Nickel-Copper Alloy Monel K-500 (UNS N05500)

Nickel-Copper alloy Monel K500 is a precipitation hardenable alloy that offers good corrosion resistance and higher strength and hardness. It has greater tendency to prevent stress corrosion cracking than Nickel 400. Higher yield strength and tensile strength. Alloy K-500 maintains its strength up to 1200oF while maintaining ductility and hardness even at the lower temperatures up to 400oF.

Monel k-500 alloy has high capacity towards the stress corrosion cracking in the particular conditions. The enhanced features are received with the addition of aluminum and titanium and heating in the restricted environments so that the submicroscopic particles of Ni3, titanium and aluminum are precipitated from the matrix.

Chemical Composition

Aluminum (Al)	2.3 to 3.15 %
Carbon (C)	0.18 %
Iron (Fe)	2 %
Nickel (Ni)	63 %
Copper (Cu)	29.5 %
Titanium (Ti)	0.6 %
Manganese (Mn)	1.5 %
Silicon (Si)	0.50 %
Sulfur (S)	0.010

Physical Properties

Density	8.44 g/cm3 or 0.305 lb/in3
Melting Point	1350oC or 2460oF
Coefficient of thermal expansion	13.7 micro-m/moC at 20oC to 100oC or 7.6 x 10(6)in/inoF at 70 to 212oF
Modulus of Rigidity	66 kN/mm2 or 9573 ksi

Modulus of Elasticity	179 kN/mm2 or 25962 ksi

The beneficial features of Monel K-500 are that it is virtually non-magnetic at the low temperatures though it is possible to produce the magnetic layer on the surface of material while treatment. Aluminum and copper may be selectively oxidized while heating that leave a highly nickel rich magnetic layer on the material. The effect is certainly evident on the thin wire or strip that possesses large ratio of surface to weight. The magnetic layer can be eradicated by pickling or bright dipping in acid and the non magnetic properties of the material will be restored.

Heat Processing Monel K500 in free air has an adverse effect on its strength

Condition	Tensile Strength		Application temperature	
Annealed	650 to 850 N/mm2	94 to 123 ksi	-100 to 260 oC	-150 to 500 oF
Annealed and aged	950 to 1050 N/mm2	138 to 167 ksi	-100 to 260 oC	-150 to 500 oF
Spring Temper	1000 to 1300 N/mm2	145 to 189 ksi	-100 to 260 oC	-150 to 500 oF
Spring Temper + Aged	1200 to 1500 N/mm2	174 to 218 ksi	-100 to 260 oC	-150 to 500 oF

Thermal Properties

Temp,	Linear thermal expansion	Thermal conductivity	Special heat	Electrical resistivity
Of	Inch/inch-oF x 10(-6)	Btu-in-hr-sqft-oF	BTU-lb-oF	Ohm-circ-mil-ft
-320 of	6.2 Inch/inch-oF x 10(-6)	-	-	-330.8 Ohm-circ-mil-ft
-200 of	6.8 Inch/inch-oF x 10(-6)	92 Btu-in-hr-sqft-oF	0.077 BTU-lb-oF	-
70 of	-	121 Btu-in-hr-sqft-oF	0.100 BTU-lb-oF	370 Ohm-circ-mil-ft
200 of	7.6 Inch/inch-oF x 10(-6)	136 Btu-in-hr-sqft-oF	0.107 BTU-lb-oF	372 Ohm-circ-mil-ft
400 of	8.1 Inch/inch-oF x 10(-6)	156 Btu-in-hr-sqft-oF	0.114 BTU-lb-oF	378 Ohm-circ-mil-ft
600 of	8.3 Inch/inch-oF x 10(-6)	178 Btu-in-hr-sqft-oF	0.117 BTU-lb-oF	385 Ohm-circ-mil-ft
800 of	8.5 Inch/inch-oF x 10(-6)	198 Btu-in-hr-sqft-oF	0.120 BTU-lb-oF	390 Ohm-circ-mil-ft
1000 of	8.7 Inch/inch-oF x 10(-6)	220 Btu-in-hr-sqft-oF	0.125 BTU-lb-oF	393 Ohm-circ-mil-ft
1200 of	9.1 Inch/inch-oF x 10(-6)	240 Btu-in-hr-sqft-oF	0.132 BTU-lb-oF	396 Ohm-circ-mil-ft
1400 of	9.3 Inch/inch-oF x 10(-6)	262 Btu-in-hr-sqft-oF	0.141 BTU-lb-oF	400 Ohm-circ-mil-ft
1600 of	9.6 Inch/inch-oF x 10(-6)	282 Btu-in-hr-sqft-oF	0.157 BTU-lb-oF	408 Ohm-circ-mil-ft
1800 of	-	302 Btu-in-hr-sqft-oF	0.186 BTU-lb-oF	418 Ohm-circ-mil-ft

Magnetic Properties

Condition	Tensile strength, psi	Permeability	Curie temperature, oF for permeability			
			1.01	1.02 oF	1.05 oF	1.10 oF
Annealed, cooled	92,500 psi	1.0011	-210 oF	-210 oF	-	-
Annealed, age hardened	151,000 psi	1.0018	-153 oF	-178 oF	-202 oF	-210 oF
Cold drawn 20%	137,000 psi	1.0011	-210 oF	-	-	-
Cold drawn 20% + age hardened	186,500 psi	1.0019	-130 oF	-150 oF	-182 oF	-210 oF

