COPPER ALLOYS +

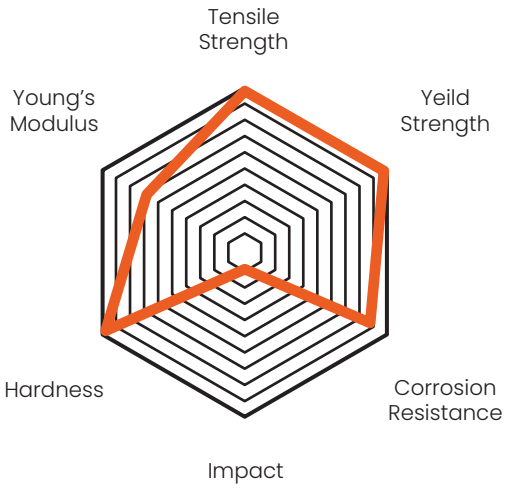
ELITE MARINE®

CAL T-1000

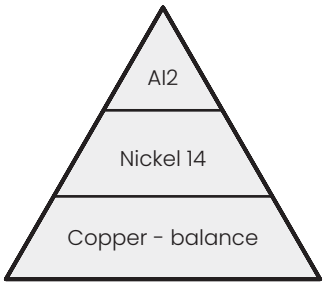
Extreme strength wrought Cupro Nickel alloy CuNi14Al2 (compliant with generic alloy DIN 2.1504).

Highest strength and hardness within the suite of Elite Marine Alloys, with tensile strengths over 1000MPa possible.

COMBINATION OF PROPERTIES



COMPOSITION %



THE BENEFITS OF CAL T-1000

- Extreme mechanical strength
- High hardness
- Outstanding resistance to sea water corrosion both general and pitting corrosion
- Lack of selective phase attack
- Immune to hydrogen embrittlement and stress corrosion cracking in sea water
- High resistance to impingement /erosion / cavitation / pitting in sea water
- Good resistance to stress corrosion cracking in hydrogen sulphide conditions
- Low relative magnetic permeability
- Anti-bio-fouling (lack of marine growth)
- Anti-galling against stainless steel
- No loss of properties at cryogenic temperatures
- High modulus of elasticity compared with other copper -based alloys
- Low relative magnetic permeability - virtually non magnetic
- Easily machined to a high surface finish and dimensionally stable
- Non-sparking
- Uniform fine grain structure permits volumetric inspection using ultrasonic techniques
- Cost-effective

PHYSICAL PROPERTIES

Extreme Strength Copper-Nickel Aluminium Alloy CAL T-1000

CuNi14Al2

Table 1 - Physical Properties

Properties	**Metric**	**Imperial**
Melting point	1,070-1,120°C	1,958-2,048°F
Density	8,500 kg/m³	0.3070 lbs/in³
Specific Heat	0.416 J/(g.K)	0.0993 Btu/ (lb.°F)
Thermal Conductivity @ 20°C	45 W/(m.K)	26 Btu ft/hr/ft2
Electrical Conductivity %IACS at 20°C	11	11
Electrical Resistivity at 20°C	0.17 µ.Ω.m	6.7 µ.Ω.in
Magnetic Permeability (µr)	< 1.01	< 1.01
Coefficient of linear expansion (20-100°C)	16.0 x 10^{-6}/°C	8.89 x 10^{-6}/°F
Coefficient of linear expansion (20-200°C)	12.0 x 10^{-6}/°C	6.67 x 10^{-6}/°F
Coefficient of static friction against mild steel	0.22	0.22
Young's Modulus, Modulus of Elasticity	143,000 N/mm²	20,740 ksi
Compressive Strength σdB	2,350 N/mm²	340.8 ksi
Poisson's Ratio	0.33	0.33
Torsional Modulus 25mm dia. bar	53 x 10^{3} N/mm²	7,687 ksi
Fatigue reversed bending σbw 20 x 106	190 N/mm²	27.56 ksi

Additional information can be provided upon request.

BACKGROUND

T-1000E is amongst the strongest copper based alloys available anywhere.

This extremely high strength wrought cupro nickel is used in a variety of marine applications including the oil and gas and defence sector, for its outstanding corrosion resistance combined with extreme strength and hardness. This material is also highly resistant to wear, has a low magnetic permeability, resists galling against stainless steel and does not suffer from marine growth (bio-fouling) or hydrogen embrittlement.

The main strengthening mechanism involves the precipitation of an extremely fine nickel-aluminium Ni3Al phase. Our deep metallurgical understanding of this mechanism and our advanced manufacturing techniques enable us to induce industry-leading properties unavailable anywhere else.

