

## **Modified 1% Chromium Copper**

This alloy, a modification of the CDA-815 alloy, has an excellent combination of electrical and thermal conductivity and strength. CDA-815 permits 0.4-1.5% Chromium and the conductivity is increased by holding this to the low side.

The following properties are typical:

<b>Property</b>	<b>Range</b>
Tensile Strength (PSI)	35-50,000
Yield Strength (PSI)	23-40,000
% Elongation	20-30
Hardness (RB)	68-78
Electrical Conductivity (% I.A.C.S.)	78-85
Thermal Conductivity (C.G.S.)	0.77
Coefficient of Expansion (in/in C at R.T.)	17x10 <sup>-6</sup>
Density (Pounds/Cubic Inch)	.032

The chemical composition is:

Chromium	0.4 - 1.2 %
Silicon	0.15 max %
Copper	Balance

The castings are normally solution heat treated at 1865-1885 degrees F in a protective atmosphere. This dissolves the chromium and the rapid water quench which follows retains the chromium in solution. In this form, the alloy has poor conductivity and is soft. Aging 880-900 degrees F for one to five hours raises the hardness from below the RB scale to 68-78 RB and the conductivity increases from about 41% I.A.C.S. to about 85% I.A.C.S. If lower hardness is desired, the castings can be overaged to a softer condition without lowering the conductivity.

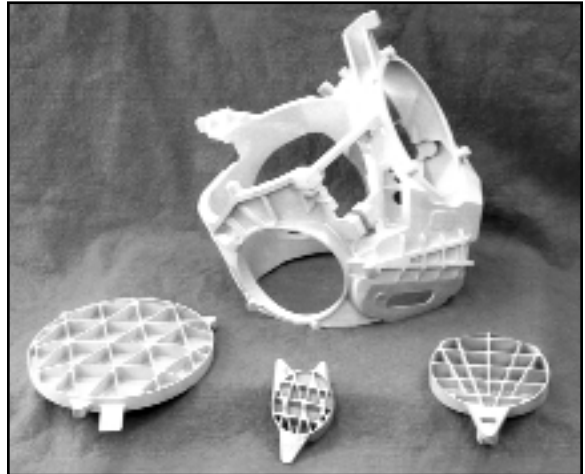
Modified Chromium Copper can meet the property requirements of Resistance Welders Manufacturing Association Group A, Class 2.

This alloy's high conductivity makes it ideal for applications such as arms for gun welders, circuit breaker parts, contact backings, and heat sinks for computer devices as well as other current carrying components.

## ***O'Fallon Casting's Process, Casting Complexity, and Unique Material Combine to Satisfy Customer Needs***

The accompanying photograph depicts an Afocal Housing and related mirrors used by Lockheed Martin on an EOSS, Targeting System for a Military Helicopter. The unique material was a Silicon Carbide Metal Matrix Composite (SiC MMC) cast to near net shape by O'Fallon Casting utilizing their countergravity casting techniques.

Due to both time and cost restraints, and compounded by the high probability of future design changes, it was necessary to produce the complex 14" x 16" x 17" afocal housing from SLA (stereolithography) patterns. The afocal housing mates with the three SiC MMC high quality mirrors which were also cast by O'Fallon Casting. It was critical that all parts be produced in the same alloy to maintain a constant CTE (Coefficient of Thermal Expansion).



The following comments were furnished by Lockheed's Program Procurement Manager.

"In order to push the state-of-the-art stand-off ranges and perform under temperature extremes encountered by the modern warfighter on it's EOSS Targeting System, Lockheed Martin needed an extremely stiff mirror set and thermally matched housing for the afocal subassembly. Achieving the near perfect optical wavefront error meant aluminum mirrors were too flimsy, sagging under their own weight. Beryllium would have provided the required stiffness, but thermally matching the housing meant a Beryllium afocal housing hogout, which would have been cost prohibitive, if it could be done at all in the large complex housing geometry. The SiC MMC mirrors and housings provide the stiffness, thermal match and castability."

O'Fallon Casting accepted this challenging project.

Three factors make the part unique.

- The casting was produced from SLA patterns. It was necessary to CAD/CMM inspect the patterns and the castings, both before and after heat treatment, to verify dimensional accuracy.
- The material was a Silicon Carbide Metal Matrix Composite (SiC MMC). O'Fallon Casting is the major producer of SiC MMC investment castings.
- The casting was produced utilizing our countergravity casting techniques which has proven to be the process of choice for this family of alloys. This process excels in casting highly viscous alloys and provides a well-controlled casting method with minimal metal turbulence.