Cold drawn 50 %	151,250 psi	1.0010	-210 oF	-	-	-
Cold drawn 50 %+ age hardened	198,000 psi	1.0019	-130 oF	-150 oF	-182 oF	-210 oF

Mechanical Properties

Alloy form	Condition	Tensile strength, ksi	0.2 % yield strength	Elongation %	Hardness
Monel K500 Rod & Bar	Hot finished + Aged	140 ksi to 190 ksi	100 ksi to 150 ksi	30 % to 20 %	27 HRC to 38 HRC
Monel K500 Rod & Bar	Hot finished + Annealed	90 ksi to 110 ksi	40 ksi to 60 ksi	45 % to 25 %	75 HRC to 90 HRC
Monel K500 Rod & Bar	Hot finished + annealed + aged	130 ksi to 165 ksi	85 ksi to 120 ksi	35 %to 20 %	24 HRC to 35 HRC
Monel K500 Rod & Bar	Cold drawn + aged	135 ksi to 185 ksi	95 ksi to 160 ksi	30 % to 15 %	25 HRC to 41 HRC
Monel K500 Rod & Bar	Cold drawn + annealed + aged	130 ksi to 190 ksi	85 ksi to 120 ksi	30 %to 20 %	24 HRC to 35 HRC
Monel K500 Plate	Hot finished + aged	140 to 180	100 to 135	30 to 20	27 HRC to 37 HRC
Monel K500 Sheet	Cold rolled + annealed	90 to 105	40 to 65	45 to 25	85 HRC

Shear Strength

Condition	Max Strength	Deflection at max strength	Tensile strength	Elongation
Annealed	65.3 ksi	0.08 ksi	97.5 ksi	49 %
Annealed + aged	96.5 ksi	0.06 ksi	147.2 ksi	29 %

Room temperature Fatigue strength

Forms, condition	Fatigue strength at 10(6) cycles	Tensile strength	(Fatigue strength/ tensile strength) ratio
Rod, annealed	38 ksi	88 ksi	0.43
Rod, hot rolled	43 ksi	99 ksi	0.43
Rod-hot rolled + aged	51 ksi	155 ksi	0.33

Corrosion Resistance

The resistance to corrosion produced by **Monel K-500** is partially equivalent to Monel 400 in the age toughening condition. Monel k500 wire has higher capacity towards the stress corrosion cracking in the particular conditions.

Monel K-500 offers resistance to the sour gas environment. Within six days of continuous immersion in the saturated hydrogen sulfide solutions in the acidic and basic solution in the U bend, age hardening material shows no cracks. The toughness lies between 28 to 40 Rc. The combination of minimum corrosion rate in the high velocity sea water and large firmness make Monel K500 wire highly fit for making shaft of centrifugal pump in the marine applications. The alloy shows stability in the stagnant or slow moving sea water after pitting though this pitting is reduced after quick initial attack. The resistance offered by the alloy K500 and other alloys is attacked by the different corrosive media.

Fabrication

Monel K-500 is easily fabricable by following the common industrial methods. In the hot processing, providing the complete temperature for deformation is an essential factor in receiving the hot malleability. The highest preferable heating temperature for hot processing of Alloy K-500 is 2100oF. The alloy should be set into hot furnace and taken back when it's all sections are equally heated.

The extended absorption at this temperature is risky. If it gets late then the material should be set into extended absorption while the temperature should be set at 1900oF as long as the metal is ready to use for particular purpose and then brought at temperature of 2100oF. When all parts of metal are equally heated it should be taken out from the furnace. In case of large delay, the process should be discarded from the furnace and quenched by water.

The hot processing temperature is between 1600oF to 2100oF and the massive processing is excellently performed at temperature between 1900oF to 2100oF though the processing at temperature lower than 1600oF is not suitable. To develop the fine grain in forging, the eventual heating temperature is set at 2100oF and minimum 30% reduction area is obtained in the final forging process.

During hot processing, or when it is essential for **Monel K-500 Alloy,** it is quenched before further hot processing; it should not be quenched in air but at temperature about 1450o or more. If the alloy is cooled down slightly its heat processing is done by some limit and stress established may cause thermal tearing while reheating of alloy.

Moreover the material cooling provides better response to age toughening because more age hardening components are required for processing. The material surface is oxidized to slight extent and it can be pickled easily if it is water cooled consisting of 2% of alcohol.

Cold Processing of Monel K-500 Alloy

For cold processing of **Monel K-500**, the traditional methods are followed. Though the alloy needs an adequate power for formation, it offers superior ductility. The increased hardness is obtained by Monel k – 500 alloy with wider cold processing as compare to other alloys.

Machining of Monel K-500 Alloy

The heavy machining of **Monel K-500 Alloy** is completed in the best manner when it is in the annealed form or hot processed and cooled. The age hardened material is finish machined to conceal the lenience and for better finishes of alloy. The machining of alloy is done little oversize, age hardening and then end size. While aging, slight persistent contraction is obtained and minor warpage occurs due to reduced temperature and slow quenching rates of alloy K-500 that can be connected by following the traditional methods.

Welding

Welding of **K-500 Alloy** is superiorly done by the gas tungsten arc welding method. The Monel filler metal 60 is basically utilized. Though the weldments are not age hardenable and do not possess the comparative strength of hardened base metal. The weldments need strength just like the aged base metal that should be deposited with the filler metal consisting of similar constituents.

Available Forms

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