Copper-Nickel Cu-Ni 90/10 Alloy (UNS C70600)

Cu-Ni alloy 90/10 offers superior resistance to general corrosion and marine water attacks. It resists corrosion by fast moving water. It has nominal temperature coefficient of electric resistance. Alloy 90/10 prevents stress corrosion cracking and pitting and crevice corrosion. The resistance to soil erosion and abrasive fluids is incomparable in the aqueous conditions. It is commonly employed in seawater hardware, condenser tubes, automotive cooling systems and in manufacturing coin.

Chemical Composition

Carbon (C)	below 0.050 %
Copper (Cu)	85.6 to 90 %
Iron (Fe)	1 to 1.8 %
Lead (Pb)	below 0.020 %
Manganese (Mn)	below 1 %
Nickel (Ni)	9 to 11 %
Phosphorous (P)	below 0.020 %
Sulfur (S)	below 0.020 %
Zinc (Zn)	below 0.50 %

Role of Chemical Constituents:

A Copper-Nickel Alloy consists of copper and nickel as the basic elements and with or without other elements such as zinc may be present by less than 1%. Besides of other elements, nickel is added in the highest concentration after copper. In addition of copper and nickel, many industrial Cu-Ni alloys also comprise of manganese, iron and tin to enhance the certain features, moreover the casting alloys also consist of niobium and silicon.

Nickel: The pure nickel shows considerable effect on the physical and mechanical features of Cu-Ni alloys. The tensile strength, 0.2% proof strength, hot strength, solidification and liquefaction temperature and corrosion resistance improve with the addition of nickel though the thermal and electrical conductivity reduce due to its performance. The tensile strength increases with an increase in content of nickel, expansion remains same after minor reduction in its content by 5%.

Manganese: Manganese is included to be liquefied for deoxidation. It holds sulphur that is recognized for hot processing as undamaging manganese sulfide enhances the casting features, increases strength, particularly the melting point.

Iron : Iron (Fe) included in the solid mixture improves the resistance to corrosion property of **Nickel-Copper alloy**. It enhances the production of protected layer in water so increases the corrosion resistance certainly in the rapidly flowing seawater.

Tin: An addition of tin increases the tensile strength; tarnish resistance and wear resistance of **Nickel-Copper alloy**, also an alloy consisting of 2% Sn is unique as it has excellent resistance to stress relaxation. Thus these alloys are utilized in making the spring components. The alloy with large concentration of Tin such as from 4% to 10% is an age hardenable material.
Niobium: Niobium improves the tensile strength and proof competency though the elongation decreases. The positive effect of this element is on the welding character of casting **Nickel-Copper alloys**.

Lead: The concentration of lead is kept low about 0.02% in the wrought alloys for hot processing. In fact the amount of lead higher than 0.01% disturbs the welding character of alloy. Although the casting alloys having lead up to 1-11% amount are widely considered for machining.

Phosphorous: Phosphorus has powerful embrittling influence on the copper-nickel alloys and reduces the welding character due to cracking. So the amount of phosphorous is kept lower about 0.015% to 0.05%.

Physical Properties

Property	Values
Density at 20oC or 68oF	8.90 gram/ cm3 or 0.320 ln per inch3
Melting point	1170 to 1240oC or 2140 to 2265 oF
Linear Coefficient of thermal expansion at -183 to 10oC or -297 oF to 50 oF	0.000013 per oC or 0.000007 per oF
20oC to 300oC or 68 to 572oF	0.000017 per oC or 0.000009 per of
Specific heat capacity at 20oC or 68 oF	0.09 cal/goC or 0.09 Btu/lb oF
Thermal conductivity at 20oC or 68oF	0.12 cal cm/cm2 s oC or 29 BTU ft/ft2 h oF
Electrical conductivity at -269oC or -452oF (annealed)	5.8 microhm mm2 or 10% IACS
20 oC or 68oF (annealed or cold processed	5 microhm mm2 or 9% IACS
200oC or 392of (annealed or cold processed)	5 microhm mm2 or 8% IACS
Temperature coefficient of electrical resistance at 20oC or 68oF (annealed or cold processed) for temperature limit from 0oC to 100oC or 32 to 212oF	0.00007 /oC (IACS 5%) or 0.00004 / oF (5 % IACS)
Modulus of elasticity (tension) at 20oC or 68 oF annealed	13800 kg/mm2 or 19600000 lb per inch3
Cold processed	13000 kg / mm2 or 18500000 lb/ inch3

