Nickel-Iron-Chrome Alloy Incoloy 825 (UNS N08825)

Austenitic Incoloy 825 is approved for manufacturing ASME pressure vessels up to 538oC. It is a Nickel-chrome-Iron super alloy offering good mechanical properties from small to high temperatures. Easy weldability. Hot processing is allowed up to 2150oF.

Alloy 825 additionally contains molybdenum, copper and titanium. The concentration of nickel provides high resistance to chloride ion stress corrosion cracking. The combination of nickel, molybdenum and copper offers superior resistance to the reducing media that includes sulfuric and phosphoric acids. Alloy 825 also resists the oxidizing media and pitting and crevice corrosion. The content of titanium ensures the stability of alloy against intergranular attacks.

Chemical Composition

Nickel (Ni)	38 to 46 %
Iron (Fe)	22 %
Chromium (Cr)	19 to 23.5 %
Molybdenum (Mo)	2.5 to 3.5 %
Copper (Cu)	1.5 to 3 %
Manganese (Mn)	1 %
Titanium (Ti)	0.6 to 1.2 %
Carbon	0.05 %
Sulfur (S)	0.03 %
Silicon (Si)	0.5 %
Aluminium (Al)	0.2 %

Physical Properties

Electrical resistivity			
Temperature		microhm-inch	microhm-meter
RT	RT	44.4	1.13
200	93	44.9	1.14
400	204	46.5	1.18
600	316	47.6	1.21
800	427	49.2	1.25
Mean Coefficient of Thermal Expansion			
Temperature		microin./inch.-°F	X 10(-6)m/m-K
oC	oF		
80 to 200	27 to 93	7.9	14.0
80 to 400	27 to 204	8.3	14.9
80 to 600	27 to 316	8.5	15.3
80 to 800	27 to 427	8.7	15.7
Thermal Conductivity			
Temperature		Btu-in/ft²-hr-°F	W/m-K
oC	oF		
Room temperature	Room temperature	77	11.1
200	93	85	12.3
400	204	98	14.1
600	316	110	15.9
800	427	120	17.3

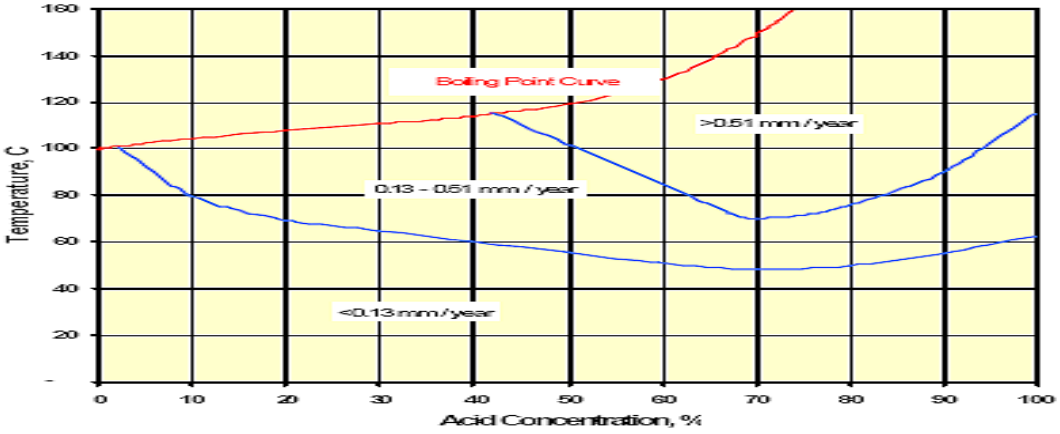
Mechanical Properties

Incoloy 825 offers superior mechanical characteristics from cryogenic temperatures to elevated temperature limits. When it is kept at temperatures more than 1000oF, certain microstructural variations have been noticed that tend to decrease its ductility and impact strength. Due to this, Incoloy 825 is not employed in the conditions that need high creep rupturing features.

