Hastelloy C-4 Alloy

The **Hastelloy C-4 alloy** is a Nickel-Chromium-Molybdenum alloy that offers exceptional stabilization at the elevated temperatures, large ductility and resistance to corrosion and retains its characteristics even after aging up to 1200oF to 1900oF or 649oC to 1038oC. The alloy offers resistance to grain development precipitation in the welding area so it is highly suitable for the chemical processes in the welding condition. The C-4 alloy offers extremely high resistance to stress corrosion cracking and oxidizing conditions up to 1900oF or 1038oC.

Chemical composition % of Hastelloy C-4 Alloy

Ni	Co	Cr	Mo	Ti	Fe	Si	Mn	C	P	S
65	2.0	14 -18	14-17	0.70	3.0	0.08	1.0	0.01	0.025	0.010

Physical properties of Hastelloy C-4 alloy

Density	8.64 g/cm.3
Electrical Resistivity	1.25 microhm-m
Mean Coefficient of Thermal Expansion	10.8 x 10-6 m/m-K at 68-200oF
Thermal Conductivity	10.1 W/m-K at 74oF
Specific Heat	406 J/kg-K
Thermal Diffusivity	2.8 x 10-6 m2/s

The hardness and tensile properties offered by **Hastelloy C-4 high alloy** are shown below:

Alloy Form	Condition	Temp. oF & oC	Tensile Strength, MPa	Yield strength, MPa	Elongation %	Hardness, Rc
Sheet, 0.065 in (1.7 mm) thick	Heat-treated at at 1950oF (1066oC) quick cooling	400, 204	706	403	49	B-90
		600, 316	675	371	52	-
		800, 427	656	320	64	-
Sheet, 0.125 in (3.2 mm) thick	Heat-treated at at 1950oF (1066oC) quick cooling	600, 316	672	303	59	B-92
		800, 427	644	303	62	-
		1000, 538	645	299	55	-
Sheet, 0.156 in. (4.0 mm) thick	Heat-treated at at 1950oF (1066oC) quick cooling	600, 316	657	249	61	-
		800, 427	656	250	68	B-91

Hastelloy C Series Alloys

The dynamic modulus of elasticity at the different temperatures is provided below:

oF	oC	Gpa
200	93	211
400	204	207
600	316	201
800	427	194
1000	538	187

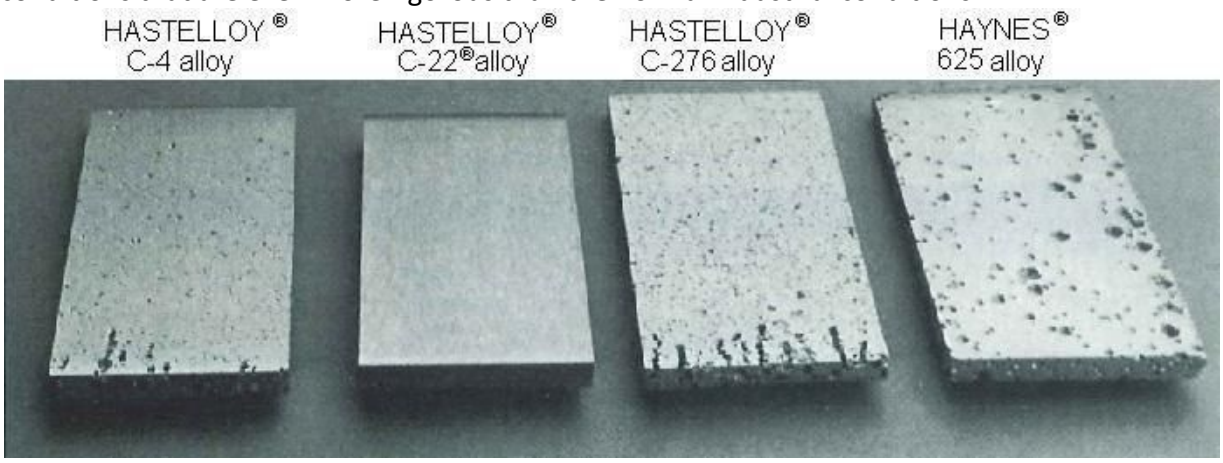
Formability of Hastelloy C-4 alloy

Form	**Condition**	**Average Olsen Cup Depth**	
Sheet, 0.065 in. (1.7 mm) thick	Heat-treated at at 1950°F (1066°C), rapid quench	0.52 inch	13.2 mm
	Aged 1000 hours at 1600°F (871°C)	0.52 inch	13.2 mm

