Introduction

HIDURON® 130 is a wrought high strength copper-nickel alloy which has a proven track record in the oil and gas, defence and aerospace industries. It has been primarily used for its high strength, anti-galling and wear characteristics but also offers many other attributes allowing designers to successfully solve many of today's engineering challenges within a marine environment. Significantly, it is non-magnetic, non-biofouling and does not suffer from the effects of hydrogen embrittlement. HIDURON® 130 has physical strengths considerably higher than many conventional corrosion resistant alloys, the high strength characteristics are achieved via tightly controlled chemical composition, attaining the alloys peak aged condition through a thermo-mechanical age hardening process.

Its qualities can be summarised as:

- Superior strength to most corrosion resistant alloys.
- Excellent resistance to galling
- High corrosion resistance in marine environments
- Non-magnetic and non-sparking
- High biofouling resistance
- Fully inspectable by Ultrasonic Testing to API 6A
- Ease of machinability

HIDURON® 130 is an alloy originally patented and manufactured by Langley Alloys, the company's long history of alloy development has given an unrivalled experience and in-depth knowledge of the capabilities and optimum manufacturing techniques for high strength copper nickel materials.

Composition

HIDURON® 130 is a proprietary copper nickel alloy with an addition of aluminium. Aluminium is the alloys key strengthening element through the formation of finely dispersed nickel aluminium precipitate Ni_3Al , (γ-Gamma) phase, strengthening the alloy in a similar way to MONEL® K500. Precipitates are formed through the closely controlled forging reduction stages in manufacture, these are then naturally aged as the material cools, no further heat treatment is normally required to meet the alloys properties, although further heat treatments can be given to improve the properties if required. HIDURON® 130 also contains small amounts of iron and manganese which help the precipitation process and refine the alloys grain structure, further improving general properties.

The chemical composition (wt %) is shown below:

Ni	Al	Fe	Mn	Cr	Pb	Sn	Si	Zn	Cu
13-16	2-3	0.6-1.5	0.1-1.0	0.5max	0.05max	0.2max	0.1max	0.3max	Balance

Typical Physical Properties:

HIDURON® 130 offers designers and engineers one of the highest strength copper alloys available with more than 30 years service in marine and offshore environments. With a strong reputation and consistent performance, HIDURON® 130 has long demonstrated it is tough enough to meet the challenge.

Minimum mechanical properties of HIDURON® 130 at room temperature

	Bar and sections ≤65mm	Bar and sections >65mm
0.2% Proof strength, N/mm² (ksi)	630 (91)	555 (80)
Tensile strength, N/mm² (ksi)	850 (123)	770 (111)
Elongation, % on 5.65 $\sqrt{So}$	10	10
Izod impact strength Joules, J, at room temperature	14-20	14-20
Brinell hardness, HB	240 max	229 max

A detailed purchasing specification for bar and forgings is available on request or from our website.

“...highest strength copper alloy with more than 30 years service”

Typical Physical Design properties	
Coefficient of thermal expansion (20-300°C)	16.4 x 10^{-6} K^{-1}
Poisson's ratio	0.33
Young's Modulus	141 GPa
Modulus of Rigidity	55 GPa
Wöhler Fatigue limit	270 N/mm (5 x 10^7 reversals)
Thermal conductivity at 20°C	46.1 W/mK
Specific heat at 20°C	435 J/kgK
Electrical resistivity at 20°C	0.17 microhm-m
Electrical conductivity at 20°C	10.0% I.A.C.S.
Magnetic permeability	‹1.01
Density at 20°C	8.50 g/cm3

