COPPER ALLOYS LTD

Highly Engineered Alloys
for Extreme Environments

elite ALLOYS THERMAL

Beryllium copper alternative
forgings and components

CAL C700
CAL C800
CAL C900

copperalloys.net

Benefits of using Elite Thermal Alloys

Highly Engineered Alloys for Extreme Environments

High Strength

> Can be manufactured to a range of high strength properties depending on the customer's requirements.

High Hardness

> High modulus of elasticity compared with other copper based alloys.
> No embrittlement at sub-zero temperatures.

High Conductivity

> Exhibits both high heat and electrical conductivity properties.

Corrosion Resistant

> High resistance to seawater corrosion and industrial atmospheres.
> Excellent all-round corrosion resistance.
> Immune to hydrogen embrittlement.

Biofouling resistant

> Effectively resists the deposition and build-up of marine organisms.

Low Magnetic Permeability

> Virtually non-magnetic.

Excellent anti-galling and wear resistant properties

> Very resistant to pick-up even against stainless steel.

Good machinability

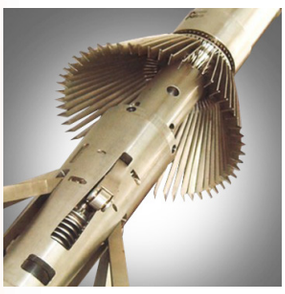
> Easily machined to an extremely fine finish and close tolerances.
> Good dimensional stability.

Non Sparking

> An important property when the component is in contact with potentially explosive environments.

Uniform Fine Grain Structure

> Detailed ultrasonic inspection - most ultrasonic procedures / acceptance criteria accommodated to ensure material is sound.
> Uniformity of mechanical and physical properties.



Creating new options for engineers

Highly Engineered Alloys for Extreme Environments

The Elite Thermal Alloys benefit from a unique combination of properties make it the ideal material choice for equipment requiring high strength and high conductivity.

The Elite Thermal Alloys have been designed by our renowned metallurgists to give an advantage to engineers working in extreme environments.

Specifying Elite Thermal Alloys will reduce reliance on toxic high cost materials such as beryllium copper.

Performance can be improved and service life extended by using these alloys, resulting in significant cost advantages in oilfield exploration and processing, moulding applications, fine measurement tooling and other applications where high wear resistance and conductivity are important.

Specify the Elite Thermal Alloys to lock-in these benefits.

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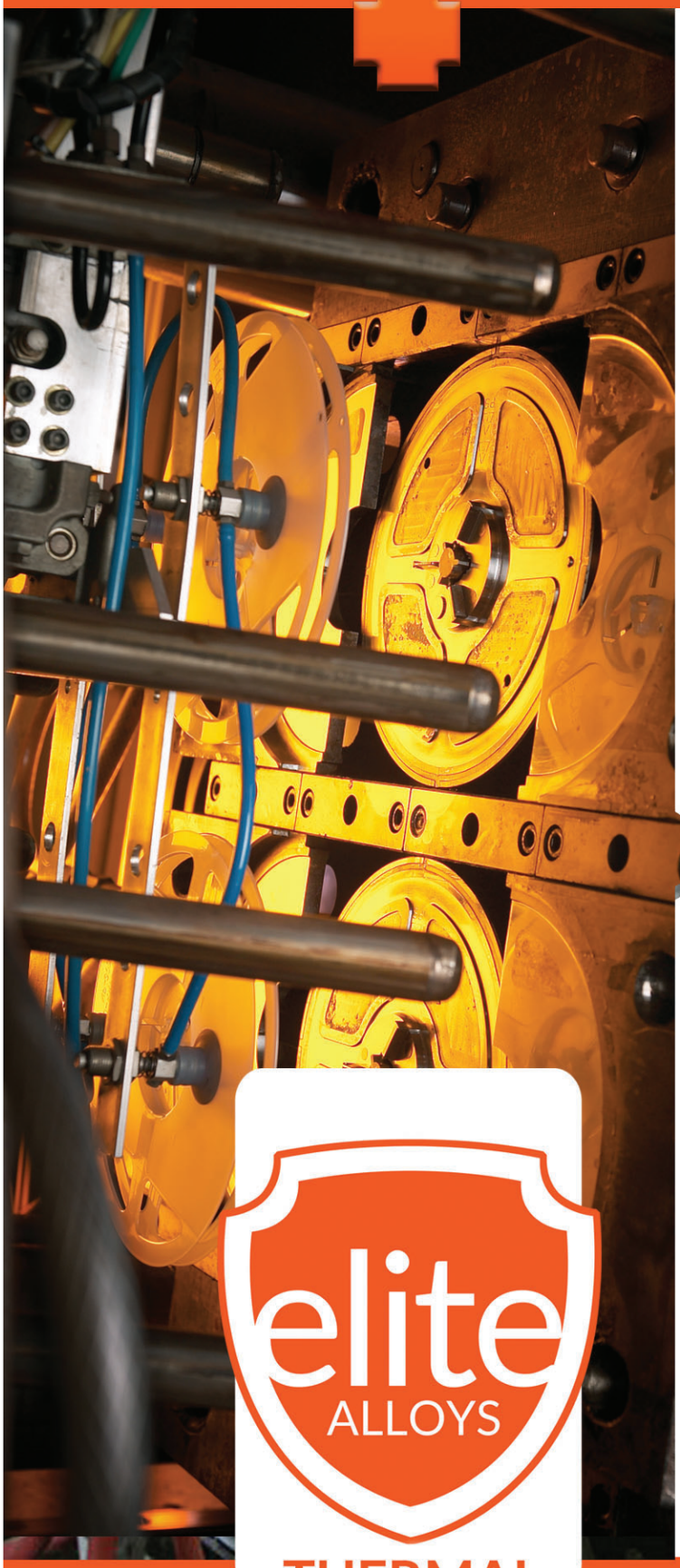