Silicon Carbide Metal Matrix Composites are routinely cast by O'Fallon Casting with SiC concentrations of up to 40%. 20 and 30% are more commonly required and specified by our customers.

We, and our customer, are pleased to have participated so successfully on this very critical application.

## ***Silicon Carbide Metal Matrix Composite Alloys (SiC MMC)***

This family of alloys is relatively new to designers and users of near net shape investment castings.

Silicon Carbide (SiC) particles, ranging in size from about 12 to 38 microns, are added to the standard aluminum alloys in volumes of 20 to 40 percent. 20% or 30% are more commonly specified to achieve the following advantages with lower density than other alloy alternatives.

- High Stiffness (Young's Modulus)
- Low Coefficient of Thermal Expansion (CTE)
- Long Term Dimensional Stability
- High Thermal Conductivity
- High Wear Resistance
- Good Dampening Characteristics
- Higher Strength

O'Fallon Casting has achieved much success and expertise in the casting of 20-40% Silicon Carbide Metal Matrix Composites (SiC MMC). The advantages listed above have contributed to the increased use of these alloys for the following applications.

- High Speed Automated Precision Machinery
- Silicon Wafer Processing Equipment
- Robotics
- High Quality Reflective Mirrors
- High Performance Bicycle Junctions and Components
- Brake Parts
- Optical and Laser Equipment
- Semiconductor Manufacturing Equipment

Cast Metal Matrix Composite (MMC) materials satisfy these needs and requirements. The material is readily melted and cast into complex geometries utilizing our counter-gravity casting techniques.

O'Fallon Casting's near net shape investment cast Silicon Carbide Metal Matrix Composite (SiC MMC) alloys can offer a lower cost alternative to high-Beryllium content alloy applications. Near net shape investment castings can also decrease the cost of subsequent secondary operations of these difficult to machine alloys.

When customer's requirements and annual usages justify, adjustments may be made to the base alloy (A356, A359, or A360) and the particle size to "tailor" the CTE and machinability to your specific needs. Higher silicon content of the base alloy can reduce the CTE to even lower values than those shown in the accompanying Table 1 (on reverse side), while smaller particle size can increase the machinability.

Please let our process, our expertise and this family of alloys offer a solution to your ever increasing design requirements by forwarding your inquiry to O'Fallon Casting.

**Table 1. Typical Property Comparison for MMC and Traditional Engineering Alloys**

Material Property	Units	Si C Metal Matrix Composite			A356-T6	Class 30 Gray Iron
		20%	30%	40%		
Matrix	Vol %	359Al-80	359Al-70	359Al-60	-	-
Reinforcement	Vol %	20	30	40	-	-
Elastic Modulus	MSI	14.3	17.4	21.3	10.5	14.7
	Gpa	99	120	147	72	101
Density	lb/in <sup>3</sup>	0.0989	0.1011	0.1040	0.0970	0.2580
	g/cm <sup>3</sup>	2.74	2.80	2.81	2.69	7.14
Specific Stiffness	in x 10 <sup>9</sup>	144.6	172.1	205.4	108.2	57.0
	Gpa-cm <sup>3</sup> /g	36.1	42.9	51.2	26.7	14.1
Mean CTE (to 212°F)	ppm/°F	9.1	8.1	6.6	11.9	5.6
	(to 100°C)	ppm/°C	17.5	14.6	11.9	21.4
Thermal Conductivity	BTU/ft-hr-°F	107	107	107	88	27
	W/m-°C	185	185	185	152	46
Specific Heat	BTU/lb-°F	0.20	0.19	0.17	0.21	0.12
	J/kg-°K	837	795	763	900	502
Tensile UTS	KSI	52	31.4	32.7	38	30
	MPa	359	216	226	262	207
Tensile YS (0.2%)	KSI	44	30.5	28.9	27	N/A
	MPa	303	210	199	N/A	
Tensile Elongation	%	<1.0	<1.0	<1.0	5.0	N/A

Note: The above values are "typical" and are being furnished for "informational purposes" only.

## **Aluminum and Copper Base Alloys**

### **Aluminum Alloys**

Aluminum Alloy castings represent the major portion of O'Fallon Casting's business. Most aluminum alloys are heat treatable and therefore can be furnished with the most optimal physical properties for the end product.

**356** and **A356** are the most common and economically produced aluminum alloys cast by O'Fallon Casting. These alloys are readily cast in complex, thin walled configurations with an excellent surface finish. They also combine good strength and corrosion resistance and are the first alloy preference for electronic housings within the investment casting industry.

Also routinely cast are aluminum alloys **A357** and **C355**. Alloy A357, and the Beryllium free variation **F357**, are stronger than A356 and should be specified when higher properties are required. Alloy C355 is also stronger than A356, especially at elevated temperatures, but is less ductile.