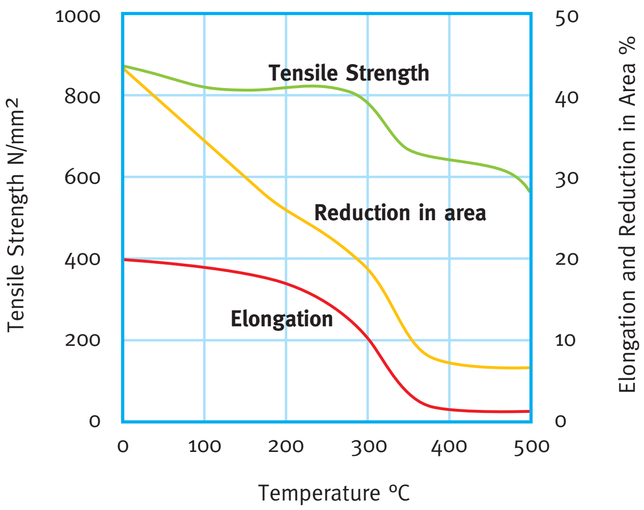
Temperature Capabilities

HIDURON® 130 has excellent low temperature capabilities with no significant loss of mechanical properties including impact properties down to -196°C. This characteristic gives opportunity's for use in cryogenic and ultra-deep subsea applications. A fracture toughness study carried out at TWI confirmed ductility and material toughness being fully retained at these temperatures.

HIDURON® 130's high temperature limits for continuous use are set at 200°C and 300°C for short term exposure, above these temperatures there is a drop in the alloys elongation.

Mechanical properties for HIDURON® 130 at elevated temperatures are shown in the following graph.

Results obtained from 25mm diameter rolled bar held at temperature for 2 hrs.



"HIDURON® 130 for cryogenic and ultra-deep subsea applications"

Typical Applications

HIDURON® 130's service environments often capitalise on one or more of the alloys key properties. In particular, the alloys high galling resistance and non-biofouling features allow applications where a high torque load is required on the components along with long term reusability, requirements often essential for subsea connectors and Stabs which need to be reliably engaged and dis-engaged over many years of service. HIDURON® 130 has been used successfully for more than 10 years in this type of application.

Furthermore, the alloys acceptance under NACE for sour service and its low magnetic permeability allowing applications within directional drilling and data logging components for the oil and gas industry.

The alloy's good electrical and heat conductivity have also been successful exploited in electrical connectors, electrical rota bars and also as heat sinks.

The alloys high torsional strengths and bearing properties have allowed application use in high strength aerospace bearings, low frictional shafts and valve stems.

Oil and Gas

Wireline Tooling
Shafts For Pumps And Valves
Hydraulic Control System Connectors
Actuator Components
Tooling Bits
Pressure Housings
Intervention Tooling
Valve Stems
Sub Sea Clamps

Defence

Tow And Winch Components
Drive Bushes And Bearings
Sonar Equipment

Aerospace

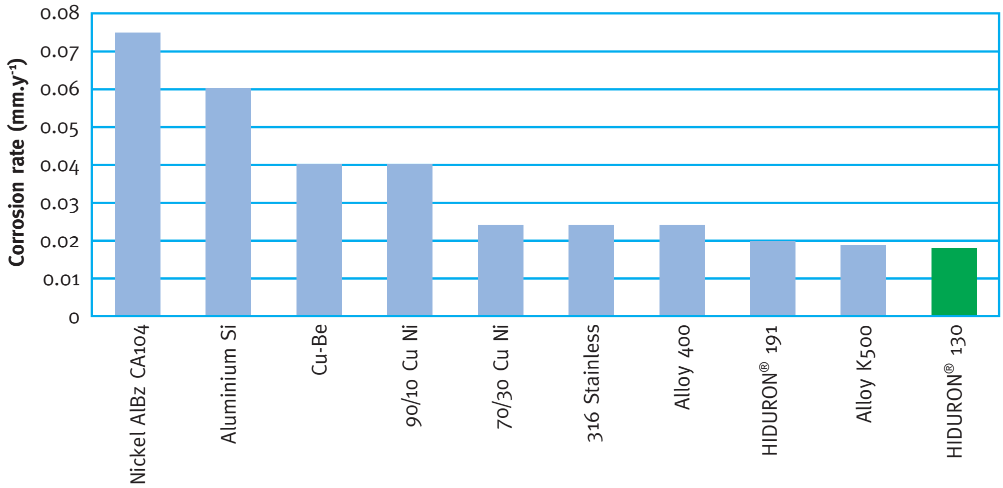
Flight Refuelling Connections
Landing Bearings