Modulus of rigidity (torsion) at 20oC or 68 oF annealed	5100 kg/mm3 or 7300000 lb / in2
Cold processed	4800 kg/mm2 or 6800000 lb per inch2
Electrical resistivity at -269oC or -452oF (annealed)	0.17 ohm/mm2/m or 104 ohms (circ mil per ft)
	17 microhm cm or 6.8 microhm inch
20 oC or 68oF (annealed or cold processed	0.19 ohm mm2/m or 115 ohms (circ mil/ft)
	19 micro ohm cm or 7.5 micro ohm inch
200oC or 392of (annealed or cold processed)	0.22 ohm mm2/m or 130 ohms (cir mil per ft)
	22 micro ohm-cm or 8.5 micro ohm - inch

Fabrication Properties

Casting temperature	1225 oC to 1300 oC	2235 oF to 2370 oF
Annealing temperature	700 oC to 825 oC	1290 oF to 1515 oF
Stress relieving temp	275 oC to 400 oC	525 oF to 750 oF
Hot processing temp	825 oC to 950 oC	1560 oF to 1740 oF
Hot formability	Suitable	
Cold formability	Outstanding	
Cold reduction in annealed	80 %	
Machining rate (free cutting brass – 100)	20	
Soldering	Outstanding	
Brazing	Suitable	
Oxy acetylene welding	Not preferred	
Carbon arc welding	Not preferred	
Gas shielded arc welding	Outstanding	
Coated metal arc welding	Suitable	
Resistance welding	Suitable	
Butt welding	Suitable	

Mechanical Properties

Cu90/Ni10 alloy offers high mechanical features at the elevated temperatures. The hot strength of copper enhances with the small amount of nickel. Nickel influences the molten cold treated **Copper-Nickel alloy** at the high temperatures. An addition of iron increases the mechanical properties at the room as well as high temperatures. The Cu-Ni alloys can be utilized in making the pressure vessels about 300oC to 350oC. With an increase in temperature, the strength decreases significantly, especially the creeping strength and strain limit.

Tensile properties and hardness values

Form	Temper	Tensile strength		Proof stress offset		Elongation		Vickers hardness	Shear strength		size
		Hbar	Ton/inch2	Hbar	Ton/inch2	%	Gauge length		Hbar	Ton/inch2	
Plate	Annealed	32	21	12	8	42 %	5.65	85	25	16	-

	Hot rolled as produced	34	22	14	9	40 %	5.65	95	26	17	12 to 50 mm thick or 0.5 to 2 inch
Sheet Strip	Annealed	32	21	12	8	45 %	50 mm or 2 inch	85	25	16	-
	Hot rolled as produced	36	23	19	12	40 %	50 mm or 2 inch	105	26	17	3 to 10 mm or 0.125 to 0.375 inch
Tube	Annealed	32	21	14	9	40 %	5.65	85	25	16	-
	Cold drawn or temper annealed										
	Temper annealed	36	23	19	12	35 %	5.65	120	28	18	50 to 255 mm or 2 to 10 inch outer dia, 2 to 5 mm wall
	Temper annealed	36	23	19	12	38 %	5.65	115	28	18	
	Temper annealed	43	28	32	21	30 %	5.65	140	32	21	6 to 50 mm or 0.25 to 2 inch outer dia 0.5 to 2 mm or 0.02 to 0.08 inch wall
	As drawn (hard)	54	35	46	30	13 %	5.65	165	36	23	

Low Temperature Mechanical Properties

Tensile properties – impact properties

Form	Temper	Temp		Tensile strength			Yield strength 0.5 % ext, under load psi	Elongation %		Reduction area %	Impact strength	
		oC	oF	Kg/mm2	Ton/inch2	psi		%	Gauge length		Kgm/cm2	Ft. lb
Flat products	Hot processed	20 oC	68 oF	34.5	22	49000 psi	29000 psi	34 %	4.52 mm	64	7.2	42
		-92 oC	-134 oF	42	27	60000 psi	33000 psi	43 %	4.52 mm	65	9.7	56
		-126 oC	-195 oF	47	29.5	66500 psi	33600 psi	50%	4.52 mm	62	12	68
Rod 19 mm dia, 0.75 inch diam	Annealed Annealed	22 oC	72 oF	35	22	49600 psi	21400 psi	37 %	4.52 mm	79	19.7	114
		-78 oC	-108 oF	38.5	24.5	54700 psi	24700 psi	42 %	4.52 mm	77	19.5	113
		- 197 oC	-323 oF	50.5	32	72000 psi	24800 psi	50 %	4.52 mm	77	19.9	115
		-253 oC	-423 oF	58	37	82500 psi	30200 psi	50 %	4.52 mm	73	20	116
		-269 oC	-452 oF	56.5	36	80600 psi	24900 psi	53 %	4.52 mm	73	-	-