Corrosion resistance

The **Hastelloy C-4 alloy** offers very high resistance to the different chemical processing conditions. These comprise of warm contaminated mineral acid, solvent, chlorine and chlorine mixed sources, arid chlorine, formic and acetic acid, acetic anhydride and seawater and brine mixtures and more.

The laboratory precipitation on the Hastelloy alloy shows that the intermetallic precipitation with the other nickel alloys at the temperature ranges of 1200 to 2000oF are not identified. The refined intergranular M6C carbide can be formed though with the minor destruction result. The accelerated analysis can be made to evaluate the resistance to corrosion offered by the hastelloy C-4 alloy. The analysis is made in the rigorous conditions that are even more rigorous than the normal industrial conditions.



The above image shows the extent of corrosion in the different Hastelloy C series alloys.

Rate of Oxidation of Hastelloy C-4 Alloy

Test Temperature		Average Oxidation Rate per 100-hour test period - 100 hours, intermittent*	
oF	oC	mils	mm
1900	1038	0.16	0.004

Hastelloy C Series Alloys

The average corrosion rate **Hastelloy C-4 high temperature resistance alloy** is shown as following:

Medium	Weight	oF or oC	Average corrosion rate		
			Unwelded, mm	As-welded, mm	Aged, mm
Formic Acid	20	Boiling	0.07	0.09	0.09
Hydrochloric Acid	10	167 or 75	0.91	0.86	0.89
Nitric Acid	10	Boiling	0.15	0.18	0.23
Phosphoric Acid	85	Boiling	1.5	1.30	2.20
Sulfuric Acid	10	167 or 75	0.56	0.64	0.51

The tensile properties of aged Hastelloy C-4 alloy sheet and plate:

Form	Condition	Temp		Tensile strength		Yield strength		Elongation
		oF	oC	Ksi	Mpa	Ksi	Mpa	%
Sheet, 0.125 in (3.2 mm) thick	Aged 100 hrs. at 1650°F(899°C)	400	204	103.2	712	47.1	325	54
		600	316	99.5	686	43.1	297	57
		800	427	97.0	669	40.6	280	60
		1000	538	93.3	643	39.9	275	57
		1200	649	86.6	597	37.2	256	56
Plate, 3/8 in (9.5 mm) thick	Aged 100 hrs. at 1650°F (899°C)	400	204	100.6	694	39.5	272	51
		600	316	98.0	676	37.0	255	56
		800	427	97.2	670	37.1	256	57
		1000	538	89.6	618	32.1	221	53
		1200	649	89.6	618	34.1	235	56

Ferric Sulfate Analysis- The Hastelloy C-4 material is evaluated for 24 hours period as per the ASTM G - 28A that includes boiling 50% sulfuric acid with 42 gm per liter of ferric sulfate. The grain precipitates provide high corrosion rate of alloy.

Stress Corrosion of Hastelloy C-4 Alloy

The stressed C-4 alloy materials were analyzed in the boiling 42 percent magnesium chloride that increases the corrosion attack. The Hastelloy C-4 alloy remains untouched for 1000 hours.

The **Hastelloy C-4 alloy** can be formed, hot stressed and impact extruded though it tends to be hardened to get easily deep drawn, spun, or punched. The popular welding techniques are used among of which the oxy acetylene and submerged arc techniques are not preferred due to the risk of corrosion.

Hastelloy C-22 Alloy

Hastelloy C-22 is a flexible alloy comprising of nickel, chromium, molybdenum and tungsten as the prime elements. It offers the higher resistance than the Nickel-Chromium-Molybdenum alloy. The **Hastelloy C-22 alloy** offers exceptionally high resistance to pitting, crevice corrosion and stress corrosion cracking. It offers superior resistance to oxidizing aqueous conditions as well as hydrates chlorine and nitric acid and other oxidizing acids and chlorine ions.