Typical Properties in Torsion and Shear	
(taken from 80 mm diameter bar)	
0.1% proof strength in torsion	360MPa
Ultimate shear stress in torsion	670MPa
Maximum twist in torsion	530°
Double shear stress	60-65% of UTS

Marine Corrosion Resistance

Within marine environments HIDURON® 130, being a copper based alloy, does not suffer from localized corrosion attacks such as pitting which is exhibited in many stainless steel and duplex alloys; it is also extremely resistant to crevice corrosion attack even at elevated temperatures. Where copper based alloys tend to suffer is from higher general corrosion rates, HIDURON® 130 conversely maintains excellent resistance to general corrosion realizing a loss of only 0.02 mm/year. This is due to its ability to rapidly form a dark copper rich oxide layer which acts to stifle any general corrosion. This resistance also increase with time as the oxide layer continues to strengthen and thicken.

HIDURON® 130 works well in many marine environments including brackish or polluted waters.



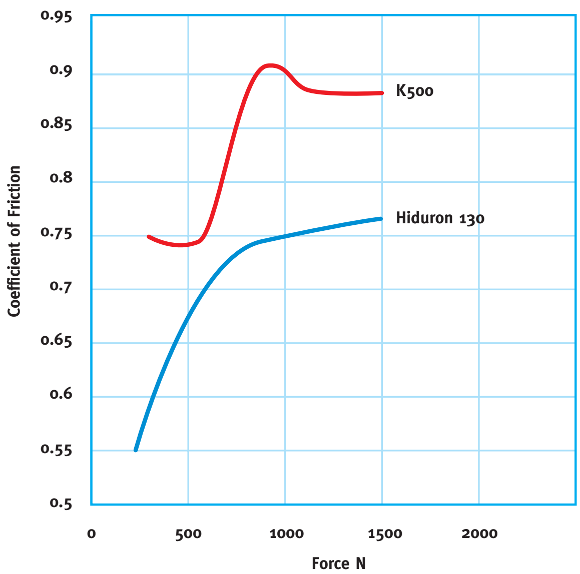
Anti-Galling Properties

The resistance to galling and pickup by HIDURON® 130 is excellent and the alloy's most common reason for material selection. This applies to the alloy either operating against itself or with many of today's leading high strength engineering alloys, including super-duplex, nickel alloys and high strength steels in bearing and actuator applications. HIDURON® 130 is seen as the alloy of choice for many subsea fit and forget connection application, relying on the alloys free running properties without the need of lubrication, other than sea water for many years of trouble free service.

"HIDURON® 130 the alloy of choice for subsea fit and forget connectors"

Tests at the National Centre for Tribology, Risley (UK) have shown that HIDURON® 130 operating against itself exhibits a low coefficient of friction over a wide range of loads, indicating a small propensity to gall or seize. By comparison, K-500 has a 20% higher co-efficient of friction.

Coefficient of friction versus applied load (N) running on FERRALIUM®



Hydrogen Embrittlement

What is Hydrogen Embrittlement and how does it affect an alloy?

Many high-strength engineering alloys suffer in a reduction in mechanical strength when they come in to contact with Hydrogen. This effect is called Hydrogen Embrittlement (H.E.) and has been linked to many offshore material failures due to the release of nascent Hydrogen from Cathodic Protection systems which can penetrate a materials surface.

Once inside the material, Hydrogen can act to reduce ductility through several mechanisms, depending on the alloy type. Titanium alloys undergo embrittlement due to the formation of internal hydrides. Steel, stainless steel and nickel alloys lose ductility through the retention of Hydrogen at internal discontinuities within the microstructure. Thus, if a component is under a high tensional load and cathodic protection conditions are present in seawater, material failure through H.E. can occur rapidly with these alloy types. High strength copper nickels, however, have been found to be immune to the effects of H.E. as they allow Hydrogen to pass through their structure without being trapped.