High Temperature Mechanical Properties

Short term tensile Characteristics

Form	Temper	Temperature		Tensile strength			Proof stress		Elongation	
		oC	oF	Kg/mm2	Ton/in2	psi	Kg/mm2	Ton/in2	%	Gauge length
Plate	Annealed	20 oC	68 oF	35	22.2	49500 psi	16.2	9.6	37 %	2 inch
		66 oC	150 oF	35.5	22.7	51000 psi	12.4	7.5	37 %	2 inch
		121 oC	250 oF	33.5	21.4	48000 psi	11.5	6.7	30 %	2 inch
		177 oC	350 oF	32.5	20.5	48000 psi	10.4	6.3	35 %	2 inch
		232 oC	450 oF	31.	19.7	44000 psi	10.6	6.2	31 %	2 inch

		288 oC	550 oF	30	19	42500 psi	10.2	8	30 %	2 inch
		316 oC	600 oF	29	18.5	41500 psi	9.29	5.2	29 %	2 inch
	Hot processed	20 oC	68 oF	31	19.5	44000 psi	12	-	-	-
		100 oC	212 oF	31	19.5	44000 psi	12	-	--	-
		200 oC	392 oF	28	18	40000 psi	11.3	-	-	-
		250 oC	482 oF	26.5	17	37500 psi	10.6	-	-	-
		300 oC	572 oF	24.5	15.5	35000 psi	10	-	-	-
		350 oC	662 of	23	14.5	32500	9.5			
Rod 25mm dia., 1 inch	Cold processed 21 %	27 oC	80 oF	40	25.5	56600 psi	37.5	-	24 %	2 inch
		93 oC	200 oF	37.5	24	53300 psi	35.7	-	21 %	2 inch
		204 oC	400 oF	34.5	22	49000 psi	33.2	-	18 %	2 inch
		316 oC	600 oF	31.5	20	44700 psi	30.4	-	15 %	2 inch
		427 oC	800 oF	27	17	38200 psi	24.6	-	11 %	2 inch
	Cold processed 36 %	27 oC	68 oF	46.5	29.5	66400 psi	44.9	-	16	2 inch
		93 oC	482 oF	43.5	27.5	61900 psi	41.1	-	17	2 inch
		204 oC	400 oF	41	26	58400 psi	38.3	-	15	2 inch
		316 oC	600 oF	37	23.5	52600 psi	35.5	-	13	2 inch
		427 oC	800 oF	31.5	20	44900 psi	28.5	-	9	2 inch
Condenser tubes	Annealed	20 oC	68 oF	34	24.5	48500 psi	12.8	-	36 %	11.3 inch
		100 oC	212 oF	32	29.5	45500 psi	11	-	30 %	11.3 inch
		200 oC	392 oF	28	18	40000 psi	10.5	-	30 %	11.3 inch
		300 oC	572 oF	25	16	35500 psi	10	-	28 %	11.3 inch
		400 oC	752 oF	24	15	34000 psi	9	-	22 %	11.3 inch
		500 oC	932 oF	18	11.5	25500 psi	8	-	26 %	11.3 inch
		600 oC	1112 oF	11	7	15500 psi	7	-	32 %	11.3 inch
Tube 32 mm outer dia, 2 mm wall	Annealed	20	68	38	24	54000	-	10.3	35	2 inch
		149	300	35	22.3	50000	-	9.8	31	2 inch
		177	351	34.5	21.8	49000	-	9.6	29	2 inch
		204	399	33.5	21.3	47500	-	9.5	28	2 inch
		232	450	33	21	47000	-	9.5	26	2 inch
		260	500	32.5	20.7	46500	-	9.4	25	2 inch
		315	599	32	20.2	45000	-	9.2	23	2 inch
		400	752	29.5	18.6	41500	-	9	18	2 inch

Magnetism

Copper-Nickel alloys do not show ferromagnetism. Copper shows diamagnetic nature and nickel shows ferromagnetic. The magnetic nature of nickel-copper alloys varies from diamagnetic to paramagnetic then ferromagnetic with the change in the concentration of nickel. On the base of alloy, iron shows nominal effect when it is kept in the solid solution. The precipitation of iron in the ferromagnetic microscopic particles leads to increase in ferromagnetism.