The material of C-22 wire is analyzed to measure the resistance to corrosion offered by the material. The alloy comes in the category of UNS number N06022 though with the limited composition to provide an enhanced functionality. The improvements are very important that the wire is highly patented in the whole world

Hastelloy C Series Alloys

Chemical composition of Hastelloy C-22 Alloy

Ni	Co	Cr	Mo	W	Fe	Si	Mn	C	V
56	2.5	22	13	3	3	0.08	0.50	0.010	0.35

Corrosion resistance

The alloy offers superior resistance to reducing and oxidizing media offered in the process streams. Due to its large flexibility it can be subjected in the severe conditions that normally occur in the multifunctional plants. The alloy offers intense resistance to the various chemical processing conditions such as strong oxidizers like ferric and cupric chloride, hot solutions containing organic and inorganic acids, formic and acetic acids, acetic anhydride.

The high resistance C-22 alloy also resists the production of grain precipitates in the welded areas so it is best fit for using in the chemical processing in the welded applications.

Physical properties of Hastelloy C-22 Alloy

Density	75oF	0.314 lb/in.3	24oC	8.69 g/cm.3
Melting Range	2475-2550oF		1357-1399	
Thermal Conductivity	118oF	70 Btu-in./ft.2 hr.-°F	48oC	10.1 W/m-K
Specific Heat	126oF	0.099 Btu/lb.-°F	52oC	414 J/Kg-K

Electrical and thermal properties of Hastelloy C-22 Alloy

Temp., oF	Temp., oC	Electrical Resistivity microhm-in.	Mean Coeffi of thermal expansion, microinches/in.-°F
75	24	44.8	6.9
212	100	48.3	6.9
392	200	48.7	7.0
572	300	49.3	7.4
752	400	49.6	7.7
932	500	49.9	8.1

Dynamic Modulus of Elasticity

Form	Condition	Temperature		Modulus of elasticity	
	Heat-treated at 2050°F or (1121°C) quick Quenched	oF	oC	10-6 psi	GPa
Plate		200	93	29.4	
		400	204	29.4	203
		600	316	28.5	196
		800	427	27.6	190
		1000	538	26.6	183
		1200	649	25.7	177

Corrosion protection in the chemical processing house

	Alloy	Corrosion rate (mpy)	Output
Reactor Vessel 10-15% Sulfuric Acid + Solids /Impurities 212°F (100°C) — 12 Months	316L Stainless Steel	>61	Sample Dissolved
	Carpenter 20Cb-3® alloy	>57	Sample Dissolved
	Alloy 825	>58	Sample Dissolved
	HASTELLOY® B-2 alloy	>58	Sample Dissolved
	HAYNES® 625 alloy	29	Severe Corrosion Attack
	HASTELLOY C-276 alloy	28	Severe Corrosion Attack
	HASTELLOY C-22® alloy	4.7	Severe Corrosion Attack

Hastelloy C Series Alloys

Average tensile properties of Hastelloy C-22 Alloy

Form	Temp, oF	Tensile Strength, ksi	Yield Strength, ksi	Elongation, %
Sheet, 0.028 - 0.125 in (0.71 - 3.2 mm) thick**	200	110	54	58
	400	102	44	57
Plate, 1/4 - 3/4 in. (6.4 - 19.1 mm)	200	107	49	65
	400	98	41	66
Bar, 1/2 - 2 in (12.7 - 50.8 mm diameter	200	105	45	73
	400	96	38	74

Rate of corrosion in Flue Gas Desulfurization (FGD)

	Alloy	Pitting (in)	Crevice (in)
Pulverized Coal Fired Unit 4.8% Sulfur Outlet Duct 129°F (54°C) — 27 Months	316L Stainless Steel	0.011	0.015
	Alloy 904L	0.010	0.005
	Jessop JS700® alloy	0.010	0.011
	HAYNES 625 alloy	No Attack	0.005
	HASTELLOY C276 alloy	No Attack	0.007
	HASTELLOY C-22 alloy	No Attack	0.002

