

Materials Services
Copper and Brass Sales

Aluminum & Copper Mold Materials

for the plastics industry



thyssenkrupp



Aluminum & Copper Mold Materials for the Plastics Industry.

Copper and Brass Sales is a division of thyssenkrupp Materials NA, is the preeminent supplier and processor of nonferrous mold materials in aluminum and copper alloy products for the plastics molding industry.

Within the pages of this brochure, you will find useful information on nonferrous mold materials, stock availability, physical and mechanical properties, as well as extensive machining and welding data.

thyssenkrupp Materials NA, Copper and Brass Sales stocks a full line of alloys, shapes and sizes and is ready to process and ship these materials from one of our many service centers located throughout North America.

In addition to large dependable stocks of materials, our service doesn't stop when your order is placed. Our precision processing and value-added operations are ready and waiting to supply your order in immediately usable condition, when and where you need it.

At Copper and Brass Sales, we provide thick plate sawing of mold materials in sizes up to 40 inches thick. Standard sawing services with precision tolerances are also available. This saves you time and money by minimizing your need for costly additional machining.

As this publication illustrates, Copper and Brass Sales is your best source for complete inventory, precision processing, and fast delivery of nonferrous mold materials from stock.

For more information or to place an order, call our nearest service center toll-free at (800) 926-2600.

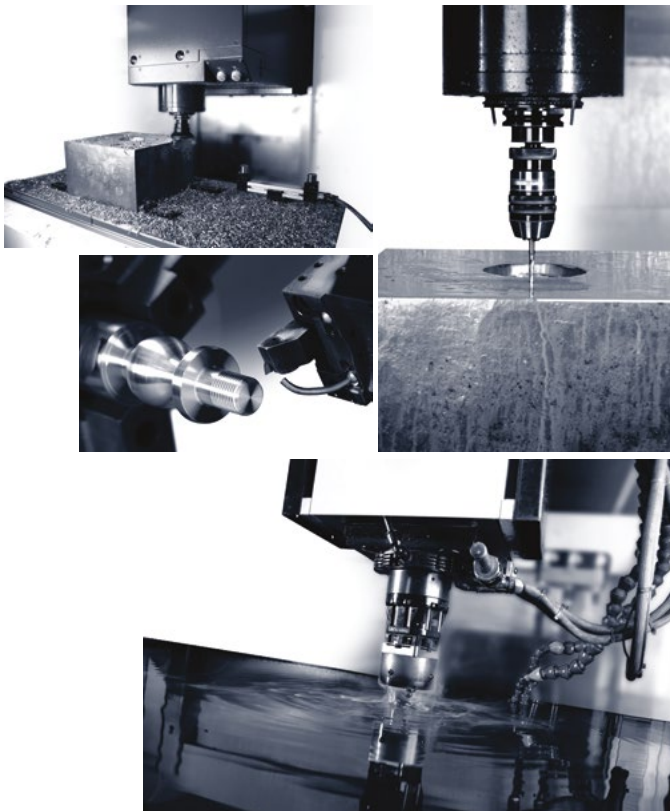
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Properties of Mold Materials

Name	Description	Size	Typical Properties (ksi)			Surface Hardness	Thermal Conductivity (Btu/ft/hr/ft ² /°F)	Specific Heat @ 70°F (Btu/Lb)	Poisson's Ratio	Charpy V-Notch Impact Strength (Ft-Lb)	Corrosion Resistance			Weldability	Machinability	Polishability	Avg. Coefficient of Thermal Expansion (x10 ⁻⁶ /in/in/°F) 68-212°F	Modulus of Elasticity (x10 ⁶ lb/in ²)	Density (lb/in ³)
			UTS	YTS	Elong%						General	Exfoliation	SCC						
Aluminum Alloys																			
tk Ultra 7 Mold Plate®	High Strength Wrought Aluminum	1	82	76	15	170-150 Hb	88	0.192	0.33		B	A	A	D	B 70%	Excellent	13.7	10.4	0.103
		4	81	74	11														
		6	80	72	7														
		8	80	70	5														
		10	75	68	4														
		12	74	66	4														
		16	71	62	4														
QC-10®	Arconic High Strength	1	81	78	15	170-150 Hb	92	0.210	0.33		B	A	A	D	B 70%	Excellent	13.7	10.4	0.103
		4	80	74	14														
		6	80	74	6														
		8	77	71	8														
		10	76	70	6														
		12	74	68	6														
		16	74	67	5														
Alumold 500®	Constellium High Strength Wrought Aluminum	1	85	78	10	175-150 Hb	88	0.205	0.33		C	C	C	D	B 70%	Excellent	13.2	10.4	0.102
		4	84	77	6														
		6	82	75	4														
		8	80	74	2														
		10	76	67	9														
		12	76	67	8														
		16	76	67	7														
Hokotol®	Aleris High Strength Wrought Aluminum	1				180 Hb	89		0.33		D	D	D	D	B 70%	Excellent	13.1	10.2	0.102
		4	83	77	8														
		6																	
		8	79	70	4														
		10																	
7022-T6511	High Strength Wrought Aluminum	1				160 Hb	75		0.33		C	C	C	D	B 70%	Excellent	13	10.4	0.101
		4	81	75	13														
		6	83	75	13														
		8	75	63	11														
		10	67	53	11														
7075-T651	High Strength Wrought Aluminum	1				150 Hb	75	0.209	0.33		C	C	C	D	B 70%	Very Good	13.1	10.4	0.101
		4	83	75	13														
		6	67	53	11														
		8	57	39	14														
		10	52	32	14														
Weldural®	Aleris High Strength Wrought Aluminum	4	66	51	7	130 Hb	71		0.33		C	C	C	A	C 50%	Good	13.5	10.7	0.102
		6																	
		8	63	48	6														
		10																	
		12	59	46	4														
		16	53	44	3														
2024-T351	Medium Strength Wrought Aluminum	1	67	46	18	120 Hb	70	0.209	0.33		D	D	D	B	B 70%	Good	12.9	10.6	0.100
		4	68	47	16														
		6	62	43	12														
6013-T651	Medium Strength Wrought Aluminum	1	57	51	11	120 Hb	95	0.214	0.33		A	A	A	A	B 70%	Very Good	13	10.1	0.098
		4	60	54	6														
		6	59	52	7														
		8	56	51	5														
6061-T651	Medium Strength Wrought Aluminum	1	46	42	14	95 Hb	96	0.214	0.33		A	A	A	A	C 50%	Good	13.1	10.0	0.098
		4	48	43	13														
		6	47	43	11														
		8	45	39	11														