This material is available in two strength versions. T-1000S (Table 3 standard material) and T-1000E (Table 4 enhanced version). The enhanced versions T-1000E is only available in bars (square/flat/round/shapes) to around 70mm ø.

COMPOSITION

Our team of experienced metallurgists exercise precise control over alloy composition and using our advanced melting and casting techniques, produce high quality ingots and slabs for converting into an extensive variety of wrought products.

Our highly calibrated laboratory ensures we are consistently fully compliant with material composition requirements. Traceability from source to customer guaranteed.

Table 2 - Composition requirements weight %

CAL T-1000 (Extreme Strength Copper-Nickel-Aluminium Alloy)							
Cu	Ni	Al	Fe	Mn	Zn	Si	Total Others
Remainder	13.0 - 16.0	2.0 - 3.0	1.5 max	1.0 max	0.3 max	0.1 max	0.5 max

Related Specifications

DIN WL 2.1504 | ASNA 6127A | NFL 14-702 | UN14A2 | GAM MM11 | CuNi14Al3

FORMS AVAILABLE

Copper Alloys Ltd can provide the largest ingots and heaviest-section forged products available anywhere due to industry-leading process technology that ensures a large total forging reduction and a uniform fine-grain wrought structure in the finished product.

Our capacity continues to evolve and widen as we service ever increasing customer demands

- Bars (square / flat / round) from 10mm to 500mm (0.375”-20”) in section
- Forgings (to 25,000Kgs): Blocks / Rings to 2400mm (8ft) outer ø / Shafts to 7000mm (23ft) long / Discs to 1270mm (50”) ø
- Proof machined or finished components built to print

INSPECTION AND CERTIFICATION

Full chemical analysis performed on every cast to ensure compliance with Table 2. Each batch (same size / same cast / same process-run) is mechanically tested to ensure compliance with minimum mechanical property requirements in Tables 3 and 4, which exceed the generic specification requirements. 100% ultrasonic inspection can be applied - most test standards and acceptance criteria can be accommodated. Certification provided as standard in both wet-signed and electronic form (soft-copy) in accordance with EN 10204 type 3.1 (3.2 Certification can also be provided).

APPLICATIONS

Marine applications requiring extreme strength and high hardness coupled with excellent marine corrosion resistance combined with low magnetic permeability and anti-galling properties against stainless steel. Valve and pump bodies including internal components (stems / shafts / balls / seals). Actuators, pressure housings, clamps and fasteners, bushings, bearings and sonar equipment. The materials ability to resist bio-fouling (lack of marine growth) is another important feature of this alloy.

Aerospace components such as landing gear bushings, sleeves and highly stressed aero frame parts, refuelling connectors, noting its non-sparking properties.

Maximum service temperature ~ 250ºC / 482ºF (long term) ~ 280ºC / 536ºF (short term exposure); above these temperatures the material weakens and becomes less ductile.

MECHANICAL PROPERTIES T-1000S (STANDARD)

CAL T-1000S Standard Version | Extreme Strength Copper-Nickel-Aluminium Alloy CuNi14Al2
Exceeds the requirements of DIN 2.1504

Table 3 - Guaranteed Minimum Mechanical Properties

Product	**Bars** - round, square, flats, hexagon, shapes **Forgings** - discs, blocks, shafts, rings, tubes			
	Material section-size (minor dimension)			
Property	Below 25mm	25mm to 50mm	50mm to 80 mm	Over 80mm
Ultimate Tensile Strength Rm MPa	900 (131Ksi)	880 (128Ksi)	850 (123Ksi)	820 (119Ksi)
0.2% Proof Stress Rp0.2 MPa	750 (109Ksi)	720 (128Ksi)	700(102Ksi)	600 (87Ksi)
% Elongation after Fracture 5.65 √So%	10	10	10	10
Hardness Brinell HB 10/3000	260	255	255	240
***Typical Impact J**	*10-16 (7-12ft lbf)	*10-16 (7-12ft lbf)	*10-16 (7-12ft lbf)	*1-16 (7-12ft lbf)

**For reference only - does not form part of the acceptance criteria unless agreed.*

MECHANICAL PROPERTIES T-1000E (ENHANCED)

CAL T-1000E Enhanced Version | Extreme Strength Copper-Nickel-Aluminium Alloy CuNi14Al2
Exceeds the requirements of DIN 2.1504