Rate of corrosion in Refinery Industry

	Alloy	Corrosion Rate (mpy)	Output
Coke Refinery Vaporizer 203°F (95°C) — 2 Months	316L Stainless Steel	139	Severe Crevice Attack
	Carpenter 20Cb-3® alloy	227	Partially Dissolved
	Avesta 254 SMO® alloy	83	Pitting, Crevice Attack
	Allegheny AL-6XN® alloy	60	Pitting, Crevice Attack
	HAYNES 625 alloy	29	Pitting, Crevice Attack
	HASTELLOY C-22 alloy	3.4	Pitting, Crevice Attack

Corrosion-Resistant Weld Filler Metal

The welded alloys often suffer from corrosion. For reliable and economical solutions, Hastelloy C-22 filler metal is used. The following table shows the corrosion rate of different weld metals and base metals:

Medium	Base Metal	Filler Weld	Corrosion Rate (mpy)
3M NaCl+0.1M FeCl3+0.1M NaF 167°F (75°C), pH = 1	625	625	100
	625	Hastelloy C-22	94
	Hastelloy C-22	Hastelloy C-22	0.17

Thermal Stability

The weldments of alloy C-276 and C-22 are set into oxidizing sulfuric acid process solution. The Hastelloy C-276 suffers from uncommon attack on the severe base metal, weld metal and heat affected area in this condition. It is found that only 1/3rd of heated alloy's thickness is corroded. The Hastelloy C-276 is rarely corroded in the other conditions.

The C-22 alloy is preferably chosen for its wider testing in the bleach water conditions. It has already provided prolonged performance of several years more than 10 without getting any corrosion. Apart of Hastelloy C-22 other 20 different samples were analyzed though all were failed. The C-22 alloy gives much more enhanced resistance to corrosion as compare to the original metal.

Fabrication of Hastelloy C – 22 Alloy

The wrought C-22 alloy is prepared in the heat processed solution until it is recommended. The alloy is heat processed at 2050oF temperature or 1121oC and quickly quenched. The components that are hot forged or intensely cold forged must be solution heat processed before fabrication.

Applications

The range of applications of **Hastelloy C-22 alloy** is discussed below:

Acetic Acid/Acetic Anhydride Acid Etching, Cellophane Manufacturing, Chlorination Systems, Complex Acid Mixtures, Electro-Galvanizing Rolls, Expansion Bellows, HF Furnace Scrubbers, Nuclear Fuel Reprocessing, Incineration Scrubber Systems and SO2 Cooling Towers and more.

The electrogalvanizing finish rolls made of Hastelloy C-22 alloy are utilized in the steel finish manufacturing. The alloy decreases the defects on rolls that is essential to produce defect free galvanized steel in the automotive industry.

The solid rocket propellant effluents and salt air causes pitting and crevice corrosion attack to the stainless steel. The **Hastelloy C-22 alloy** is selected over 19 different alloys due to extensive resistance to corrosion.

Hastelloy C-276 Alloy

The **Hastelloy C-276** alloy is a member of Nickel-Molybdenum-Chromium alloy family that is characterized with an extreme resistance to corrosion. The C-276 alloy is an enhanced quality of corrosion resistance material. It doesn't need to be heat processed after welding and provides extremely improved fabricability. It resists the production of grain precipitation in the welded areas so it is very much fit for using in the chemical processing applications in the welded form. But in the conditions when there is a feasibility of corrosion of alloy C-276 welds, Hastelloy C-22 weld filler metal is recommended for use.

The C-276 corrosion resistance alloy offers superior resistance to the localized corrosion and oxidizing and reducing environments. The versatile hastelloy C-276 can be set into upset conditions to use in the multifunctional places.