Name	Description	Size	Typical Properties (ksi)			Surface Hardness	Thermal Conductivity (Btu/ft/hr/ft ² /°F)	Specific Heat @ 70°F (Btu/Lb)	Poisson's Ratio	Charpy V-Notch Impact Strength (Ft-Lb)	Corrosion Resistance			Weldability	Machinability	Polishability	Avg. Coefficient of Thermal Expansion (x10 ⁻⁶ /in/in/°F) 68-212°F	Modulus of Elasticity (x10 ⁶ lb/in ²)	Density (lb/in ³)
			UTS	YTS	Elong%						General	Exfoliation	SCC						
6061-T6	Medium Strength Wrought Aluminum	12 16	38 38	33 29	9	95 Hb	96	0.214	0.33		A	A	A	A	C 50%	Good	13.1	10.0	0.098
G.AL®C330R	Gleich Cast 7021	1-19	53	47	4	115 Hb	81	0.209	0.33		C	C	C	D	B 70%	Very Good	12.8	10.3	0.101
Max 5®	PCP Canada Cast 5083	3-41	41	18	16	70 Hb	81	0.215	0.33		A	A	A	A	B 70%	Very Good	13.2	10.3	0.096
G.AL®C210R	Gleich Cast 5083		41	18	10-15	70 Hb	81	0.215	0.33		A	A	A	A	B 70%	Very Good	13.2	10.3	0.096
ACP 5080R	Alime Cast 5083	1/4-4	41	18	15	70 Hb	81	0.215	0.33		A	A	A	A	B 70%	Very Good	13.2	10.3	0.096
Duramold 5™	Vista Metals Cast 5083	2-38	41	18	12-15	70 Hb	81		0.33		A	A	A	A	B 70%	Very Good	13.1	10.1	0.096
Alca 5®	PCP Canada 5083 CT&J	1/4-6	41	18	16	70 Hb	81	0.215	0.33		A	A	A	A	B 70%	Very Good	13.2	10.3	0.096
G.AL®C250	Gleich 5083 CT&J	5-41	41	18	10-15	70 Hb	81	0.215	0.33		A	A	A	A	B 70%	Very Good	13.2	10.3	0.096
ACP 5080	Alimes 5083 CT&J	5-42	41	18	15	70 Hb	81	0.215	0.33		A	A	A	A	B 70%	Very Good	13.2	10.3	0.096
ATP-5™	Vista Metals 5083 CT&J	1/4-4	41	18	12-15	70Hb	81		0.33		A	A	A	A	B 70%	Very Good	13.1	10.1	0.096
Mic-6®	Alcoa CT&J	1/4-4	24	15	3	65	Hb	83		0.33	C	C	C	D	C 50%	Good	13.1	10.3	0.101
Copper Alloys																			
MoldMAX High Hard®	Beryllium Copper	1/4-12	170	145	5	36-42 Rc	75	0.086	0.3	5						Excellent	9.7	19.0	0.302
MoldMAX Low Hard®	Beryllium Copper	1/4-12	140	110	15	26-32 Rc	90	0.086	0.3	12						Excellent	9.7	19.0	0.302
MoldMAX V®	Copper Nickel Silicon Chrome	1/2-8	125	105	7	28 Rc	92	0.098	0.3	5						Excellent	9.7	18.5	0.314
MoldMAX XL®	Copper Nickel Tin	2-12	115	105	6	30 Rc	40	0.090	0.3	15						Excellent	9.0	17.0	0.322
CDA 180	Copper Silicon Chrome	1/2-4	97	75	13	210 Hb	135	0.091	0.3	35						Very Good	9.7	19.0	0.320
Wearite 954™	Aluminum Bronze	1/4-4	94	50	20	196 Hb	36							60%		Very Good	9.0	18.0	0.269
Wearite 959™	Aluminum Bronze	1/4-3	90	50	0.5	286 Hb	25							60%		Very Good	9.0	15.0	0.260
Steel Alloys																			
1020			55	30	25	66 Rb	34	0.116	0.28	91							8.2	29.0	0.283
4140			95	58	26	197 Hb	25	0.113	0.28	40							6.8	29.0	0.283
P-20			150	130	15	26-34 Rc	17	0.110	0.28	50							6.8	29.0	0.282
S-7			275	230	10	55-62 Rc	17	0.110	0.28	10							6.8	29.0	0.282
H-13			200	170	10	50-54 Rc	16	0.120	0.28	6							6.0	23.0	0.281
420 SS Prehard			205	180	12	46 Rc	13	0.110	0.28								6.2	29.0	0.282

Shaded items are not currently stocked by the Copper and Brass Sales

Introduction to Mold Materials

Wrought Aluminum Alloys

tk Ultra 7 Mold Plate® — a high-strength 7000-series aluminum alloy designed for use in various mold-making applications such as injection molds or blow molds. tk Ultra 7 Mold Plate® has high thermal conductivity, high strength, consistent hardness throughout the thickness, and greater corrosion resistance than typical 7000-series aluminum alloys. Due to its chemistry and the heat treat practice, tk Ultra 7 Mold Plate® is a better choice over other high-strength alloys for resisting exfoliation corrosion and stress corrosion cracking.

QC-10® — This is a very high-strength aluminum mold plate especially developed for the injection mold market. It combines the highest strength and hardness by thickness for any aluminum mold product and maintains very high thermal conductivity. The product has very low quench sensitivity therefore it has very high uniform through thickness hardness even up to 24 inches in size. This results in very good stability when machining. It also has superior corrosion resistance for a 7xxx series mold alloy. It is produced to a minimum of .030 inch over nominal thickness.

QC-7® — This is a high-strength aluminum mold plate was designed for the injection mold market, die shoe and other end uses where high strength, uniform through thickness is desired. This product is produced to a minimum of .030 inch over nominal thickness.

Alumec 89 — This is a high-strength aluminum mold plate was designed for the injection mold market, die shoe and other end uses where high strength, uniform through thickness is desired. This product is produced to a minimum of .030 inch over nominal thickness.

Alumec 99 — This high-strength aluminum alloy has been developed with specifically to resist exfoliation and stress cracking corrosion in blow mold water lines. This resistance to corrosion will minimize the problems of cracked molds and blocked waterlines. It has mechanical and physical properties equal to or greater than 7075-T651 with much less quench sensitivity, resulting in more uniform properties throughout the thickness. It is produced to a minimum of .030 inch over nominal thickness.

Alumold 500® — This is a very high-strength aluminum mold plate developed for the injection mold market. It combines high strength and hardness through thickness and maintains very high thermal conductivity. The product has low quench sensitivity therefore it has very high uniform through thickness hardness. This results in good stability when machining.

HokotoI® — This is a very high-strength aluminum mold plate developed for the injection mold market. It combines high strength and hardness through thickness and maintains very high thermal conductivity.

7022-T6511 — This extruded, high strength alloy has higher hardness and tensile properties than 7075-T651. These properties are also more uniform through the thickness.

7075-T651 — This high-strength aluminum alloy is commonly used in the construction of injection and blow molds. It is a quench sensitive alloy, so thicker sections experience a variation in properties through the thickness.

Weldural® — This medium strength aluminum alloy is used in some injection and blow molds. This alloy tolerates prolonged exposure to elevated temperatures better than most heat treated aluminum alloys.

2024-T351 — This medium strength aluminum alloy is used in some injection and blow molds. This alloy can tolerate prolonged use at elevated temperatures better than most heat treated alloys.

6013-T651 — This medium strength aluminum alloy combines the high corrosion resistance, thermal conductivity, and weldability of 6061 with the higher hardness and strength of 2024. It machines with the same feed and speeds, chip sizes and surface finish that you experience with 7075 and 2024. It is produced to a minimum of .030 inch over nominal thickness.

6061-T651/T6 — This alloy is heat treated (and stress relieved in the case of T651) is generally suited for low pressure applications including large blow molds, Rim Molds, and structural foam molds. This alloy has excellent thermal conductivity but relatively low strength and surface hardness. Therefore this alloy is not recommended for applications requiring high strength and high hardness.