Elite Thermal Alloys for ORIGINAL DESIGN

The Elite Thermal Alloys present engineers with design flexibility.

Manufactured in three tempers of increasing strength, it is also possible to customise the alloys to specific applications.

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Physical Properties

Highly Engineered Alloys for Extreme Environments

Table 1 Typical Mechanical and Conductivity Properties of the Elite Thermal Alloys for Rod, Bar and Tube for Standard Tempers

Mechanical and Physical properties	Units	CAL C700 CuNi2SiCr	CAL C800 CuNi3Si	CAL C900 CuNi7Si2Cr	CuBe2
Tensile Strength Rm	N/mm ² Ksi	700 102	820 119	938 136	1206 175
Yield Strength Rp 0.2%	N/mm ² Ksi	600 87	780 113	820 119	1034 150
Elongation	%	15	12	5	5
Hardness Brinell	HB30	185	240	250	365
Rockwell Hardness	HRC	18	27	31	39
Electrical Conductivity	% I.A.C.S.	48	40	30	22
Thermal Conductivity 20°c/68°F	W/mK Btuft /hr.ft².°F	208 120	159 92	156 90	113 65

Table 2 Elite Thermal Alloy Chemical Composition (weight percentage)

Alloy	Copper Alloy UNS Number	Cu	Ni	Si	Cr
CAL C700	C18000	Bal	1.8-3.0	0.4-0.8	0.1-0.8
CAL C800	C64700	Bal	2.4-3.4	0.6-1.1	Zero
CAL C900	None – new technology	Bal	6.0-8.0	1.5-2.5	0.5-1.5