"...unrivalled record of immunity to Hydrogen Embrittlement"

Slow strain rate testing (SSRT) under Hydrogen charging conditions is the most common method of determining the H.E. characteristics of an alloy. Ductility measurements derived from SSRT can include elongation, time to failure and reduction of cross-section area of the test piece at the fracture. The latter is most commonly used, thus an Embrittlement Factor Ration (EFR) can be defined as follows:-

$$\text{EFR} = \frac{\text{[change in reduction of cross section area between environments] x 100}}{\text{Reduction of Cross-section area Without Hydrogen Charging}}$$

Independent testing to NACE TM0198-98 on a range of alloys, including high strength copper nickels, alloy K500 and super duplex stainless steels shown below, demonstrates how Hydrogen can quickly effect the performance of an alloy if it is susceptible to H.E. It is generally accepted that an EFR of greater than 20 represents an alloy susceptibility to embrittlement.

		UTS (N/MM²)	Elongation %	Reduction of area (%)	Embrittlement Factor Ration (EFR)
Copper Nickel	Before exposure	947	18	30	7
	After exposure (1500 h)	943	15	28	
Alloy 625	Before exposure	1146	44	54	13
	After exposure (915 h)	1150	44	47	
Alloy K-500	Before exposure	1015	24	37	54
	After exposure (915 h)	986	15	17	
Super Duplex	Before exposure	885	40	72	69
	After exposure (915 h)	845	19	22	

HIDURON® 130 is Langley Alloys' highest strength copper nickel alloy available today. Having been in continuous service for over 30 years within the offshore and subsea environment with an unrivalled record of immunity to the effects of Hydrogen induced cracking, HIDURON® 130 is the natural choice for marine applications which require high strength and trouble free operation in deep water or splash zone environment while under active cathodic protection.

Hydrogen Sulphide Environments

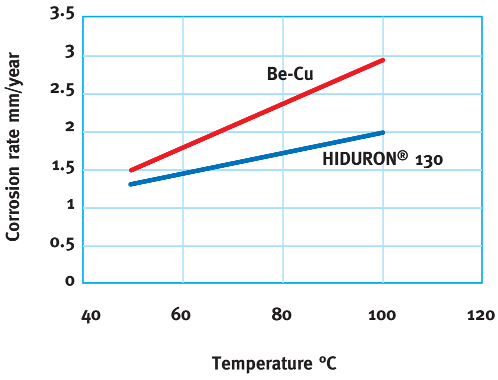
HIDURON® 130 has been in successful service for many years, within both sour and sweet down-hole environments, performing well in the standard NACE TM-0177 sulphide stress corrosion test, where resistance to cracking and debilition being demonstrated.

NACE MR-0175 allows the use of copper alloy in oilfield sour service but gives advice to expect enhanced general corrosion. HIDURON® 130 when exposed to a sulphide environment will develop a thick Nickel-aluminium rich oxide layer which affords a considerable degree of corrosion protection, resulting in significantly higher performance in this environment to many other copper alloys available.

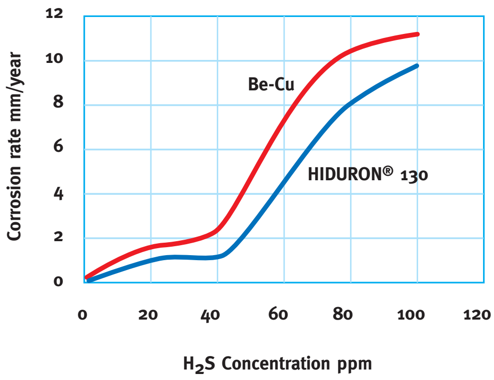
"HIDURON® 130 outperforms Be-Cu alloys in sour services"

Testing based on the prevailing salinity in the Gulf of Mexico (5% NaCl) and various partial pressures of H_2S (ppm) has demonstrated that HIDURON® 130 outperforms the industry standard alloy, Beryllium Copper, across a full range of environments.

The following are typical results for varying temperature, and partial pressure of H_2S:



The corrosion rate (in mm/yr) collected at a H_2S partial concentration of 50 ppm



Data collected at a temperature of 100°C. Corrosion rate measured in mm/yr.