Cast Aluminum Alloys

C330R — This direct Chill cast aluminum plate exhibits very low internal stress. It has high strength for a cast product and machines well and is stable during machining. The product is available with a precision milled surface, as well as a sawn surface.

5083 Mold Plate — Direct chill cast aluminum plate exhibits very low internal stress. It also machines, welds and anodizes quite well. It is provided with a sawn surface on all 6 sides. It is suitable for low pressure mold applications. This product is sold under many brand names such as Max 5® (PCP Canada), Duramold 5® (Vista Metals), C210® (Gleich), and 5080R® (Alimex).

Mic-6® — This 7xxx series continuous cast aluminum tooling plate exhibits very low internal stress. It is provided with a milled surface (<20 RMS) on the top and bottom faces. It is suitable for use where flatness and stability are the desired characteristics.

5083 Tool & Jig Plate — DC cast aluminum tooling plate exhibits very low internal stress. It also machines, welds and anodizes quite well. It is provided with a milled surface (<20 RMS) on the top and bottom faces. It is suitable where flatness and stability are the desired characteristics. This product is sold under many brand names such as, Alca 5® (PCP Canada), ATP-5® (Vista Metals), C250® (Gleich), and ACP5080® (Alimex)

Copper Alloys

MoldMAX® HH/LH — These high-strength beryllium copper alloys are suitable for mold applications requiring high thermal conductivity, high hardness and high strength. The alloys are supplied in both 40 Rc and 30 Rc conditions. They offer good corrosion resistance, excellent polishability, food wear resistance, good polishability, excellent weldability and resistance to high temperatures (600°F). They can be used for entire molds or inserted into steel or aluminum molds.

MoldMAX PROtherm® — This very high thermal conductivity beryllium copper alloy is suitable for mold applications requiring more rapid removal of excess heat than can be attained with other materials. It offers excellent corrosion resistance, good polishability, excellent weldability and resistance to elevated temperatures (800°F). It is also suitable for gates and nozzle tips.

MoldMAX XL® — This Spinodally cast copper-nickel-tin alloy has a hardness similar to P-20 (Rc 30) and good thermal conductivity. It is highly polishable with very good corrosion resistance.

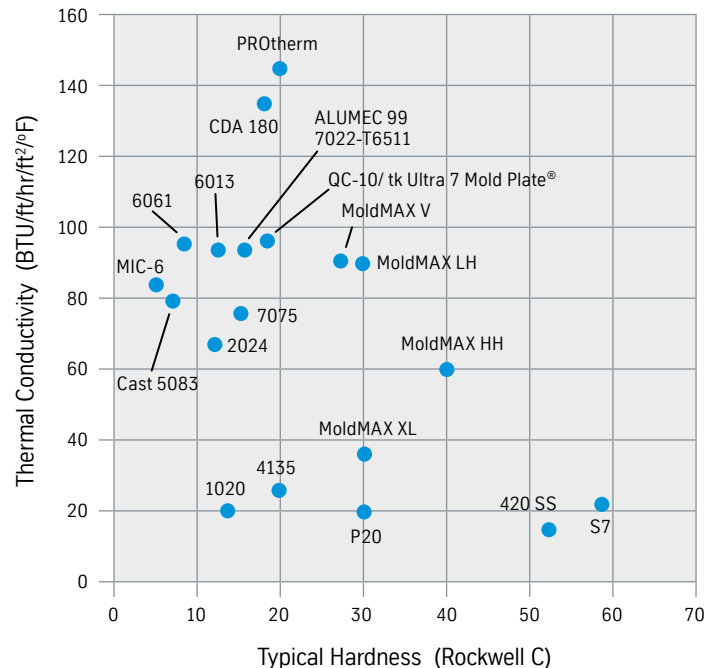
MoldMAX V® — This copper-nickel-silicon-chrome alloy combines excellent surface hardness and thermal conductivity and contain no beryllium. It is suitable for injection and blow molds and components. It combines very good corrosion resistance and polishability.

CDA 180 — This copper-nickel-silicon-chrome alloy features very high thermal conductivity, polishability, corrosion resistance and weldability. It is suitable for use in injection and blow mold components.

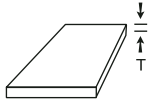
CDA 954 and CDA 959 — These aluminum bronze alloys are suitable for use in wear plates, guides, slides and other bearing applications.

Comparative Characteristics of Typical Mold Materials

Figures are approximate and shown for comparison only. For complete comparative properties see pages 5-6.



Aluminum Mold Materials

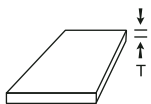


tk Ultra 7 Mold Plate^{®†}
Aluminum Mold Plate

Thickness in Inches					
1	2-1/4	3-1/2	5	8	14
1-1/4	2-1/2	3-3/4	5-1/2	9	16
1-1/2	2-3/4	4	6	10	18
1-3/4	3	4-1/4	6-1/2	11	20
2	3-1/4	4-1/2	7	12	24

QC-10^{®*†}
Aluminum Mold Plate

Thickness in Inches					
1	2-1/4	3-1/2	5	8	14
1-1/4	2-1/2	3-3/4	5-1/2	9	16
1-1/2	2-3/4	4	6	10	18
1-3/4	3	4-1/4	6-1/2	11	20
2	3-1/4	4-1/2	7	12	24



7075-T651
Aluminum Plate

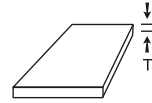
Thickness in Inches					
1/4	3/4	1-1/2	2-1/2	3-1/2	6
3/8	7/8	1-3/4	2-3/4	4	7
1/2	1	2	3	4-1/2	8
5/8	1-1/4	2-1/4	3-1/4	5	

2024-T351
Aluminum Plate

Thickness in Inches					
1/4	5/8	1-1/4	2	2-3/4	4
5/16	3/4	1-1/2	2-1/4	3	5
3/8	7/8	1-3/4	2-1/2	3-1/2	6
1/2	1				

6013-T651 Power Plate
Aluminum Plate

Thickness in Inches					
1/4	3/4	1-1/2	2-1/2	3-1/2	5-1/2
5/16	1	1-3/4	2-3/4	4	6
3/8	1-1/4	2	3	4-1/2	7
1/2	1-3/8	2-1/4	3-1/4	5	8
5/8					

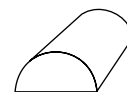


6061-T651*
Aluminum Plate

Thickness in Inches					
1/4	7/8	1-3/4	3-1/4	5-1/2	8
5/16	1	2	3-1/2	6	8-1/2
3/8	1-1/8	2-1/4	4	6-1/2	9
1/2	1-1/4	2-1/2	4-1/4	7	9-1/2
5/8	1-3/8	2-3/4	4-1/2	7-1/2	10
3/4	1-1/2	3	5		

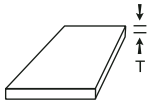
6061-T6
Aluminum Plate

Thickness in Inches					
8	9	10	11-1/2	14	16
8-1/2	9-1/2	11	12	15	



7022-T6511
Half Round Aluminum Bar

6 Inch Diameter



Cast Aluminum Mold Plate

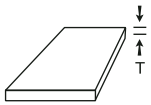
Thickness in Inches	5083	Thickness in Inches	5083
2		14	•
3		15	•
4		16	•
5	•	17	•
6	•	18	•
7	•	19	•
8	•	20	•
9	•	21	•
10	•	22	•
11	•	23	•
12	•	24	•
13	•		

Cast Aluminum Tool & Jig Plate

Thickness in Inches	Mic-6	5083	Thickness in Inches	Mic-6	5083
1/4	•	•	1-1/2	•	•
5/16	•		1-3/4	•	•
3/8	•	•	2	•	•
1/2	•	•	2-1/4	•	•
5/8	•	•	2-1/2	•	•
3/4	•	•	2-3/4	•	•
13/16	•		3	•	•
7/8	•	•	3-1/2	•	•
1	•	•	4	•	•
1-1/8	•	•	5	•	•
1-1/4	•	•	6		•

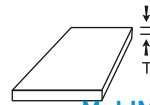
*Thickness tolerances are all on the plus side.
 †0.030" minimum added to the thickness with tolerances added to that dimension.

