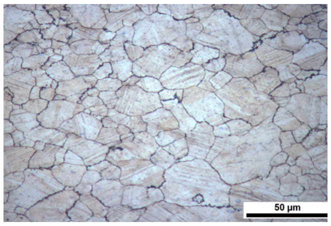


Alloy 25 AT Longitudinal

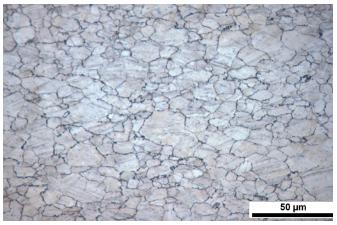


Alloy 25 AT Omega Longitudinal

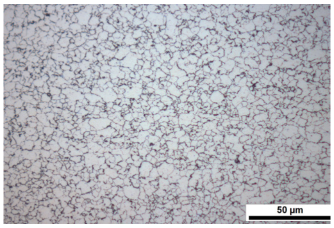
During the hot working processes the cast grain structure breaks down and recrystallizes. Some customers require a more uniform grain structure than what occurs during standard hot working. In response, Materion developed a special soaking process called omega soak designed to produce more equiaxed grains. Above is a comparison of the standard process to the Omega process.



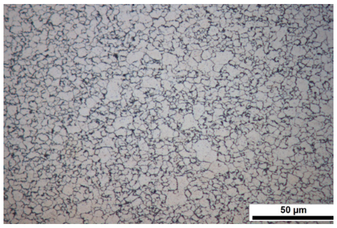
Alloy 190 HM



Alloy 190 XHM



Alloy 290 TM04



Alloy 290 TM06

The microstructure of Alloy 190 is similar to that of peak agedAlloy 25. The higher strength tempers are more heavily coldworked prior to mill hardening. Some grain boundary precipitateis visible. The 290 alloys show a more equiaxed microstructurewith a finer grain size than the 190 Alloys.

Fatigue Strength

Copper beryllium strip and wire have a long history of success in the cyclic stress environment of electrical and electronic contact springs. Copper beryllium in heavier sections also is used in components subject to cyclic loading. Examples include aircraft landing gear bushings, races and rollers in rolling-element bearings, and oil and gas well downhole drilling and measurement tools.

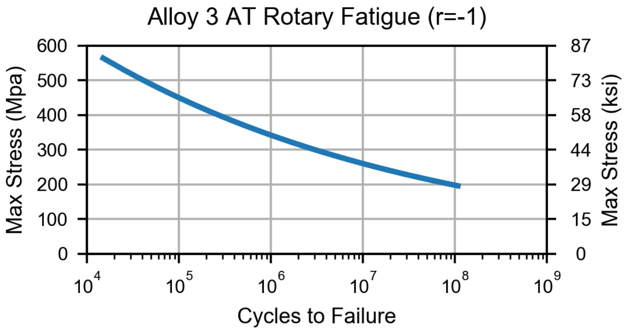
In these applications an outstanding characteristic of copper beryllium and copper nickel tin is their ability to withstand cyclic stress. Cyclic conditions are produced by cantilever bending, axial loading and rotational bending.

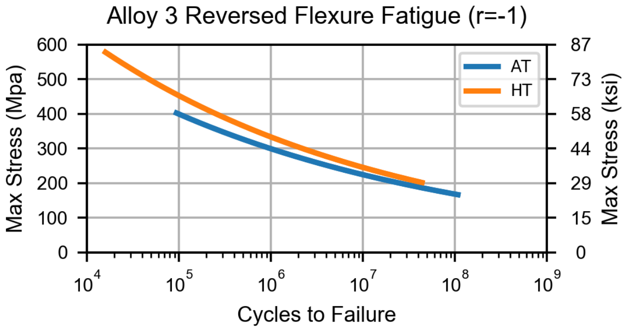
Fatigue strength is defined as the maximum stress that can be endured for a specified number of cycles without failure. Low cycle fatigue strength approaches the static strength. Unlike steels, copper alloys show a continuously falling S-N curve. Copper beryllium and copper nickel tin alloys resist fatigue failure with high static strength, toughness and an ability to diffuse strain by work hardening.

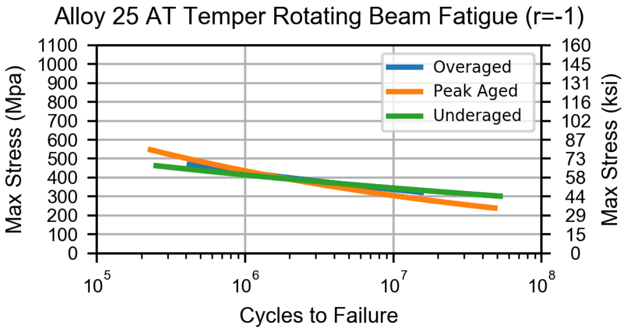
Copper beryllium and copper nickel tin fatigue curves are provided in the graphs on the next two pages. The ratio of minimum to maximum stress is termed the stress ratio, "R". This term defines the test conditions. Spring contacts deflected in a single direction (R = 0) display a higher fatigue strength than those flexed in reverse bending (R = -1). Rod also is measured in fully reversed (R = -1) rotating beam tests.

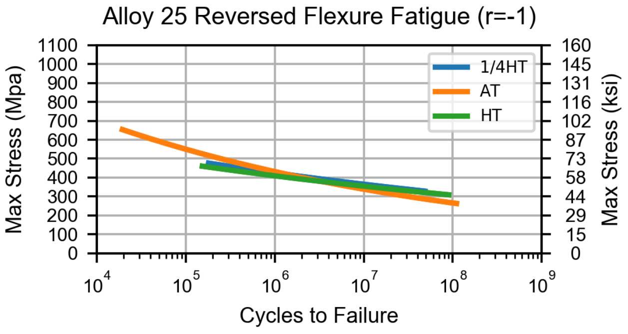
Standard tests measure fatigue behavior of flat springs and round beams. Some spring manufacturers have developed their own tests to suit their particular design requirements. Agreement among testing methods is generally good.

All curves shown on these pages are for testing in the longitudinal direction, unless otherwise specified. These charts serve as a guide, since fatigue performance depends on the surface condition and service stress state. Care should be taken to insure high surface quality, particularly at edges and fillet radii, to take maximum advantage of these important alloys. Furthermore, the curves represent a best fit of scattered data.


Alloy 3 AT Rotary Fatigue (r=-1)


Alloy 3 Reversed Flexure Fatigue (r=-1)


Alloy 25 AT Temper Rotating Beam Fatigue (r=-1)


Alloy 25 Reversed Flexure Fatigue (r=-1)

MATERION

Materion is the world's leading supplier of high-performance alloys, providing high-strength, high-conductivity copper and nickel beryllium products, and non-beryllium-containing specialty alloy products. With unparalleled technical expertise and global service, we are your first choice for the most demanding applications.

CONTACT OUR ENGINEERS FOR TECHNICAL INFORMATION FOR YOUR NEXT DESIGN:

TECHNICAL SERVICE

Tel: +1.800.375.4205
+1.216.692.3108
Email: BrushAlloy-Info@materion.com
Visit: www.Materion.com/Alloys

DOWNLOAD THE FULL GUIDE

GUIDE TO HIGH PERFORMANCE ALLOYS

6070 Parkland Boulevard
Mayfield Heights, OH 44124 USA
Toll-free: 1.800.375.4205
Phone: +1 216.383.6800
www.materion.com/alloys