Erosion, Corrosion and Cavitation Resistance

HIDURON® 130's ability to regenerate a protective oxide film, quickly re-stabilizing its surface allows the alloy to be used where it might suffer scratching or abrasion even under high flow rate conditions. Jet impingement tests have shown that the behaviour of HIDURON® 130 in this respect is found to be twice that of standard copper nickels and similar to that of nickel aluminium bronze.

Stress Corrosion Cracking

Stress corrosion is a specific type of localised corrosion attack which can occur under the simultaneous action of corrosion and stress. It sometimes manifests itself when components are over loaded in hostile environments. Both conditions are usually required to first initiate and then propagate a crack. Copper alloys have been found to be susceptible to Stress Corrosion Cracking (SCC) if they are highly stressed in environments where ammonia, organic amines or high sulphide concentrations are present. Brass alloys have been identified to be the most susceptible to SCC, with bronze alloys being significantly better and copper-nickels, including HIDURON® 130, being the most resistant but still not immune under very aggressive conditions. The use of cathodic protection can offset this susceptibility with no instances of stress corrosion being reported in service when employed particularly with high strength copper-nickels.

Copper alloys, however, show very high resistance in chloride containing environments to stress cracking, whereas stainless steels can be susceptible at temperatures above 50°C.

Biofouling Resistance

In common with standard copper nickel alloys, HIDURON® 130 is able to effectively resist the colonisation and build-up of marine organisms, making it an ideal alloy where inspection and maintenance is required while employed in submerged seawater service. The optimum resistance is achieved when the alloy is freely exposed and the flow of copper ions in the surface film is not restricted by cathodic protection.

Important to Note If biofouling resistance is a specific design requirement in a component, ensure there is no galvanic influence from less noble alloys.

A sample of HIDURON® 130 immersed for 6 months in sea water at Langstone Harbour, Portsmouth (UK) is shown below. What can be seen is no marine growth just a discoloration of the surface due to the formation of copper oxide. This discoloration is emphasised by the clean area that was covered by a washer around the hole in the specimen.

HIDURON® 130 after 6 months immersion in sea water.

Galvanic Corrosion

HIDURON® 130 is galvanically compatible with most Copper-based alloys, including standard copper-nickel and Bronze alloys with an electrode potential of -0.10 Volts (SCE).

HIDURON® 130's ability to form a rich passive oxide layer protects it from significant preferential corrosion when coupled with more noble alloys like stainless steels and nickel alloys.

Although, when galvanic corrosion is a possibility and in the absence of cathodic protection, steps should be taken at the design stage to minimize the risk of galvanic corrosion by ensuring that the more noble components are of smaller surface area. Where this is not possible, the two metals need to be electrically insulated from each other by a non-conducting material or by coatings, in line with normal precautions against galvanic corrosion.

Working Practices

Lubrication

Because of the anti-galling and bio-fouling properties of HIDURON® 130, there is often no need for lubrication. However, if lubrication is required, most greases used offshore can be successfully applied to the component, although greases containing either ammines or molybdenum disulphide in their formulation should be avoided.

Cleaning

Care should be taken when cleaning a copper-nickel not to use any cleaning solution containing amines or ammonia.

Hot Working

Langley Alloys Limited, and its associate companies around the world, supply HIDURON® 130 in a wide range of wrought forms including bar, forgings and stampings. If a product is to be further hot working or stress relieving, please consult our Technical Department for specialist advice.

Welding and Brazing

HIDURON® 130 can be welded but it is not normally advised as the properties will be compromised in the heat affected zone. Nickel aluminium bronze (NAB) consumables have been used. Should welding be considered, specialist advice should be sought from our Technical Department first.

HIDURON® 130 can be brazed by the same procedures as for the aluminium bronzes using special fluxes which contain fluorides and silver brazing alloys with a low melting point (about 650°C). Soft soldering can also be carried out by similar procedures to those employed for the aluminium bronzes.

Machining

HIDURON® 130 can be easily machined to give an extremely good finish, using methods normally employed with aluminium bronzes. Details are available from our Technical Department or Website.