Copper Alloy Mold Materials



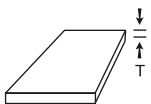
MoldMAX HH® High Hardness Beryllium Copper Plate

Thickness in Inches					
1/4	3/4	1-3/4	2-1/2	3-1/2	5
3/8	1	2	2-3/4	4	6
1/2	1-1/4	2-1/4	3	4-1/2	12
5/8	1-1/2				



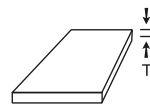
MoldMAX XL®

Thickness in Inches					
2	5	6	8	10	12
4					



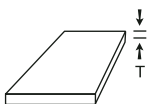
MoldMAX LH® Low Hardness Beryllium Copper Plate

Thickness in Inches					
1/4	3/4	1-1/2	2-1/4	3	4-1/2
3/8	1	1-3/4	2-1/2	3-1/2	6
1/2	1-1/4	2	2-3/4	4	12
5/8					



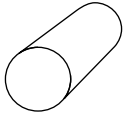
CDA 180 Copper Plate Heat Treated

Thickness in Inches					
1/2	1	1-1/2	2-1/4	3	
3/4	1-1/4	2	2-1/2	3-1/2	



MoldMAX V Beryllium Free Copper Plate

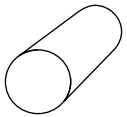
Thickness in Inches					
1	2	3			



|← D →|

MoldMAX HH®
High Hardness Heat Treated
Round Beryllium Copper Rod

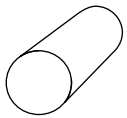
Diameter in Inches					
1/2	1-1/4	2-1/4	3	4-1/2	8
5/8	1-1/2	2-1/2	3-1/2	5	13-1/4
3/4	1-3/4	2-3/4	4	6	16-3/4
1	2				



|← D →|

MoldMAX V
Beryllium Free Round Copper Rod

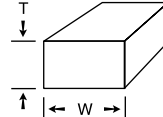
Diameter in Inches					
1/2	1-1/2	2	2-1/2	3	4
1					



|← D →|

CDA 180

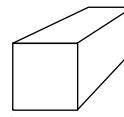
Diameter in Inches					
5/8	1	1-1/2	1-3/4	2-1/4	3
3/4	1-1/4	1-5/8	2	2-1/2	3-1/2
7/8	1-3/8				



↑ |← W →|

C954 Wearite
Rectangular Aluminum Bronze Bar

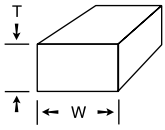
Thickness in Inches	Width in Inches	Thickness in Inches	Width in Inches	Thickness in Inches	Width in Inches
1/4	1	1/2	10	1	6
1/4	1-1/2	1/2	12	1	8
1/4	2	5/8	1	1-1/4	1-1/2
1/4	2-1/2	5/8	1-1/2	1-1/4	1-3/4
1/4	3	5/8	2	1-1/4	2
1/4	4	5/8	2-1/2	1-1/4	2-1/2
1/4	6	5/8	3	1-1/4	3
3/8	1	5/8	4	1-1/4	3-1/2
3/8	1-1/2	5/8	5	1-1/4	4
3/8	2	5/8	6	1-1/4	6
3/8	2-1/2	3/4	1	1-1/2	1-3/4
3/8	3	3/4	1-1/2	1-1/2	2
3/8	3-1/2	3/4	2	1-1/2	2-1/2
3/8	4	3/4	2-1/2	1-1/2	3
3/8	5	3/4	3	1-1/2	3-1/2
3/8	6	3/4	4	1-1/2	4
1/2	1	3/4	5	1-1/2	5
1/2	1-1/4	3/4	6	1-1/2	6
1/2	1-1/2	3/4	8	1-3/4	2
1/2	1-3/4	3/4	12	1-3/4	2-1/2
1/2	2	1	1-1/4	1-3/4	3
1/2	2-1/4	1	1-1/2	1-3/4	4
1/2	2-1/2	1	1-3/4	2	2-1/2
1/2	3	1	2	2	3
1/2	3-1/2	1	2-1/2	2	4
1/2	4	1	3	2	6
1/2	5	1	3-1/2	2-1/2	3
1/2	6	1	4	2-1/2	4
1/2	8	1	5	2-1/2	5



|← S →|

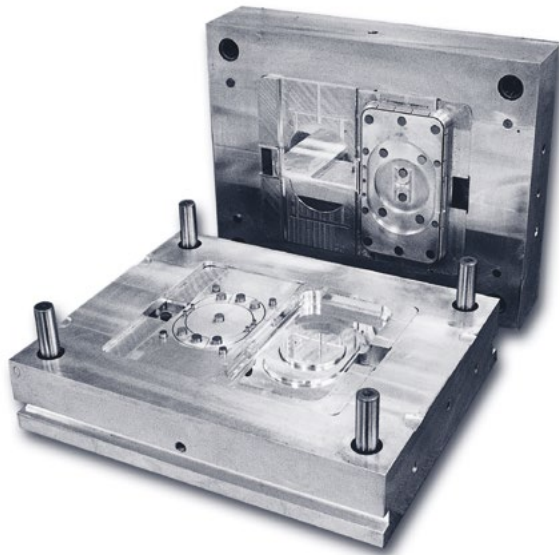
C954 Wearite
Square Aluminum Bronze Bar

Thickness in Inches					
3/4	1-1/4	1-1/2	2	2-1/2	3
1					



C959 Wearite
Rectangular Aluminum Bronze Bar

Thickness in Inches	Width in Inches	Thickness in Inches	Width in Inches	Thickness in Inches	Width in Inches
1/4	1	5/8	2	1	5
1/4	2	3/4	1-1/2	1	6
1/4	3	3/4	2	1-1/4	1-1/2
3/8	1	3/4	3	1-1/4	2
3/8	2	3/4	4	1-1/4	2-1/2
3/8	4	3/4	5	1-1/4	6
1/2	1	3/4	6	1-1/2	2
1/2	2	1	1-1/2	1-1/2	3
1/2	3	1	2	2	3
1/2	4	1	2-1/2	2	5
1/2	6	1	3	2-1/2	4
5/8	1-1/2	1	4	2-1/2	5



An injection mold from QC-10 aluminum.

General Machining Guidelines for Aluminum Plate

Machining Aluminum and Aluminum Alloys

Traditional machining operations, such as turning, milling, and drilling, are easily performed on aluminum and its alloys. Optimum machining conditions such as rotational speeds and feed rates are achieved on machines designed for high speed operation.