Dynamic Modulus of elasticity	28 x 10(6) psi or 193 GPa at room temp
Ultimate tensile strength (annealed) sheet	100 ksi or 689 Mpa
Annealed plate	95 ksi or 655 Mpa
Annealed Strip, bar	85 ksi or 590 MPa
Yield Strength at 0.2% offset annealed) sheet	55 ksi or 379 Mpa
Annealed plate	45 ksi or 310 MPa
Annealed Strip, bar	35 ksi or 240 Mpa
Elongation % in 2 inch (annealed) sheet	39
Annealed plate	44
Annealed Strip, bar	30

Corrosion Resistance

The resistance to corrosion is one of the excellent features of Incoloy 825. It offers outstanding resistance to the reducing and oxidizing conditions, pitting and crevice corrosion, stress corrosion cracking and intergranular corrosion. Alloy 825 is certainly purposeful in sulfuric acid, phosphoric acid and sour gas conditions. The following chart shows the corrosion rate of alloy 825 in the presence of sulfuric acid.



Corrosion rate of Incoloy 825 in different media

Media	Temperature		Exposure time	Corrosion rate	
	oF	oC	days	Mpy	Mm/a
Aqueous solution containing 0.5% sulfuric acid	210 oF	99 oC	12 days	2 Mpy	0.05 Mm/a
1-4% sulfuric acid, 20-25% ammonium sulfate, and 10-15% sodium sulfate. Immersed in tank.	95 oF to 104 oF	35 oC to 40 oC	-	0.1 Mpy	0.003 Mm/a
Spent acid liquor from tall oil splitting. Contains 1% sulfuric acid by weight and 1% tall oil and 2-3% lignin by volume. Acid discharge line from centrifuge	250 oF	121 oC	33 days	0.1 Mpy	0.003 Mm/a
25-50 gm/l sulfuric acid, 25-100 gm/l manganese sulfate, 1-3 gm/l ferric sulfate. Immersed in sump manganese dioxide electrolysis circuit. Flow, 100 gal/min (379 l/min).	200 oF	93 oC	19 days	2.8 Mpy	0.07 Mm/a
In uranium ore leach tank in mixture containing 60% solids, 28-55 gm/l sulfuric acid, 5-10 gm/l ferric ion, some ferrous ion, 0.1% sodium chlorate.	113 oF	45 oC	41 days	0.1 Mpy	0.003 Mm/a
100-200 gm/l sulfuric acid, 40-100 gm/l selenious acid, small amounts of sulfurous acid.	70 oF to 80 oF	21 oC to 27 oC	90 days	None	None
Mixture of sulfuric acid and sebacic acid, pH1.	RT	RT	30 days	0.1 Mpy	0.003 Mm/a
5-10% sulfuric acid plus 0.25% copper sulfate in pickling of brass. Immersed 1 ft (0.30 m) below surface in continuous strip pickler.	100 oF to 200 oF	38 oC to 93 oC	162 days	0.1 Mpy	0.003 Mm/a
5% sulfuric acid plus 10-300 mesh ore of manganese dioxide and manganese oxide. Attached to steam coil in leaching	180 oF	82 oC	245 days	0.5 Mpy	0.01 Mm/a