Table 3 Physical Properties of Elite Thermal Alloys

Mechanical and Physical properties	Units	CAL C700 CuNi2SiCr	CAL C800 CuNi3Si	CAL C900 CuNi7Si2Cr	CuBe2
Youngs Modulus Modulus of elasticity	N/mm² Ksi	140 x10³ 20.3 x10³	150 x10³ 21.7 x10³	151 x10³ 22x10³	132 x10³ 19.2 x10³
Modulus of Rigidly	N/mm² Ksi	550 x10² 79.8 x10²	572 x10² 83 x10²	680x10² 99x10²	489 x10² 71 x10²
Compressive strength 0.1% perm set	N/mm² Ksi	552 80.6	552 80.6	710 103	896 130
Density ρ	g/cm³ lbs/in³	8.71 0.3147	8.8 0.3179	8.69 0.3140	8.25 0.3
Coefficient of expansion α 20-300°C	10⁻6 /K 10⁻6 /F	17.5 9.7	16 9	15.7 8.7	18 10
Thermal Conductivity 200°c/392 °F	W/m°K Btuft /hr.ft².°F	211 122	210 121	200 116	138.5 80
Electrical Conductivity	m/Ω.mm² in/ Ωin²	28.00 1102	22 866	17.4 685	11.6 457
Electrical Resistivity	μ Ωcm μ Ωin	3.6 1.42	4.5 1.77	5.7 2.2	8.6 3.4
Specific Heat	20°C J/kg/°K BTU/lb°F	377 0.09	377 0.09	377 0.09	419 0.1
Magnetic Permeability	μr	<1.001	<1.001	<1.001	<1.001
Melting Point	°C °F	1040-1060 1904-1960	1040-1060 1904-1960	1040-1060 1904-1960	866-982 1590-1800

Hardening Mechanism

Highly Engineered Alloys for Extreme Environments

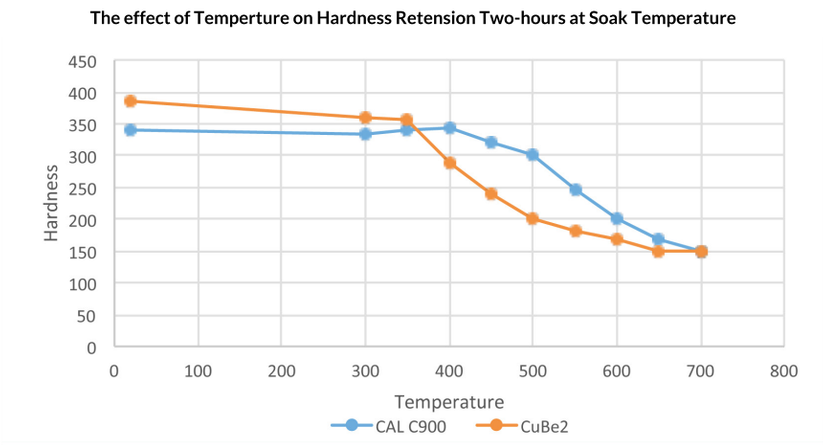
Scientific control of precipitation hardening particles from solution enable extreme hardness to be achieved without impacting conductivity.

For most other alloys, there is a compromise between the two, for the first time, the Elite Thermal Alloys, in particular CAL C900 possesses both. The increased conductivity is enhanced by primary and secondary precipitating mechanisms.

The ageing for CuNiSiCr C900 is very complex and there are two hardening mechanisms precipitation hardening by the formation of Ni2Si,Cr3Si and Cr5Si2 and spinodial decompostion. Through precise control of ageing temperatures, Copper Alloys Ltd can maximise the electrical and thermal conductivity properties using both hardening mechanism whilst still achieving the highest mechanical properties.

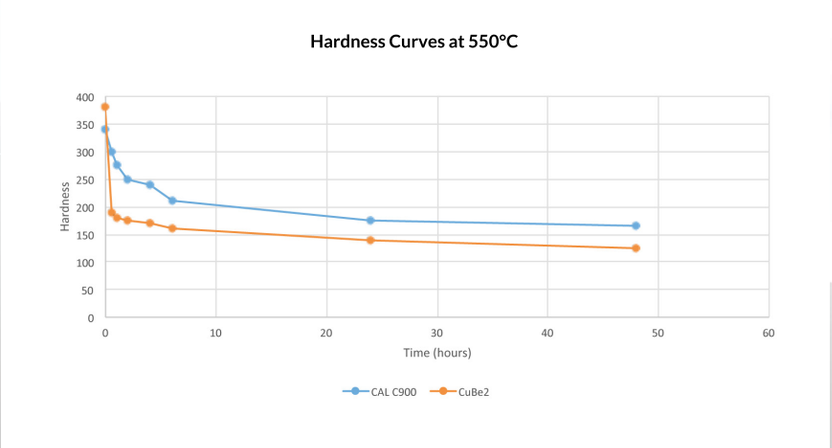
The comprehensive employment of highly engineered process technology is revealed by the ability of CAL C900 to maintain its hardness at elevated temperatures, as shown in the charts below.