The specific properties of aluminum alloys must be considered:

- Their density allows high speeds of rotation and translation as the inertia of aluminum alloy swarf is less than that of steel.
- Their modulus of elasticity, which is one third that of steel, requires appropriate chucking and clamping arrangements to avoid deformation and distortion.
- Given the high rate of chip removal, the heat generated by the machining process is taken away with the chip — without having the time to diffuse into the metal. Unlike steel, there is no need to provide heat treatment of the “stress-free annealing” type during machining.

Cutting Force

The specific cutting force needed to machine aluminum alloys is far less than is required for steel. For the same section of swarf, the force for aluminum is one third of that required for low-carbon steel. If the same cutting force is applied, chip removal is much higher with aluminum alloys.

Tooling

The geometry of the cutting tools should be designed for use with aluminum alloys. The life of tools for cutting aluminum is much longer than tools for machining steels, all other factors being equal.

Lubrication/Coolant

Lubrication is a very important factor in the machining of aluminum alloys, and has several functions:

1. Cool, or dissipate the heat generated by cutting friction.
2. Prevent material from bonding to the tools.
3. Remove chips from the point of machining.
4. Lubricate cutting edge to reduce cutting friction

Direct coolant flooding at the point of cutting operation contact is recommended for optimal machining of QC-10. The composition of cutting fluids must be compatible with aluminum alloys.

Basic Machining

Wrought aluminum plate up through 10 inches thick (QC-10 up through 30 inches thick) has been stress relieved by either stretching (T651) or cold compression (T652). Even though these products are stress relieved, they all have some degree of residual stress remaining. These stresses are caused by the rapid quenching of the metal after solution heat treatment. Generally speaking, the higher the strength of the alloy, the higher the degree of residual stress in the plate. This rapid quenching cools the top and bottom of the plate much quicker than the center of the plate, creating the stresses on the plate's surfaces.

To minimize distortion caused by these residual stresses, you should follow these basic machining practices:

1. Always machine using a good grade of coolant with a pH between 7-8 and is free of chlorides.
2. Use cutting tools of HSS, solid carbide or insert type that are designed for aluminum.
3. Important — sharp corners and tight radii should be avoided to avoid creating stress risers. Sharp corners and tight radii can focus the stresses and reduce the fatigue strength of aluminum.
4. Machine (or grind) .040 to .060 inches of material from each side of the plate.
5. Rough machine the plate to remove the majority of the metal to be machined, but leave enough metal to allow for finish machining, if there is distortion.
6. Unclamp the plate, and allow to rest 8-10 hours before finish machining. This will allow time for distortion to occur, if it is going to happen.
7. Shim and re-clamp the plate in the fixture for final machining, taking care not to distort the plate by clamp pressure, then finish machine.
8. Re-cut the top and bottom surfaces to flat.
9. It is not recommended to thermally stress relieve any heat treated aluminum, as this will compromise.

Machining 6013-T651

1. Use the same basic instructions outlined above.
2. Compared with 6061-T651, you should increase feed and speed rates 25% - 40%, depending on the length and diameter of cutting tool and the cuts being made. Even if you are running at the maximum speed of your equipment, it may still be possible to increase the feed rate beyond that for 6061-T651.
3. 6013-T651 will exhibit about 75% fewer burrs than 6061 due to the hardness of the alloy and the ease of chip breaking.
4. The surface finish should also be approximately 25% smoother than 6061, which should reduce finishing costs.

Treating of Cooling Water in Molds

All aluminum alloys are susceptible to various types of corrosion. The most common corrosion types are general, galvanic, exfoliation and stress cracking (SCC). To minimize corrosion, certain steps should be followed:

1. Keep water pH neutral, 7 - 8 is ideal, 6.5 - 8.5 is acceptable.

2. Dispersed rust, dissolved metals, chlorides, heavy metals, and phosphates in the water system can lead to corrosion in aluminum.
3. Avoid chlorinated biocides, as chlorine attacks all of the metals in the water system.
4. Verify that all additives used in the water system are compatible with all materials in the cooling system.
5. Monitor and maintain the water system composition.
6. Most high strength alloys have been heat treated to achieve maximum properties. This will make them more susceptible to exfoliation and stress cracking corrosion. Alloys that are overaged, such as QC-10 and Alumec 99, resist exfoliation corrosion and stress cracking corrosion.
7. Galvanic corrosion can be prevented by eliminating contact of two dissimilar materials in a moist environment. The use of Teflon tape on brass fittings isolates the fitting and the mold block. If using a copper alloy insert in an aluminum body, with a water channel passing through both alloys, apply a coating on the back side of the copper, such as electroless nickel, as a barrier to contact between the copper and the aluminum.

QC-10®

Machining Recommendations

QC-10 machines 8 to 10 times faster than P20 steel. The machine time savings result in lower mold costs and faster mold delivery times. Also, since QC-10 machines more easily, your cutting tools last longer.

EDM Guidelines

Wire EDM

- Recommended wire — 0.010" coated brass wire
- Machine settings — same as for copper

Conventional EDM

QC-10 can be machined utilizing conventional EDM practices. The following recommendations are only guidelines and will vary depending on specific machining requirements and different makes and models of EDM equipment

- Pure copper electrodes are recommended using positive polarity. If an electrode with one square inch of surface area is used, a starting voltage of 100 Volts is recommended, with 9 milliseconds on, and 10 milliseconds off, at a feed rate of 15 inches per minute.
- A 50% duty cycle is recommended as a starting guideline, modified as dictated by finish requirements.

QC-10 Milling Speeds and Feeds

Machining Process	Tool Description	Cutting Speed (sfm)	Feed Rate (in/tooth)	Depth Of Cut (in)		
				RPM	IPM	
Roughing	4" carbide insert face cutter	5,000	0.012 – 0.025	0.2 – 0.25	5,000	250 – 300
Roughing	1" roughing 4 flute end mill	3,500	0.01 – 0.02	0.2 – 0.25	10,000	500 – 600
Finishing	1/2" 2 flute carbide ball mill	2,500	0.005 – 0.010	0.03 – 0.06	10,000	350 – 400

Turning

Machining Process	Tool Description	Cutting Speed (sfm)	Feed Rate (in/rev)	Depth Of Cut (in)		
				RPM	IPM	
Single Point Turning	Single point Carbide Insert	6,000	0.01 – 0.03	0.05 – 0.10	5,000	50 – 150

Standard Drilling

Machining Process	Tool Description	Cutting Speed (sfm)	Feed Rate (in/rev)	Drill Size (in)		
				RPM	IPM	
Standard 2 Flute Drilling	Carbide Drill	2,000 –	0.005 – 0.010	1/2 – 1	12,000	60 –
		2,500				120

Gun Drilling

Machining Process	Tool Description	Cutting Speed (sfm)	Feed Rate (in/rev)	Drill Size (in)		
				RPM	IPM	
Standard 2 Flute Drilling	Carbide Insert Hollow Point Spade Gun Drill	300 –	0.005	5/8 – 1	2,000	5
		400				

Welding

Repair Welding

Welding QC-10 aluminum is no more difficult than welding a piece of steel. What needs to be understood is that the welding characteristics and proper procedures must be followed and performed to ensure a successful weld.

QC-10 mold surfaces are repairable in several ways:

- GTAW (Gas Tungsten Arc Welding).
- Removal of the damaged area by machining and inserting a new section of QC-10 using the 'freeze plug' method.
- In extreme cases the entire mold surface can be re-cut, providing there is enough material to ensure the molds integrity.