Chemical composition of hastelloy C-276 Alloy

Ni	Co	Cr	Mo	W	Fe	Si	Mn	C	V
57	2.5	16	16	4	5	0.08	1	0.01	0.35

Physical Properties of C-276 Alloy

Density	8.89 g/cm.^{3}
Melting Point	2415-2500 oF
Electrical Resistivity	1.30 microhm-m
Mean Coefficient of Thermal Expansion	11.2 x 10^{-6} m/m•K
Thermal Conductivity	7.2 W/m•K
Specific Heat	427 J/kg•K

Electrical and thermal Properties of Hastelloy C-276 Alloy

Temp	Thermal Conductivity	Coeff. Of Expansion	Electrical Resistivity	Young's Modulus
oF	Btu•in./ft2•h°F	10-6 in/in•°F	ohm•cmil/ft	10-3 ksi
-270	50	-	-	-
-100	60	-	0	-
0	65	-	-	-
77	-	-	739.2	29.8
100	71	-	-	-
200	77	6.8	743.8	29.5

Hastelloy C Series Alloys

Elevated Temperature Dynamic Modulus Properties

Temperature	Young's Modulus	Shear Modulus	Poisson's Ratio
oF	10-3 ksi	10-3 ksi	
70	31.30	11.81	0.33
100	31.18	11.75	0.33
200	30.77	11.57	0.33
300	30.35	11.40	0.33
400	29.92	11.23	0.33
500	29.42	11.05	0.33

Tensile Characteristics of Hastelloy C-276 at Room Temperature:

Alloy Form	Tensile Strength		Yield Strength		Elongation	Hardness
	Ksi	Mpa	Ksi	Mpa	%	Rc
Tubing	105.4	727	45.4	313	70	92
Plate	107.4	741	50.3	347	67	89
Bar	110.0	758	52.6	363	62	88
Sheet	115.5	796	54.6	376	60	86

Tensile properties of solution treated Hastelloy C-276 Alloy

Form	Temp, oF	Tensile strength, ksi	Yield strength, ksi	Elongation, %	Hardness, Rc
Sheet	Room				90
Sheet, 0.078 in.(2.0 mm) thick	400	100.6	51.6	61	
Sheet, 0.094 in.(2.4 mm) thick	400	101.0	39.9	58	
Sheet, 0.063 to 0.187 in. (1.6 to 4.7 mm) thick	400	100.8	42.1	56	
Plate	Room				87
Plate, 3/16 to 1 in. (4.8 to 25.4 mm) thick	400	98.9	38.2	61	
Plate, 1 in.(25.4 mm) thick	400	113.9	52.9	59	

Formability of Hastelloy C-276

Form	**Condition**	**Average Olsen Cup Depth**	
		In.	mm.
Sheet, 0.044 in. (1.1mm) thick	Heat-treated at 2050°F (1121°C), Rapid Quenched	0.48	12.2

Average impact strength of Hastelloy C-276 Plate

Condition	Notch Impact Strength	
	-320°F	-196°C
	ft.-lb.	J
Solution Heat-Treated at: 2050°F (1121°C), Rapid Quenched	263	357
Aged 100 hrs. at: 500°F (260°C) 1000°F (538°C	250	339
	96	130
Aged 1000 hrs. at: 1000°F (538°C)	64	87

Hastelloy C Series Alloys

Corrosion Resistance Properties of Hastelloy C-276

The **Hastelloy C-276 corrosion resistance alloy** offers tremendous resistance to the various chemical processing conditions such as powerful oxidizer like chlorides of iron and copper, hot mixed organic and inorganic acids, formic and acetic acids, acetic anhydride, and seawater and brine solutions. It offers resistance to the carbide precipitation while welding retains corrosion resistance features in the heated zones of welding points.

The C-276 alloy is used in the desulfurization processes due its very high resistance to compounds containing sulfur and chloride ions found in the scrubs. The alloy offers superior resistance to the pitting and stress corrosion cracking and it is one of the popular metals that are capable to adhere in the impact of hydrated chlorine, hypochlorite, and chlorine dioxide and other mediums.