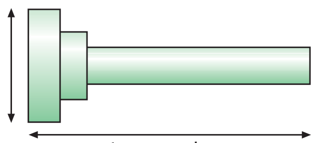
Bar stock currently available

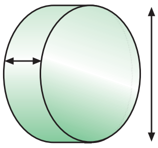
Imperial Size	Metric Size	Weight per Metre	Weight per Foot	Weight per Foot
1/2"	12.70 mm	1.08 kg	0.33 kg	0.73 lbs
5/8"	15.87 mm	1.68 kg	0.51 kg	1.12 lbs
3/4"	19.05 mm	2.42 kg	0.74 kg	1.63 lbs
7/8"	22.22 mm	3.30 kg	1.01 kg	2.23 lbs
1"	25.40 mm	4.31 kg	1.31 kg	2.88 lbs
1.1/4"	31.75 mm	6.73 kg	2.05 kg	4.52 lbs
1.1/2"	38.10 mm	9.69 kg	2.95 kg	6.50 lbs
1.3/4"	44.45 mm	13.19 kg	4.02 kg	8.86 lbs
2"	50.80 mm	17.23 kg	5.25 kg	11.57 lbs
2.1/4"	57.15 mm	21.80 kg	6.65 kg	14.66 lbs
2.3/8"	60.32 mm	24.29 kg	7.40 kg	16.31 lbs
2.1/2"	63.50 mm	26.912 kg	8.20 kg	18.08 lbs
2.5/8"	66.67 mm	29.68 kg	9.01 kg	19.86 lbs
2.3/4"	69.85 mm	32.58 kg	9.93 kg	21.89 lbs
3"	76.20 mm	38.764 kg	11.82 kg	26.06 lbs
3.1/4"	82.55 mm	45.50 kg	13.87 kg	30.58 lbs
3.1/2"	88.90 mm	52.76 kg	16.08 kg	35.45 lbs
4"	101.6 mm	68.91 kg	21.00 kg	46.30 lbs
4.1/2"	114.30 mm	87.22 kg	26.58 kg	58.60 lbs
5"	127.00 mm	107.67 kg	32.82 kg	72.36 lbs
6"	152.40 mm	155.05 kg	47.26 kg	104.19 lbs
7"	177.80 mm	211.04 kg	64.33 kg	141.82 lbs
8"	203.20 mm	275.65 kg	84.02 kg	185.23 lbs
9"	228.60 mm	348.87 kg	106.34 kg	234.44 lbs
10"	254.00 mm	430.70 kg	131.28 kg	289.42 lbs

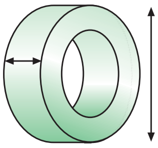
Manufactured products

If you require a bar size that is not stated above we can produce any specific size to order in 8 weeks with a minimum quantity of 400kg.

Forgings such as rings, discs and rectangular sections are also available to customers specific requirements in sizes upto 1000kg for single components with a manufacturing time of approximately 8-10 weeks. Maximum dimensions available for these particular shaped articles are as given below.







Further useful reading:

1. C A Clark, S Driscoll and P Guha. Paper 92 Copper 90 Conference, Sweden, October 1990. Development of a new fastener alloy resistant to hydrogen embrittlement.
2. K O Barr, J A Harris and R H Moeller UK Corrosion '86, Birmingham. Organised by I. Corr. S.T.
3. J G Erlings, H W de Groot and i F M van Roy. Materials Performance. October 1986. P.28 Stress corrosion cracking and hydrogen embrittlement of high strength non-magnetic alloys in brines.
4. M W Joosten, J Kolts, L H Wolfe and L S Taylor, Trondheim Conference. January 1988. Material considerations for critical service subsea xmas-trees and tubing hangers.
5. N A Sorokina, v I Malkin, v I Galtsova and I v Vaganova lzv. Akad Nauk. SSSR Met 119871, 2,133.
6. C A Clark, S Driscoll and P Guha, Br. Corr. J, vol.27 119921 p.157.
7. C D S Tuck and K C Bendall, The Development of an Ultra-high strength Cupronickel Alloy for Marine Applications; U K Corrosion 1992, Institute of Corrosion.

The figures in this brochure do not constitute a specification for any specific contract. These are subject to individual agreement as continuing research and development may lead to a modification of certain values