Cleaning and Surface Preparation

Aluminum will combine with oxygen to form an aluminum oxide layer. This layer will form instantly as the aluminum surface is ground or machined. The aluminum oxide layer while very thin can also be very porous. The oxide layer will readily trap moisture, oil,

grease and other materials adding to the potential for hydrogen pick-up. The aluminum oxide layer provides excellent corrosion resistance; however this layer must be removed before welding as it prevents fusion due to its higher melting point (3,700°F) whereas aluminum melts at 1,050°F. The weld arc gas molecules, the fore hand (push) technique, mechanical cleaning, wire brushing, solvents and chemical etching are used for the oxide removal. When un-cleaned aluminum is welded, the aluminum under the aluminum oxide coating will melt but the aluminum oxide coating will stay solid and act as a membrane. When this membrane is finally penetrated, the melted membrane will mix with the melted aluminum and contaminate the weld area.

Aluminum Filler Wire

Using Alcoa's QC-10 filler wire will reduce crack potential and give excellent adhesion properties and color match. It is very important to clean the filler wire of all contaminants and oxidation. Just as the mold surface has the invisible oxide layer, so does the QC-10 filler wire. This needs to be removed prior to the welding process. Using a Scotch Brite pad and following with acetone or M.E.K. cleaner is an excellent method for cleaning the filler wire. Welding wire stored loosely might appear clean but the oxide layer and oils must be removed. It is important to store a filler wire in a closed dry place. Please pay attention to the oxide layer removal and pre-cleaning of the weld rod. The welded parts/mold must be clean of all oxides, oil residue, moisture, steel particles and other contaminants. If not cleaned properly, the contaminants will float to the surface and contaminate the weld.

Clean as follows:

- Use a carbide de-burring tool to clean. The purpose is to remove all contaminants instead of pushing them into the softer aluminum surface.
- Use acetone or M.E.K. cleaning solution to remove oily residue, use a clean lint-free cloth.
- Use a stainless steel brush ONLY.
- The use of aluminum cleaner is ok. (This is a mild etching solution to remove contaminants.)
- If you clean and don't immediately weld after removing the oxide layer, re-clean with acetone or M.E.K prior to welding.

The most common commercial QC-10 aluminum alloy welding methods use an electric arc and a tungsten electrode plus QC-10 filler wire using AC current, either alternating or square wave form. The arc is protected by argon gas (or helium-argon gas mix) to shield the weld pool and the electrode from the surrounding atmosphere. Arc TIG welding is easy to use, attains a high temperature, provides high heat input and most important is easy to regulate during the welding process.

GTAW (TIG) Welding of Aluminum

For most economical and quality welds, TIG is recommended for aluminum on injection molds. A good TIG weld produces a regular ripple finish and on both sides of the seam there is a narrow de-oxidized zone.

TIG Welding Equipment Set Up:

1. Welding gas — use only 99.995% (N4.5) and up pure welding / shielding gas.
2. Only zirconated tungsten electrodes with a diameter of 2.4mm are to be used.
3. Water cooled systems are preferred for current ranges of 100A and above.
4. Check the diffuser screen periodically on the TIG gun to ensure an even gas flow. (The diffuser screen could be contaminated with tungsten particles and would cause a insufficient gas shielding, resulting in a contaminated weld.)
5. Ensure that the ceramic cup is large enough and WITHOUT cracks in order to ensure proper gas shielding during welding. Micro cracking will generate a venturi effect and a dirty weld (smut).
6. The end of the tungsten electrode must be ground, reducing the tip diameter to 2/3 of the overall diameter and then pre weld on a TEST piece of aluminum to remove any loose tungsten splatter before welding on the QC-10 work piece.
7. Use 75% helium / 25% argon as a shielding gas. Use for aluminum due to high heat conductivity of aluminum.
8. Shielding gas flow — depends on the amperage — usually 15 to 25 L/min of shielding gas.

After each welding pass, you MUST clean the next pass area from the slight smut with a stainless steel brush in order to prepare for the next welding pass.

You MUST preheat the tungsten of the torch by creating an arc on a test piece before you attempt the next welding pass on your work piece. This should only take about 3 seconds. Without this, the tungsten will embed tungsten particles into the weld piece thus contaminating the weld.

ALUMEC 99

Repair Welding

This information presents the generally recommended procedures for repair welding these materials, however, in practice these procedures (weld preparation, welding parameters, and conditions) will have to be developed and qualified in accordance with the approval of the mold maker or user to ensure that the welds produced are of acceptable integrity for the specific service conditions of the intended application.

Surface Preparation

- Machine or chip open any cracks or other surface breaks to their full depth. Taper the groove depth at both ends.
- Pre-weld cleaning and oxide removal are very important to successful mold plate welding.

Residual machining lubricants and moisture will produce porosity in welds. Prior to welding, vapor degrease or solvent clean and dry the base metal to remove these surface contaminants.

Aluminum's natural oxide melts at 3,700°F (2,035°C) while aluminum melts at approximately 1,200°F (650°C). This oxide can

act as a barrier to adequate fusion between the weld and base metal. Usually, a light brushing with either a stainless steel hand brush or power brush will remove the oxide film.

Pre-weld Preparation

On some large molds, a preheat may be required. In most cases, welding can be performed without a preheat by using an argon and helium shielding gas mixture. If a preheat is required, the temperature should be limited to 250°F (120°C) maximum to maintain a high thermal gradient during welding to avoid weld cracking. If multiple passes are required, maintain a maximum interpass temperature of 150°F (66°C).

Welding

Mold repairs can be performed with either the gas metal arc (GMAW) or the gas tungsten arc (GTAW) welding processes. The GTAW process is the preferred method for mold repair, because it lends itself to excellent control of the welding arc when repairing cavities or building up corners in confined areas. However, the GMAW process, providing faster rates of metal deposition than GTAW, will result in a lower rate of heat input to the parent metal and therefore a narrower heat affected zone and reduced weld induced distortion.

In these materials, the strength of the parent metal is considerably higher than that achievable in welds. However, the strongest welds are obtained using a 5xxx filler alloy, such as 5356, 5556, 5654, or 5087. Using a 4xxx filler such as 4145 or 4043 will minimize the tendency for weld cracking in high strength mold materials, hence they may be more suitable where surface aesthetics or smoothness are important, although their use results in a softer and less abrasion resistant weld than 5xxx fillers.

The preferred shielding gases depend on the welding process and filler alloys being used for repairs.

- AC-GTAW, any filler — 50% He + 50% Ar
- DC-GTAW, any filler — 95% He + 5% Ar
- GMAW with 4xxx filler — 100% Ar
- GMAW with 5xxx filler — 75% He + 25% Ar

Welding parameters will vary depending upon the type of repair being made and material thickness. Specific parameters can be found in various welding handbooks such as *Welding Aluminum — Theory and Practice* from The Aluminum Association. When using the GTA-W process for making repair welds, use either pure tungsten or zirconiatype electrode(s). These electrodes perform well when used with alternating current, as they retain a balled end during welding and have a high resistance to contamination.

Peening the individual weld beads immediately following their deposit minimizes weld cracking. This procedure stretches the weld metal and reduces residual stress. Less residual stress reduces both weld cracking and distortion of the mold.