Aqueous Corrosion rate of Hastelloy C-276 in the Acidic Media:

Media	Weight %	Temp, oF	Average Corrosion Rate per year, Mils*		
			C-276 Alloy	C-22® alloy	C-4 alloy
Acetic Acid	99	Boiling	<1	No corrosion	No corrosion
Ferric Chloride	10	Boiling	2	<1	
Formic Acid	88	Boiling	1	1	2
Hydrochloric Acid	1	Boiling	13	3	25
Hydrochloric Acid + 42g/l $Fe_2(SO_4)_3$	1	200	41	2	-
Hydrochloric Acid + 2% HF	5	158	26	59	34

Fabrication of Hastelloy C-276

The **Hastelloy C-276 alloy** can be produced, hot set and impact extruded. Though it causes the work toughening, it can be vitally deep drawn, fabricated and stressed. It is welded by using the common and traditional welding methods though oxyacetylene method is not preferred. The serious provisions are followed to prevent the excessive heating of alloy.

The shaped C-276 alloy is prepared in the heat processed solution until it is recommended. The alloy is heat processed at the 2050oF temperature or 1121oC and quickly quenched.

The dehydrated chemical composition of hastelloy electrodes includes C by 0.02 %, Silicon by 0.20 %, Phosphorous by 0.03 % and sulfur by 0.015 %. In the rigorous corrosive conditions the **Hastelloy C-276 alloy** is utilized as the most trusted alloy. The excellent service in the tough conditions for several years has proven the quality performance of this alloy.

The **Hastelloy C-276 alloy** is purposeful in the chemical processing and other industrial operations and it has become the prior choice of engineers. Before employing in the industry, the Hastelloy C-276 alloy goes through the exacting process, chemical controls, heat mechanical treatments, analysis and criteria for the rigid norms. Moreover the welded alloy specimen offers the enhanced functionality.

Hastelloy C-2000 Alloy

Hastelloy C-2000 corrosion resistance alloy introduces the novel configuration to the versatile Nickel-Chromium-Molybdenum alloy offering extensive resistance to the corrosive environments. By the excellent resistance to the oxidizing and reducing conditions, the **Hastelloy C-2000 alloy** offers an outstanding performance in the chemical processing operations.

Hastelloy C Series Alloys

Chemical composition of C-2000 alloy

Ni	Cu	Cr	Mo	Co	Fe	Si	Mn	C
59	1.6	23	16	2	3	0.08	1	0.01

Physical properties of hastelloy C – 2000 alloy

Density	At room temperature	8.50 g/cm3
Thermal Conductivity	At room temperature	9.1 W/m•K
Mean Coefficient of Thermal Expansion	77oF to 200oF	12.4 m/m•K
Electrical Resistivity	At room temperature	128 microhm-m
Thermal Diffusivity	At room temperature	0.025 cm^2/s
Specific Heat	At room temperature	428 J/kg.°C
Dynamic Modulus of Elasticity	At room temperature	207 GPa
Melting Point	1328-1358°C	

Corrosion Resistance by Hastelloy C-2000 Alloy

To make the nickel alloy resistant to corrosive media, it needs the high concentration of chromium by which the alloy becomes able to resist the wider oxidizing media like ferric acids, cupric ions and more. The reducing media like hydrated hydrochloric or sulfuric acid needs high concentration of molybdenum as well as tungsten.

With the help of high content of chromium, the C-2000 corrosion resistance alloy offers excellent resistance to oxidizing media like nitric acid and solutions like ferric ions, cupric ions and dissolved oxygen.
The tensile properties of **Hastelloy C-2000 corrosion resistance alloy** at the room temperature are provided below:

Thickness, inch	Tensile Strength, ksi	Yield Strength, ksi	Elongation, %
0.063	109.0	52.0	64.0
0.125	111.0	57.0	63.0
0.250	113.0	55.0	62.0
0.500	110.0	50.0	68.0
1.00	109.0	54.0	63.0

The Hastelloy C-2000 solves the alloy design dilemma. The large magnitude of chromium is mixed with molybdenum and copper, adequate to offer resistance to the reducing conditions while no loss of metallurgical consistency. In the hot reducing concentration of sulfuric acid, the C-2000 alloy offers better performance than the alloy C-276. The C-2000 alloy also offers excellent resistance to the boiling and hydrated hydrochloric acid.
On the other side the rate of corrosion increases to 20 mpy at the concentration between 1 to 1.5 wt %. The C-2000 alloy offers superior resistance to corrosion at the concentration of 3% weight.