tanks.					
Evaporation of aluminum sulfate solution from 28.2 to 58.7% aluminum sulfate containing 0.1% ferric oxide, 0.3% ferrous oxide, and traces of chromium oxide and alumina.	195 oF to 250 oF	91 oC to 121 oC	44 days	0.8 Mpy	0.02 Mm/a
9% sulfuric acid, 1% hydrofluoric acid, 3% sodium sulfate, 1% silica 0.5% sodium fluosilicate, and balance water. Immersed in tank near entrance	80 oF to 120 oF	27 oC to 49 oC	62 days	1 Mpy	0.03 Mm/a
12% sulfuric acid pickling solution containing copper sulfate up to 11.2%. Immersed inside tank of Mesta pickler.	180 oF	82 oC	26 days	0.2 Mpy	0.005 Mm/a
20% sulfuric acid plus 4% sodium dichromate. Immersed in cleaning solution for aluminum	150 oF to 160 oF	66 oC to 71 oC	77 days	19 Mpy	0.48 Mm/a
Up to 20% sulfuric acid, 100 gm/l cupric sulfate, 10 gm/l nickel sulfate, and traces of chloride. Treatment of copper residue in nickel refining. Immersed in concentration plant air blowers.	195 oF	91 oC	7 days	5 Mpy	0.13 Mm/a
In sulfuric acid solutions of various concentrations in vacuum evaporator. Recovery of sulfuric acid in paper making: 39% sulfuric acid 42% sulfuric acid 55% sulfuric acid	 120 oF 135 oF 160 oF	 49 oC 57 oC 71 oC	 120 days 120 days 120 days	 None 0.3 Mpy 4 Mpy	 None 0.008 Mm/a 0.10 Mm/a
50% sulfuric acid, 22% nitric acid, and 19% water. Immersed in laboratory tests.	150 oF 182 oF	66 oC 83 oC	6 days 5 days	0.5 Mpy 4.3 Mpy	.01 Mm/a .011 Mm/a
67% sulfuric acid plus gas mixture containing 44% propylene and 56% propane. In outlet piping from second stage reactor circulating pumps, pressure 400 psi (28.1 kg/cm2).	125 oF	52 oC	170 days	0.2 Mpy	0.005 Mm/a
In 78% sulfuric acid with traces of benzene sulfonic acid in bottom of acid settling tank.	100 oF to 130 oF	38 oC to 54 oC	8 days	5 Mpy	0.13 Mm/a
78% sulfuric acid containing 3.5% hydrogen peroxide plus various salts of iron, manganese, chromium, and nickel in holding tank.	100 oF to 300 oF	38 oC to 149 oC	8 days	5 Mpy	0.13 Mm/a
79-93% sulfuric acid containing small amounts of phosphine, ammonia, and hydrogen sulfate. In exit of packed tower in falling acid stream.	50 oF to 90 oF	10 oC to 32 oC	189 days	2.2 Mpy	0.056 Mm/a
91.6% benzene sulfonic acid, 3.5% sulfuric acid. Immersed in glass-lined vessel	140 oF	60 oC	7 days	45 Mpy	1.14 Mm/a
36% sulfuric acid, 28% oxalic acid, 32% water, and 4% ash. On agitator support in vacuum evaporation pan. Alternately immersed and exposed.	140 oF	60 oC	171 days	2.4 Mpy	0.061 Mm/a

Fabrication

Incoloy 825 is heat processed while production to produce the adequate blend of stability, resistance to corrosion, mechanical characteristics and formability. In order to maintain

such features while fabrication, alloy 825 is annealed from 1700oF to 1800oF then quick air cooling or water cooling is performed. The heat processing in the lower end of range is permitted to obtain stability.

Although annealing at temperature in the top end of this temperature is recommended to get soft and grain development while retaining the corrosion resistance features of alloy. Cooling of alloy 825 is often not important for the components that have thin cross section such as Incoloy 825 sheet, wire and strip however it is opposed to prevent sensitization in the alloy forms that have large cross section.

Hot and cold processing

The hot processing temperature of Incoloy 825 is between 1600oF to 2150oF. It is heat processed from 1600oF to 1800oF to get high resistance to corrosion. The quenching subsequent to hot processing is done by quick air cooling. The massive sides may be sensitized while quenching from hot processing temperature, so it may become prone to the intergranular corrosion in the particular conditions. The stable annealing maintains the corrosion resistance features.

When Incoloy 825 is welded or sent for further thermal processing, it may get intergranular corrosion, the stable annealing is done irrespective of quenching rate from hot processing temperature. The cold fabrication features and processes are similar to Inconel 600 alloy. The work processing rate is lesser than the ordinary grades of austenitic stainless steel however it is still higher. The forging device is well powered and well designed to recompense the increased yield strength with plastic bending.

Welding of Incoloy 825

Incoloy 825 shows excellent welding character and it can be welded through all traditional methods. In many operations, the Inconel welding electrode 112 for shielded metal arc welding and Inconel filler metal 625 for gas shielded methods are utilized. For excellent corrosion resistance purposes, Inco weld welding electrode 686CPT and inco weld filler metal 686CPT are utilized.

The traditional welding techniques work better with Incoloy 825. The similar alloy filler metal should be utilized. In case it is not available then the closest alloy that constitutes of matching elements should be chosen. The weld beads should be convex. It is not essential to preheat the alloy. The weldable surface should be clean and the clean area should expand till two inch at least beyond any side of welded joint.

Available Forms

Wire, Mesh, Pipe, Tubing, Bar, Rod, flanges, Strip, Sheet, Plate, Foil