EDM Guidelines

See QC-10®

Machining Recommendations

See QC-10®

5083

Repair Welding of 5083

Welding Procedure

The welding shall be done semi-automatically using the GMAW (gas metal arc welding) process.

Filler Metal

The aluminum wire to be used shall be selected with regard to the mechanical and/or chemical properties of filler and base metals used as well as to the number of passes necessary for the required weld. We choose 5356 alloy in order to have more ductile properties and viability of filler alloy.

Gas Protection

The shielding gas shall conform to the following nominal compositions:

- Argon 100%
- Argon 75% and He 25%

These gases shall have a dew point of at least -76°F (-60°C).

Position

The welding shall preferably be done in the flat position, but other positions such as horizontal, vertical and overhead are permissible providing the proper datasheets are supplied and approved and the welders are qualified for one or all positions.

Preheat

No welding shall be done when the base metal temperature is below 0°F (-20°C). For temperatures below 32°F (0° C), the joint and adjacent surfaces, 3 inches (75mm) each side of weld, shall be preheated to 70°F (20°C). Preheat may be done either electrically or with a neutral flame. Minimum preheat temperature will be verified using a contact pyrometer or a temperature indicator pencil (Tempil Stick). The maximum preheat temperature and maximum interpass temperature should be 150°C (350°F). The maximum holding time when preheat and interpass temperature is 150°C should be less than 15 minutes in order to avoid ALMg₂ precipitation well at joint boundary which can lead to stress corrosion fracture.

Heat Treatment and Stress-Relief Heat Treatment

No post weld treatment is planned on parts after welding.

Electrical Characteristics

Electrode wire shall be used with gun and wire feed connected to a DC power source, characteristic volt ampere curve is constant voltage. Electrode wire will be on positive circuit pole (DCRP) and as per manufacturer's instructions. Description of type of welding current (DC), reverse polarity (RP), and amperage and voltage recommended for the process and electrode wire diameters covered by the specification shall be shown on every welding procedure data sheet.

Welding Technique

The work shall be positioned for flat position welding whenever practicable. The classification and size of electrode, arc length, voltage and amperage shall be suitable for the thickness of the base metal, type of groove, welding positions and other circumstances pertaining to the work and shall conform to the manufacturer’s instructions.

All aluminum wire used with Argon 75% / He 25%:

	Amperage Range	Voltage Range	Stick Out
.045in (1.2mm)	1608 – 300	238 – 30	3/8 – 5/8in
.062in (1.6mm)	1908 – 400	258 – 32	1/2 – 3/4in

Thickness and Width of Layers

The welding current or wire feed speed, arc voltage, and speed of travel shall be such that each pass will have complete fusion with adjacent base metal and weld metal, and there will be no overlap or excessive porosity or undercutting. The maximum thickness of layers shall not exceed 3/16 inch (5mm) and multipass welding shall be used if the width of bead exceeds 5/8 inch (16mm). One pass fillet welds shall not exceed 1/2 inch (12mm) in horizontal position and 5/16 inch (8mm) for overhead.

Protection

Gas metal arc welding with external gas shielding shall not be done in a draught or wind unless the weld is protected by a shelter. This shelter shall be of material and shape appropriate to reduce wind velocity in the vicinity of the weld to a maximum of 7-1/3 feet (223.5cm) per second.

Alignments

Butt welds: Nozzle will be perpendicular to welding joints. On the length of weld, nozzle will be between 10° to 15° push angle.

Fillet welds: Nozzle will be adjusted with an angle of 40° to 50° from vertical. On the length of weld, nozzle will be between 10° to 15° push angle.

Preparation of Base Material

The edges of parts to be joined by welding shall be prepared by grinding, machining and by plasma. Where hand cutting is involved, the edges shall be ground to a smooth surface. All surfaces and edges shall be smooth, uniform and free from fins, tears, cracks or any other defects which could adversely affect the quality and strength of the weld. All oxide, rust, moisture, grease or other foreign material that could prevent proper welding or produce objectionable fumes shall be removed. The base material shall be welded in the next six hours after the cleaning. If it is not possible, the joint shall not be exposed to any dirt by protecting it correctly. The cleaning can be done with chemical solvents or other mechanical ways like milling, sanding or brushing (stainless steel) depending on the condition of the surface to clean. Brushes that have been previously used on steel or copper alloys should not be used on aluminum.

CDA 180

Welding

GTAW (TIG) Procedures

- Preheat: 500°F (necessary only if piece is large)
- Gas: Helium at a flow rate of 45 - 55 CFH, or argon at a flow rate of 20 CFH
- Current: AC or DC, straight polarity
- Amperage: Varies, depending on size of piece and application
- Voltage: 5 - 25 (automatic on GTAW welding machines)
- Tungsten Diameter: 3/32" - 1.8"
- Filler Rod Diameter: 1/16" - 3/32"

Types of Filler Rod

Several types of filler rod may be used successfully. The best and easiest to apply are any of the AMPCO-TRODE® rods. Hardness and application desired will dictate which is most appropriate. For a higher localized hardness, 420SS or 17-4SS may be used with great success. This will result in a much higher hardness in a localized area, but will maintain outstanding thermal conductivity. Stellite may also be used in certain applications.

Electronic Discharge Machining

Wire EDM

- Wire Specification: 0.010" diameter, full hard brass wire
- Machine Settings: Similar to those for P20 tool steel

Conventional EDM

- Electrodes: Premium grade or copper graphite
- Polarity: Negative electrode polarity
- Amperage: 30 Amps or less is not as effective since the heat generated by the EDM spark is quickly dispersed. 50 to 60 Amps seems to overpower the thermal conductivity of the material and is more efficient.
- Surface Finish: Surface finish will be 30% better compared to steel at the same power settings

Machining

Coolant and Cutting Oil

- Coolant: All operations may be performed with soluble oil, 1 part to 50 parts water, applied as a spray mist.
- Tapping: "TAP MAGIC" or equivalent.
- Cutting Oil: NOT recommended when machining copper alloys except on screw machine operations where it performs as a coolant and lubricant. To prevent metal oxidation, finished parts MUST be cleaned with a detergenttype solvent.

Grinding

Silicon carbide and aluminum oxide wheels can be used. As a general rule, the selection of the grinding wheel is best left to the wheel manufacturer, since so many variables must be considered. Emulsions of soluble oil and water are satisfactory grinding fluids.

Turning

Carbide Tool	Roughing	Semi-finish	Finish
SFM	300	700	950
Feed	.009	.006	.003

Face Milling

Carbide Insertable	Roughing
SFM	350
Feed	.005 @ .250

End Milling

Solid Carbide	Roughing
SFM	350
Feed	.005

Drilling

Solid Carbide	
SFM	150
Feed/Rev.	.007

Tapping

HSS	
SFM	30

MoldMAX HH[®]/LH[®] and MoldMAX SC[®] (PROtherm[®])

Welding

Surface Preparation

Best results are obtained with a clean surface, free of dirt, oil, paint, grease, tarnish and oxide. Conventional cleaning, such as solvent or vapor degreasing, is effective in removing organic contaminants. Aggressive brushing, abrasive blasting, or acid pickling is required for adherent contaminants such as oxides. Cleaned parts should be welded immediately. If a delay is unavoidable, they should be stored in a protected environment away from shop dust, acid and sulfurous or ammonia fumes.