Pitting and Crevice corrosion resistance

The **Hastelloy C-2000 corrosion resistance alloy** also offers resistance to pitting and crevice corrosion that is widely introduced in the commercial processes. In order to determine the pitting and crevice corrosion provided by Hastelloy C-2000, it is evaluated at the critical crevice and pitting temperature in the acidic medium of 6 % ferric chloride by following the ASTM G 48 procedures

Hastelloy C Series Alloys

ALLOY	Critical Crevice Temperatures, oC	Critical Pitting Temperatures, oC
316L	0	15
254SMO	30	60
625	40	100
C-22	80	>120
C-276	55	>120
C-2000	80	>120

The above data shows the minimum temperature at which the pitting and crevice corrosion occurs in the acidic ferric chloride in 72 hours. Another acidic solution is 11.5 % sulfuric acid, 1.2 % hydrochloric acid, 1 % ferric chloride and 1 % cupric chloride that is widely used to evaluate the resistance to pitting corrosion. This solution is called as green death. The following table shows the comparison of critical pitting temperature of Hastelloy C-2000 with other alloys:

Alloy	Critical Pitting Temperature, oC
316L	25
625	75
C-4	90
C-22	120
C-276	105
C-2000	110

Seawater is one of the strongest corrosion media that consists of aqueous salts. It is bumped into marine operations and seashore oil refineries as well as used as coolant in the coastal industries. The crevice test is conducted in the still and dynamic water at 29oC or 3oC. Double samples of every testing alloy in the still and dynamic water are evaluated for 180 days. Every sample consists of double crevice spots.

ALLOY	Still water	Still water	Dynamic water	Dynamic water
	No. of spots	Depth, mm	No. of spots	Depth, mm
316L	2	1.80	2	0.32
254SMO	2	1.25	2	0.01
625	2	0.11	2	<0.01
C-22	0	0	0	0
C-276	1	0.12	0	0
C-2000	0	0	0	0

Stress Corrosion Cracking:

Boiling solution of 45% magnesium chloride is used to evaluate the resistance to stress corrosion cracking offered by Hastelloy C-2000 alloy. The following table shows the time needed to cause cracks in the different alloy's materials:

Alloy	Cracking Period
316L	2 hours
254MO	2 hours
625	No cracks in 1008 hours
C-22	No cracks in 1008 hours
C-276	No cracks in 1008 hours
C-2000	No cracks in 1008 hours

Hastelloy C Series Alloys

Mechanical Properties of Hastelloy C-2000 Alloy:

Form	Annealing Temp.	Thickness/Dia.	Yield Strength	Tensile Strength	Elongation
	oC	Mm	MPA	MPa	%
Sheet	1163	0.6	372	752	61
Sheet	1163	2.0	400	786	62
Plate	1149	4.8	407	745	63
Plate	1149	6.4	393	731	63
Bar	1149	9.7	331	745	67
Bar	1149	19.1	345	738	69

Welding of Hastelloy C-2000 Alloy

The C-2000 alloy has similar welding, forming, and machining features that are equivalent to C-276 alloy. In order to weld the Hastelloy C- series alloys, basically three methods are followed. For sheet welds and plate root passes, GTAW or Gas tungsten arc welding process is recommended. For plate welding, the gas metal arc welding method is recommended.

For field welding, the shielded metal arc process is preferred by using the coated electrodes. The submerged arc welding process is not preferred because it is featured with extensive heating of the primary metal and slow weld quenching. In order to decrease the precipitation of second phase in the heat affected welding zones, high interpass temperature up to 93oC is preferred. In these processes, welding of the cold treated alloy is not preferred because these may get sensitized quickly and cause residual stress. The water quenching after the complete solution annealing is preferred for cold processed alloy prior to welding. The grease, oil and other contaminated particles should be removed.