Chart 1 - Hardness Curve verses Temperature



At 550°C (1022°F) Beryllium copper has a rapid decline in surface hardness after only 30 minutes at temperature resulting in its hardness and tensile properties falling below that of CAL C900.

Chart 2 - Hardness Curve at 550°c (1022°F) in relation to time



This is vitally important at the mould, molten metal interface which can reach high temperatures particularly with high throughput rates.

Description

CAL C700/C800/C900 are Copper Nickel Silicon and Copper Nickel Chromium Silicon alloys which can be heat treated by means of precipitation hardening to produce high strength and a range of thermal conductivity properties to accommodate a range of applications.

CAL C900 is the highest strength of this family of alloys close to Beryllium Copper (CuBe/BeCu) with the added advantage of greater hardness retention at elevated temperature which is important for high speed production for injection moulding applications.

Tests have shown that it is more than 4 times more conductive than 420 stainless steel, when used in injection moulding equipment and 25% better than CuBe.

The alloy also maintains its hardness and mechanical strength at higher temperatures and for longer periods than Beryllium Copper. (See graphs below).

Beryllium Copper starts to lose hardness rapidly after temperatures exceed approximately 350°C (662°F)

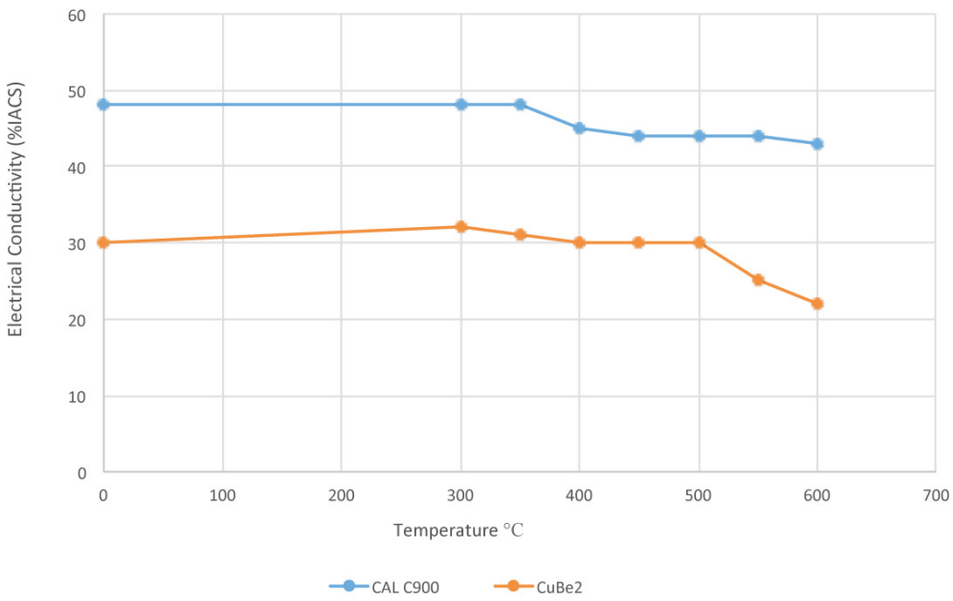
Despite their high strength, all of the Elite Thermal Alloys are completely resistant to hydrogen embrittlement.

They also would be an excellent choice for aggressive marine environments, possessing excellent corrosion resistance.

Detailed Specifications

Specification	CAL C700 CuNi2SiCr CuNi2Si	CAL C800 CuNi3Si	CAL C900 CuNi7Si2Cr
UK		BS 2B25 DTD 498 Bars/Forgings	
EUROPEAN		EN 12163 Rod EN 12165 Rod/Forgings EN 12167 Profile EN 12420 Forgings CW 111C CW112C	
GERMANY	CUNi2Si 2.0855	DIN 17666 2.0857	
USA	C18000 RWMA Class 3	ASTM B 411 C64700 Rod RWMA Class 4	RWMA Class 4

Effect of temperature on the Electrical Conductivity
Two-hours at Temperature



Copper Alloys Ltd has expert Metallurgists who oversee the processes from casting through forging, rolling and heat treatment to control the precipitation of Ni2Si, which ultimately determines the optimum mechanical properties.