Filler Metal

Beryllium copper rod should be used as the filler metal in welding beryllium copper to other metals or to itself. Beryllium copper alloy C17200 (Brush Alloy 25) rod is available in all common gauges, with 3/32 and 1/8 inch (2.38 and 3.18mm) the most widely used as filler stock. Wire coil, including fine wire, is also available. Both the high strength and high conductivity beryllium copper use C17200 filler. Alternatively, an aluminum bronze filler (ERCuA1-A2) is often used in welding beryllium copper to steel. Filler metal must be clean, and should be stored in a fume-free environment.

When high conductivity beryllium copper is welded using alloy C17200 filler, it is necessary to homogenize the part at 1,475 - 1,550°F (800- 850 °C) to prevent cracking during subsequent solution annealing.

Arc Welding Procedures

Because of the formation of refractory beryllium oxide films, the gas shielded arc welding techniques offer the only successful methods for fusion welding beryllium copper. With a matching filler metal, both TIG (GTAW) and MIG (GMAW) welding are suitable. TIG is commonly used for sections up to about 0.25 inch (6mm) thick, while MIG welding is widely used for up to 2 inch (50mm) thick material. Thin strip, less than 0.04 inch (1mm) thick can be butt welded using the TIG torch only (without filler) or fine wire MIG. In general, the high thermal conductivity of copper alloys may necessitate preheating the work to maintain fluidity in the weld pool. When preheating is required, 400°F (200°C) is usually adequate.

For shielding gases, welding grade (low oxygen) argon or helium are used, either alone or mixed. Carbon dioxide is not used, and nitrogen is used only in mixtures. Gas mixtures provide improved heat input, higher speeds, deeper penetration and improved weld quality.

Thin section beryllium copper may be square butt welded, but thicknesses above 3/16 (4mm) require a 60-90 degree V butt or a U butt. A 1/16 inch (1.5mm) root gap should be allowed in all sections thicker than 1/16 inch. Periodic tack welds will prevent distortion and misalignment in long welds. Flange or lap weld configurations are desirable, and horizontal welding is always preferred because of the high fluidity of the beryllium copper weld pool. When welding beryllium copper to other metals, the formation of complex phases in the weld can be minimized with small weld pools, characteristic of pulsed MIG welding.

The TIG welding electrode is a sharp thoriated tungsten rod designated EWTh1 or EWTh2. An AC power source is usually preferred because the weld pool agitation assists in dispersing the oxide for smoother welding conditions and better welds. For use with a DC source, the straight polarity (electrode negative) condition carries higher current and prevents electrode erosion. The control afforded by TIG welding is well suited for small local repair work.

The high metal deposition rate in MIG welding favors this procedure for thick sections and larger jobs. The power source is DC, electrode positive. Typical MIG welding conditions are 24 - 32 volts, 250 - 450 Amps, 0.5 - 1.0 in³/min (10 - 15 cm³/min) wire feed rate, 5 - 10 liters/min argon flow rate. For beryllium copper, the high side of the manufacturer's recommended amperage range for copper alloys should be used for finer, more uniform metal transfer.

MoldMAX XL®

Weld Repair

Weld repair allows tool repair or design changes to be carried out. MoldMAX XL® can be repair welded and areas of the mold can be built up. Welding procedures outlined below apply to the Gas Tungsten Arc Welding (GTAW) process utilizing MoldMAX XL® welding rod available from Brush Wellman. Welding with other filler materials, such as copper alloys, or even tool steel, may be possible but has not been studied.

The area to be welded should be prepared by removing any surface deposits, fluids, etc., that could contaminate the weld. Cracks should be prepared by pre-machining all evidence of the crack and rounding all edges. Welding electrodes should be 1/8 inch diameter, 2% thoriated tungsten with a pointed tip (20 - 25 degree included angle). Argon is the recommended shielding gas at a flow rate of 25 CFH. Preheat and interpass temperatures should be limited to 300°F. Direct current electrode negative polarity and current levels of 180 to 200 Amps are recommended.

The weld, in the as-welded condition, will exhibit a heat affected zone of lower hardness than the surrounding material. Hardness levels may be restored to Rc 25, without affecting the hardness of the base metal by following the recommended post weld heat treatment. The welded component should be heated to 740°F (±10°F) for a period of 180 minutes. The post-weld heat treatment should be tightly controlled. Once the piece has been at the recommended temperature for the recommended time, allow it to air cool to room temperature.

If extensive welding is to be carried out — for example, a major design change — consider replacing the affected area with an insert of MoldMAX® LH especially in an area of the tool that is expected to be damaged repeatedly. Alternatively, carry out the post-weld heat treatment periodically and keep the component temperature under 300°F when welding.

Industrial hygiene precautions for welding should be followed in accordance with the Material Safety Data Sheet for this material.

- Data courtesy of Brush Wellman, Inc.

Machining MoldMAX

Milling (Roughing)

MoldMAX	Tool Material	Cutting Speed (sfm)	Feed Rate (in./tooth)	Depth of Cut (in.)
HH	C-2 Carbide	375-800	0.004-0.015	0.1-0.2
LH	C-2 Carbide	500-1000	0.004-0.015	0.1-0.2
V	C-2 Carbide	350-500	0.003-0.006	0.1-0.2
XL	C-2 Carbide	800-2400	0.005-0.015	0.1-0.15
SC	C-2 Carbide	800-2000	0.005-0.008	0.1-0.15

Milling (Finish)

MoldMAX	Tool Material	Cutting Speed (sfm)	Feed Rate (in./tooth)	Depth of Cut (in.)
HH	C-2 Carbide	400-1500	0.001-0.003	0.1-0.10
LH	C-2 Carbide	500-1500	0.001-0.003	0.1-0.10
V	C-2 Carbide	400-1500	0.001-0.004	0.1-0.10
XL	C-2 Carbide	800-2400	0.001-0.005	0.1-0.10
SC	C-2 Carbide	800-2000	0.001-0.005	0.1-0.10

Turning

MoldMAX	Tool Material	Cutting Speed (sfm)	Feed Rate (in./tooth)
HH	C-2 Carbide	900-1200	0.01-0.02
LH	C-2 Carbide	1200-1500	0.01-0.02
V	C-2 Carbide	900-1400	0.003-0.010
XL	C-2 Carbide	1200-3000	0.01-0.02
SC	C-2 Carbide	1500-2000	0.01-0.025

Drilling

MoldMAX	Tool Material	Cutting Speed (sfm)	Feed Rate (in./tooth)
HH	Cobalt Steel	100-300	0.002-0.009
LH	Cobalt Steel	100-400	0.002-0.009
V	Cobalt Steel	125-200	0.002-0.007
XL	Cobalt Steel	150-500	0.002-0.005
SC	Cobalt Steel	125-500	0.002-0.005

*The high conductivity of MoldMAX alloys may result in the drill bit binding. Grinding the point slightly off-center may alleviate this problem.

Sink EDM

MoldMAX	Electrode*	Polarity	Current	Voltage	Duty Factor	Estimated Burn Rate
HH	Copper	Negative	50	220	50%	2 cm./hr.
LH	Copper	Negative	50	220	50%	1.8 cm./hr.
V	Copper	Negative	60	220	50%	1.8 cm./hr.
XL	Copper	Positive	40	110	90%	2.5 cm./hr.
SC	Copper	Negative	50	220	50%	1.3 cm./hr.

*Graphite electrodes can be used, but wear rates may be up to 2-4 times greater.

Notes

Notes

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