Filler Metal

Hastelloy C-2000 filler wire is preferred for gas tungsten arc and gas metal arc welding. Hastelloy C-2000 electrodes are preferred for shielded metal arc welding.

Impact properties of Weldments

Welding Process	Form	Position	Temp, oC	Impact Strength, J
Synergic Gas Metal arc welding	Transverse Sample from Welded Plate of Thickness 12.7 mm./0.5 in	Mid-Weld	-196	142
		Heated Region	-196	203
Shielded metal arc welding	All Weld Metal Sample taken from Plate Weld	In Weld	Room Temp	71
			-196	45

The tensile properties of weldments are shown as following:

Welding Process	Form	Temp	Yield strength	Tensile Strength	Elongation
		oC	MPa	MPa	%
Gas Tungsten Arc Welding (GTAW	Transverse Sample from Welded Plate of Thickness of 12.7 mm/0.5 in	260	326	642	42.1
	All Weld Metal Sample of Diameter 12.7 mm/0.5 in from Cruciform	260	391	614	47.4
Synergic Gas Metal Arc Welding (GMAW)	Transverse Sample from Welded Plate of Thickness of 12.7 mm/0.5 in	260	352	654	43.1
	All Weld Metal Sample of Diameter 12.7 mm/0.5 in from Cruciform	260	394	620	46.4

Hastelloy C Series Alloys

Machining of Hastelloy C-2000 alloy

In the below table the instructions are provided to perform the machining process on the wrought materials. The particular machining tasks change with the conditions of operation.

Operations	Carbide Tools	High Speed Steel Tools
Drilling	C-2 grade not recommended, but tipped drills may be successful on rigid setup of no great depth. The web must be thinned to reduce thrust Use 135° included angle on point, Gun drill can be used. Speed: 50 sfm. Oil2 or water-base coolant. Coolant-feed carbide tipped drills may be economical in some setups	M-33, M-40 series1 or T-15: Use short drills, heavy web, 135° crank-shaft, grind points wherever possible. Speed: 10-15 sfm Feed: 0.001 in. rev. 1/8 in. dia. 0.002 in. rev. 1/4 in. dia 0.003 in. rev. 1/2 in. dia. 0.005 in. rev. 3/4 in. dia 0.007 in. rev. 1 in. dia. Oil or water-base coolant. Use coolant feed drills if possible.
Normal Roughing; Turning or Facing	C-2 or C-3 grade: Negative rake square insert, 45° SCEA4 , 1/32 in. nose radius Tool holder: 5° neg. back rake, 5° neg. Speed: 90 sfm depending on rigidity of set up, 0.010 in. feed, 0.150 inch., depth of cut, Dry , oil, or water-base coolant.	
Finishing; Turning or Facing	C-2 or C-3 grade: Positive rake square insert, if possible, 45° SCEA, 1/32 in. nose radius. Tool holder: 5° pos. back rake, 5° pos. side rake. Speed: 95-110 sfm, 0.005-0.007 in. feed, 0.040 in. depth of cut. Dry or water-base coolant	

Heat Processing of Hastelloy

Wrought Hastelloy C – 2000 alloy is kept into solution annealed form, if specified. The standard solution annealing processing includes heating up to 1135oC, subsequently air or water quenching is performed. The components that are hot forged are solution annealed before final forging.

Fabrication

The Hastelloy C-2000 alloy offers superior fabrication properties, and cold forging is the recommended method of shaping. It can be conveniently work processed due to its high ductility. It is normally stiffer as compare to the austenitic stainless steels so more energy is needed while cold forging.

Applications of Hastelloy C-2000 Alloy

1. Chemical processing industrial reactors, heat exchangers
2. Pharmaceutical industrial reactors and dryers
3. Flue gas desulfurization systems.

Hastelloy C Alloy Product Forms Available:

Wire, Wiremesh Screen, Strip, Sheet, Rod, Pipe, Bar, Tubing, Plate, Ribbon, Tape

Heanjia Super Metals Co., Ltd **Room 2108, 21/F, BLK128, Yinling International Zone, Wangjing West Rd, Chaoyang, Beijing, China (100102)**