The precipitated free matrix remains diamagnetic or paramagnetic. Copper-Nickel alloys containing 20-25% nickel, 20% iron or 25% cobalt, are used in the construction of magnetic materials. Due to their remanence and coercive forces, these fit best for making the permanent magnets. The physical features of the wrought copper-nickel alloys have been analyzed completely and these are significant from the room temperature to 1000oC.

Creeping Strength

Form	Temper	Temp		Stress			Time	Elongation	Intercept	Creeping rate
		oC	Of	Kg/mm2	Ton/in2	Psi	Hours	%	%	% per 1000 hours
Rod 3mm dia, 0.125 inch	Annealed (grain size 0.025 mm)	149 oC	300 oF	10.5	6.7	15000 psi	6000	0.8705 %	0.128 %	Below 0.0001 %
				14.1	8.9	20000 psi	6000	2.131 %	0.242 %	0.00016 %
				17.6	11.2	25000 psi	6000	4.705 %	0.1637 %	0.00022 %
		204 oC	400 oF	6.5	4.1	9200 psi	6000	0.0585 %	0.003 %	0.0001 %
				10	6.3	14200 psi	6000	0.6039 %	0.0795 %	0.00073 %
				13.5	8.6	19200 psi	6000	2.178 %	0.202 %	0.0020 %
				15.6	9.9	22200 psi	6000	2.650 %	0.465 %	0.0028 %
		260 oC	500 oF	6.5	4.1	9200 psi	6000	0.090 %	0.0143%	0.00061 %
				9.8	5.9	13150 psi	6000	0.516 %	0.2538%	0.0017 %
				12.8	8.1	18150 psi	6000	1.803 %	0.1756%	0.0038 %

Applications

Electronic Industry

Copper-Nickel Cu90/Ni10 alloy is widely chosen in the electrical engineering for spring, relays, nominal current switch and plug joints. It obtains exceptionally high relaxation features and is best for using in these applications.

Cu-Ni alloy is a quality spring material that can be utilized in the various operations like electromagnetic switches, navigation and measuring apparatus.

Sea Water

Specifically, Cu-Ni 90/10 has become essential for making the components of ships, power houses, heat exchanging device and seawater desalination houses. It is mainly purposeful for having low nickel amount for the economical operations and utilized in piping. The need of resistance to corrosion is more serious in ships containing condensers and seawater lines.

Moreover **Copper-Nickel Cu90/Ni10 alloy** is used as the preferable pipe material certainly in the dynamic seawater. This is also suitable in the various other solutions such as abrasive fluids. It is mostly used due to its high strength and resistance to corrosion. The cast Copper-Nickel Cu90/Ni0 alloys are used in the seawater quenching equipments of ships and chemical processing due to their tremendous resistance to the seawater and chloride solutions.

The Cu-Ni alloys are the specialized material to make the pipes for ships and harbour installation in the seawater, brackish water and deck steam streaks. These are also utilized for intake ships shafts, rings and discs for the hydraulic plants.

The valves, pumps, fitting, flanges, solver fitting and small components made of Cu-Ni alloys have been known to become the excellent material for ship parts due to excellent resistance to the seawater. The Cu-Ni alloys are also utilized in the firewater systems, lifeboat and more. The die forged parts of **Copper-Nickel Cu90/Ni10 tubing** are used in the production of T and bend parts of hydraulic equipments in the ships.

The **Copper-Nickel Cu90/Ni10 sheet** is utilized in the swimming batch heater, cooling condenser and oil coolers. The approved functionality of Cu-Ni alloy pipe in the marine operations has made it the best choice for offshore commerce.

In the various quenching circuits 90/10 alloy is used as fitting materials. Therefore it is viable to utilize the material to obtain security from the corrosion.

Due to the fouling inhibition features and excellent resistance in the water mediums, the Copper-Nickel Cu90/Ni10 alloy is suitable for cladding. Avoiding the fouling and enhancing the tenderness of the ship hull, the significant amount of fuel can be saved at the same rate and maintenance costs can be reduced. The Copper-Nickel alloy Cu90/Ni10 cladding of platform legs resists corrosion and fouling. In the marine operations it is also used in the evaporators and other components as thin dimpled sheet in the water chambers.

Available Forms

Wire, mesh, strip, foil, sheet, plate, rod, bar, pipe, tubing, flanges