Table 4 - Guaranteed Minimum Mechanical Properties

Product	**Bars** - round, square, flats, hexagon, shapes **Forgings** - discs, blocks, shafts, rings, tubes	
	Material section-size (minor dimension)	
Property	Below 40mm	Over 40mm to 70mm
Ultimate Tensile Strength Rm MPa	1000 (145Ksi)	940 (136Ksi)
0.2% Proof Stress Rp0.2 MPa	940 (136Ksi)	920 (133Ksi)
% Elongation after Fracture 5.65 √So%	7	5
Hardness Brinell HB 10/3000	280	270
***Typical Impact J**	*5-15 (4-11ft lbf)	*5-15 (4-11ft lbf)

**For reference only - does not form part of the acceptance criteria unless agreed.*

Table 6 - Comparison of Corrosion Resistance Between Marine Alloys

	CAL Elite Marine Alloys			**Other commonly used Marine-Alloys (also offered by CAL)**								
Material	Extreme Strength Cupro Nickel	High Strength Copper-Nickel-Manganese-Aliuminium Alloy	Wrought Copper-Nickel-Chrome (CNC) Alloy	Wrought Nickel Aluminium Bronze (NAB)	Cast Nickel Aluminium Bronze (NAB)	70/30 Cupro Nickel	90/10 Cupro Nickel	Naval Brass	Nickel-Copper Alloy	Nickel-Copper-Aluminium-Titanium Alloy	Stainless Steel	Stainless Steel
Base composition	CuNi14Al2	CuNi15Mn4-Al1Fe	CuNi30Cr1 MnFeSiZrTi	CuAl9Ni5Fe4	CuAl9Ni5Fe4	CuNi30Mn1Fe	CuNi10Fe1Mn	CuZn37Sn1	NiCu30 Fe2Mn1	NiCu30Al-3Fe1MnTi	FeCr18Ni9	FeCr18Ni-12Mo2
Specification Property	CAL T-1000 (DIN 2.1504)	CAL T-850 (Def Stan 02-835)	CAL CNC-1 / CNC-2 (Def Stan 02-886 Def Stan 02-824)	Def Stan 02-833 NES 833 DGS 1043 CW307G	Def Stan 02-747 NES 747 CC333G	Def Stan 02-780 NES 780 CN107 C71500 CW354H	Def Stan (NES) 779 / CN102 / C70600 / CW352H	CZ112 / CW712R / C46400	NA13 / UNS N04400	NA18 / UNS N05500	304 Stainless	316 Stainless
General corrosion rate per year	0.02mm / 0.0008"	0.025mm / 0.001"	0.02mm / 0.0008"	0.025-0.05mm / 0.001-0.002"	0.07mm / 0.002"	0.03mm / 0.001"	0.03mm / 0.001"	0.05mm / 0.002" (4 x at 60°C)	0.03mm / 0.001"	0.03mm / 0.001"	.025mm / 0.001"	0.07mm / 0.003"
Crevice corrosion rate per year	<0.02mm / 0.0008"	<0.025mm / 0.001"	<0.02mm / 0.0008"	0.5mm / 0.02"	0.5mm / 0.02"	0.025-0.13mm / 0.001-0.005"	0.025-0.13mm / 0.001-0.005"	0.15mm / 0.006"	0.5mm / 0.020"	0.05mm / 0.002"	0.25mm / 0.010"	0.5mm / 0.02"
Selective Phase Corrosion per year	None	None	None	0.5-1.0mm / 0.02-0.04"	1.1mm (0.04") typical 1.4mm (0.055") observed	None	None	0.15mm / 0.006"	None	None	None	1.1mm (0.04") typical 1.4mm (0.055") observed
Impingement resistance limit m/second	3.7m/s (12ft/sec.)	3.7m/s (12ft/sec.)	6-8m/s (20-26ft/sec.)	4.3m/s (14ft/sec.)	4.3m/s (14ft/sec.)	4.6m/s (15ft/sec.)	3.7m/s (12ft/sec.)	3.05m/s (10ft/sec.)	>9.1m/s (>30ft/sec.)	>9.1m/s (>30ft/sec.)	>9.1m/s (>30ft/ sec.)	4.3m/s (14ft/sec.)
Corrosion Potential in Seawater ^{V}sce	-0.18	-0.19	-0.18	-0.19	-0.19	-0.18	-0.20	-0.24	-0.12	-0.12	-0.08	-0.19
Marine bio-fouling resistance	Highly resistant	Highly resistant	Highly resistant	Partially resistant	Partially resistant	Resistant	Highly resistant	Partially resistant	Not resistant	Not resistant	Not resistant	Not resistant

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