Other aluminum alloys cast at O'Fallon Casting are **D712** (also known as 40E) which is easily brazable, and **A201** (also known as KO-1), the highest strength cast aluminum alloy currently available. These alloys are significantly less castable than A356. By utilizing our countergravity casting techniques we are able to cast these difficult to cast alloys in complex configurations.

Silicon Carbide Metal Matrix Composites: Please refer to our separate technical sheet regarding the unique characteristics of this family of alloys.

### **Copper Base Alloys**

Some copper base alloys can be more difficult to cast than aluminum alloys since they often combine with oxygen in the atmosphere to form oxides. Oxide formation can be reduced by our countergravity (CLA) casting techniques. This CLA process offers a significant advantage to casting copper base alloys due to the low turbulence experienced during the casting operation.

Beryllium Copper-20C (**C82500**) and Silicon Brass (**C87400**) represent the most common and most castable of the copper base alloys. BeCu-20C is heat treatable and is often specified for electrical conductivity and non-sparking hand tool applications.

Other copper base alloys routinely cast by O'Fallon Casting include Yellow Brass (**C85400**), Red Brass or 85-5-5-5 (**C83600**), Aluminum Bronze - Grade C (**C95400**) and Navy G (**C90300**). These alloys are specified for their machinability, corrosion resistance and/or wear characteristics.

See reverse for alloy charts.

### ALUMINUM ALLOYS

Alloy (UNS Nbr)	Similar Designation	Castability	Condition	TYPICAL MECHANICAL PROPERTIES			Remarks
				Strength PSI		% Elong	
				Tensile	Yield		
354 (A13540)		Very Good	T6	43,000	33,000	2	Premium quality alloy
C355 (A33550)	AMS 4215	Very Good	T6	37,000	30,000	1	Premium quality alloy; good strength & corrosion resistance
	ASTM B 618		T6	36,000	25,000	2.5	
356 (A03560)	AMS 4260	Excellent	T6	33,000	22,000	3	Most popular aluminum alloy
A356 (A13560)	AMS 4218	Excellent	T6P	33,000	27,000	3	Good strength, corrosion resistance, stability & weldability — poor brazability
	ASTM B 618		T6	34,000	24,000	3.5	
A357 (A13570)	AMS 4219	Very Good	T6P	41,000	32,000	3	Higher strength than A356
F357	AMS 4289	Very Good	T6	41,000	32,000	3	Same as A357 except no Beryllium
D712 (40E) (A47120)	ASTM B 26	Poor	T5	34,000	25,000	4	Self aging alloy; good brazing characteristics
A201 (K01) (A02010)	AMS 4229	Poor	T7	60,000	50,000	3	Highest strength alloy— excellent machinability
	ASTM B 618		T6	60,000	50,000	5	

### PREMIUM QUALITY ALUMINUM

#### AMS A 21180 From Separately Cast Test Bars

		Class	1	2	3	10	11	12
A356-T6	Tensile Strength PSI		38,000	40,000	45,000	38,000	33,000	32,000
	Yield Strength, PSI (0.2% offset)		28,000	30,000	34,000	28,000	27,000	22,000
	Elongation, % in 2"		5	3	3	5	3	2
A357-T6	Tensile Strength PSI		45,000	50,000	-	38,000	41,000	45,000
	Yield Strength, PSI (0.2% offset)		35,000	40,000	-	28,000	31,000	35,000
	Elongation, % in 2"		3	5	-	5	3	3

### COPPER BASE ALLOYS

Alloy (UNS Nbr)	Similar Designation	Castability	Condition	TYPICAL MECHANICAL PROPERTIES			Remarks
				Strength PSI		% Elong	
				Tensile	Yield		
BeCu 20C (C82500)	AMS 4890	Excellent	Sol HT Hardened	60,000 150,000	20,000 120,000	30 2	Easiest to cast; most popular
Aluminum Bronze Grade C (C95400)	ASTM B 148	Poor	As Cast Heat Treated	75,000 90,000	30,000 45,000	12 6	Excellent corrosion resistance
Silicon Brass (C87400)	ASTM B 584	Very Good	As Cast	50,000	21,000	18	Good castability
Red Brass 85-5-5-5 (C83600)	AMS 4855 ASTM B 584	Very Good	As Cast	30,000	14,000	20	Good machinability; pipe fittings
Yellow Brass (C85400)	ASTM B 584	Poor	As Cast	30,000	11,000	20	Better machinability than naval brass; pipe fittings
Navy G (C90300)	ASTM B 584	Fair	As Cast	40,000	20,000	20	Bearings, bushings