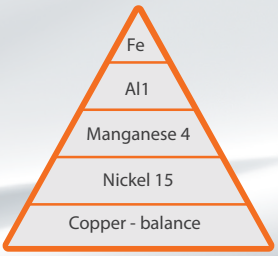
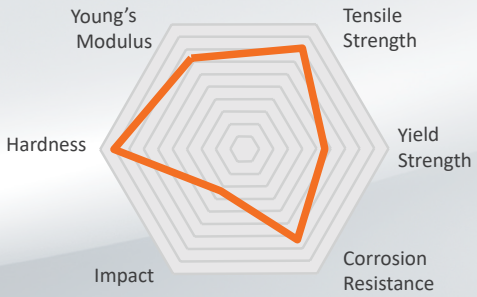
CAL T-850

Composition %



Combination of Properties



THE BENEFITS OF CAL T-850

- > High mechanical strength
- > High toughness and ductility
- > 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
- > 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
- > Uniform fine grain structure permits volumetric inspection using ultrasonic techniques
- > Cost-effective

MECHANICAL PROPERTIES

Complies fully with NES / Def Stan 02-835 Part 2
CAL T-850
High Strength Copper-Nickel-Manganese-Aluminium Alloy
CuNi15Mn4Al1Fe

Table 1 - Guaranteed Minimum Mechanical Properties

Product	Bars - round, square, flats, hexagon, shapes			Forgings
	Material section-size (minor dimension)			All sizes
Property	Below 15mm	Over 15mm to 125mm	Over 125mm	
Ultimate Tensile Strength Rm MPa	725 (105Ksi)	725 (105Ksi)	710 (103Ksi)	710 (103Ksi)
0.2% Proof Stress Rp0.2 MPa	430 (62Ksi)	430 (62Ksi)	400 (58Ksi)	400 (58Ksi)
% Elongation after Fracture 5.65 √ So %	18	18	18	18
Impact J	N/A	40 (30ft lbf)	40 (30ft lbf)	40 (30ft lbf)
*Typical Hardness Brinell HB 10/3000	210-240	210-240	210-240	210-240

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

CAL T-850

High Strength Wrought Copper-Nickel-Manganese-Aluminium Alloy CuNi15Mn4Al1Fe (compliant with generic alloy Def Stan 02-835 Part 2).

High strength and hardness combined with high toughness, good ductility and extreme resistance to corrosion.

BACKGROUND

This high strength wrought cupro nickel is used in a variety of marine applications including the oil and gas industry and defence sector, for its outstanding corrosion resistance combined with high strength and toughness with good ductility. The high impact strength makes it particularly useful in naval engineering applications, where resistance to naval shock is required, combined with excellent mechanical properties and resistance to marine corrosion.

This material is also resistant to wear, has a low magnetic permeability, resists galling against stainless steel and does not suffer from marine growth or hydrogen embrittlement. The main strengthening mechanism involves the precipitation of an extremely fine nickel-aluminium Ni3Al phase. The aluminium content of this alloy is lower than our Extreme Strength Cupro Nickel T-1000 and therefore less precipitate is formed, producing a material with higher toughness at the expense of strength and hardness.

Our deep metallurgical understanding of this mechanism and our advanced manufacturing techniques enable us to balance the mechanical properties inducing high strength combined with high toughness and good ductility.

COMPOSITION

Copper Alloys 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 (main elements) weight %

CAL T-850 (High Strength Copper-Nickel-Manganese-Aluminium Alloy)				
Cu	Ni	Al	Fe	Mn
Remainder	13.5 - 16.5	1.0 - 2.0	0.7 - 1.2	3.5 - 5.5

Related Specifications

Def Stan / NES 835 Part 2 UNS C72420 DOD-C-24676

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

APPLICATIONS

Marine applications requiring high strength coupled with excellent corrosion resistance and high fracture toughness / resistance to shock. The ability of the material to resist bio-fouling (lack of marine growth) is another important feature of this material.

It can also be used in marine applications for valve bodies, valve internals (seats, balls, stems seal-rings), actuators, pump bodies and pump internals.

Widely used on naval platforms for weapon handling systems, salt water intake valves and sumps, pump parts, sonar equipment, shafts, mechanical seals, flanges, fasteners and many other applications where high resistance to marine corrosion, in particular resistance to pitting, combined with low magnetic permeability and non-sparking properties are required.

It is used in the oil and gas industry for riser bolting, subsea manifolds, heat exchangers, caissons and splash zone applications, as well as for down-hole equipment and stab plate connectors, actuator components, shafts for pumps & valves, valve stems and subsea clamps.

CAL T-850

INSPECTION AND CERTIFICATION

All material is subjected to chemical analysis and mechanical testing to ensure compliance with Tables 1 & 2.

Different levels of testing and inspection are automatically triggered by ordering according to Table 3, derived from the generic material specification Def Stan 02-835 Part 2. Additional testing can be agreed e.g. Dye Penetrant Inspection of Grade 1 rods and bars, or alternative NDE standards.

Certification is provided as standard in both wet-signed and electronic form (soft-copy) in accordance with EN 10204 type 3.1. Certification to 3.2 can also be provided upon request.

Table 3 - Testing and Qualification Criteria

Product form		**Bars**		**Forgings**	
Grade / Class	Grade 1	Grade 2	Class 1	Class 2	Class 3
Chemical Analysis (melt)	Every cast	Every cast	Every cast	Every cast	Every cast
***Mechanical Testing**	*Every cast for each size Integral sample	*Every cast for each size Integral sample	*Each andevery forging Integral sample	*One forging every cast/ size Integral sample	*Separate forged test bar each cast
Ultrasonic Inspection	100% Def Stan 02-729 part 5	-	100% Def Stan 02-729 Part 5	100% Def Stan 02-729 Part 5	-
Dye Penetrant Inspection	-	-	100% Def Stan 02-729 Part 4	100% Def Stan 02-729 Part 4	-
Visual Inspection	100%	100%	100%	100%	100%

* For all grades and classes, except Class 3, test samples are integral to the item and the property results are therefore fully representative of the certified material.

PHYSICAL PROPERTIES

High Strength Copper-Nickel-Manganese-Aluminium Alloy CAL T-850
CuNi15Mn4Al1Fe

Table 4 - Physical Properties

Properties	**Metric**	**Imperial**
Melting point	1,040-1,080°C	1,904-1,976°F
Density	8,530 kg/m^3	0.3080 lbs/in^3
Specific Heat	0.435 J/(g.K)	0.104 Btu/(lb.°F)
Thermal Conductivity @ 20°C	25 W/(m.K)	14.4 Btu/(Hour. Ft.°F)
Electrical Conductivity %IACS at 20°C	5	5
Electrical Resistivity at 20°C	0.35 µ.Ω.m	13.8 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	145,000 N/mm^2	21,031 ksi
Compressive Strength σdB	2,350 N/mm^2	340.8 ksi
Poisson's Ratio	0.33	0.33
Fatigue 108 cycles	232 N/mm^2	33.65 ksi
Fatigue reversed bending σbw 20 x 106	190 N/mm^2	27.56 ksi

Additional information can be provided upon request.

CAL T-850

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-Aluminium 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"	0.025mm / 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