Alloy C800 was initially developed for the aerospace industry to DTD 498 but has now found a wider market in Marine environments where its combination of properties offers some distinct advantages over existing alloys that may suffer hydrogen embrittlement or corrosion problems.

This family of alloys, in addition to its corrosion resistance in sea water it can be used in most industrial atmospheres and can be used for components coming into contact with non-oxidising acids and salt solutions.

They can also be used at sub zero temperatures where it does not suffer with embrittlement at low temperatures as do many of the steels.

They can be machined to a high tolerance and surface finish and are much easier to process then some of the harder tool steels.

CAL C700 with the addition of Chromium has the highest heat and thermal conductivity and can be heat treated to meet the requirements of Class 3 RWMA.

CAL C700 is also able to maintain its superior electrical and heat conductivity properties up to 600° C (1112°F)

Mechanical Properties

Highly Engineered Alloys for Extreme Environments

For bar and forgings all sizes up to 80mm (3.14”) section

CAL C700

Properties	Units	Guaranteed	Typical
0.2% Proof Stress	N/mm² Ksi	600 87	600-750 87-109
Tensile Strength (UTS)	N/mm² Ksi	700 102	700-850 102-123
Elongation	%	15	15-30
Hardness	HB	185	185-230

CAL C800

CAL C800 meets the mechanical and chemical properties of Rolls Royce MSRR 8501, DTD 498 and BS 4577 Type A3/2 to which Copper Alloys manufactures and supplies advanced engineering industries worldwide, in either semi-finished form or finished components.

Properties	Units	Guaranteed	Typical
0.2% Proof Stress	N/mm² Ksi	700 102	700-800 102-116
Tensile Strength (UTS)	N/mm² Ksi	880 128	880-950 128-138
Elongation	%	12	12-16
Hardness	HB	240*	240-270*

• In excess of specification

CAL C900

Properties	Units	Guaranteed	Typical
0.2% Proof Stress	N/mm² Ksi	820 119	820-870 119-126
Tensile Strength (UTS)	N/mm² Ksi	900 131	900-965 131-140
Elongation	%	5	5-8
Hardness	HB	250	250-285

Every batch of forgings is certified to BS EN 10204.3.1 as standard using prolongated test pieces selected from each batch of forgings.

All material can be supplied ultrasonically tested to international requirements.

Copper Alloys manufactures a number of alloys in the CuNiSi family which exhibit varying properties of strength and conductivity to suit customer’s requirements.

Applications & Availability

Highly Engineered Alloys for Extreme Environments

Applications

Carefully controlled adjustments in composition and process parameters result in the three distinct Elite Thermal Alloys. This gives designers the opportunity to optimise material selection for their particular applications.

- Marine applications requiring high strength coupled with excellent corrosion resistance.
- Aerospace components, such as landing gear bushings and sleeves and bearing retainer rings. .
- It can be used in the manufacture of mould components for the plastic, Zinc and Aluminium injection die casting market where its high heat conductivity over conventional tool steels offers distinct advantages for high production rates.
- The alloy is utilised extensively in the motor racing circuit for valve guides and valve seats where high strength, wear and conductivity are important properties.
- It is also used for electrical application in welding, for electrode holders, spot electrodes, projection and butt welding dies principally for stainless steel and Monel.
- Other electrical applications include heavy duty switch gear components where greater strength is required than conventional high conductivity copper.
- For high stressed structures and wear resistant parts such as bevel gears, worm wheels, valves, bolts and general fasteners.

Availability

The Elite Thermal Alloys can be supplied in the form of forgings, rounds, blocks, rings and tube to a maximum piece weight of 4000kgs.

The product can also be supplied in bar form in standard lengths.

Fully machined components

Copper Alloys Ltd
Glendale Street, Burslem, Stoke-on-Trent, ST6 2EP, United Kingdom

Telephone: 01782 816888
Fax: 01782 790111
Email: sales@copperalloys.net
Web: www.copperalloys.net