

Hastelloy C-22 (UNS N06022)



Hastelloy C-22 is employed in applications that need excellent resistance to natural corrosion, intergranular corrosion, pitting and crevice corrosion and stress corrosion cracking. It is resistant to oxidizing and reducing conditions and prevents aqueous corrosion. It is used in water treatment plants, chlorination plants, incinerators and other applications.

The material of C-22 wire is analyzed to measure its resistance to corrosion. The alloy however with the limited composition provides an enhanced functionality.

Chemical Composition

Carbon (C)	0.010 %
Chromium (Cr)	20 to 22.5 %
Cobalt (Co)	2.5 %
Iron (Fe)	2 to 6 %
Manganese (Mn)	0.50 %
Molybdenum (Mo)	12.5 to 14.5 %
Nickel (Ni)	Rem %
Phosphorous (P)	0.02 %
Silicon (Si)	0.08 %
Sulfur (S)	0.02 %
Tungsten (W)	2.5 to 3.5 %
Vanadium (V)	0.35 %

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 electro-galvanized finish rolls made of Hastelloy C-22 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. Alloy C-22 is selected over 19 different alloys due to its extensive resistance to corrosion.

Physical Properties

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 Resistivity

Temperature		microhm-inch	microhm-meter
oF	oC		
75 oF	24 oC	44.8	1.14
212 oF	100 oC	48.3	1.23
392 oF	200 oC	48.7	1.24
572 oF	300 oC	49.3	1.25
752 oF	400 oC	49.6	1.26
932 oF	500 oC	49.9	1.27
1112 oF	600 oC	50.2	1.28

Mean Coefficient of thermal expansion

Temperature		microin./in.-°F	m/m-K
oF	oC		
75 oF to 200 oF	24 oC to 93 oC	6.9	12.4 x 10 ⁽⁻⁶⁾
75 oF to 400 oF	24 oC to 204 oC	6.9	12.4 x 10 ⁽⁻⁶⁾
75 oF to 600 oF	24 oC to 316 oC	7	12.6 x 10 ⁽⁻⁶⁾
75 oF to 800 oF	24 oC to 427 oC	7.4	13.3 x 10 ⁽⁻⁶⁾
75 oF to 1000 oF	24 oC to 538 oC	7.7	13.9 x 10 ⁽⁻⁶⁾
75 oF to 1200 oF	24 oC to 649 oC	8.1	14.6 x 10 ⁽⁻⁶⁾
75 oF to 1400 oF	24 oC to 760 oC	8.5	15.3 x 10 ⁽⁻⁶⁾
75 oF to 1600 oF	24 oC to 871 oC	8.8	15.8 x 10 ⁽⁻⁶⁾
75 oF to 1800 oF	24 oC to 982 oC	9	16.2 x 10 ⁽⁻⁶⁾

Thermal Conductivity

Temperature		Btu-in/ft ² -hr-°F	W/m-K
oF	oC		
118 oF	48 oC	77	11.1
212 oF	100 oC	93	13.4
392 oF	200 oC	108	15.5

572 oF	300 oC	121	17.5
752 oF	400 oC	135	19.5
932 oF	500 oC	148	21.3
1112 oF	600 oC	148	21.3

Thermal Diffusivity

Temperature		Inch ² per sec	meter ² per sec
oF	oC		
70 oF	21 oC	0.004	2.7 x 10(-6)
212 oF	100 oC	0.005	3.0 x 10(-6)
392 oF	200 oC	0.005	3.5 x 10(-6)
572 oF	300 oC	0.006	3.9 x 10(-6)
752 oF	400 oC	0.007	4.2 x 10(-6)
932 oF	500 oC	0.007	4.6 x 10(-6)
1112 oF	600 oC	0.007	4.8 x 10(-6)

Mechanical Properties

Alloy Forms	Temperature		Ultimate Tensile Strength		Yield Strength at 0.2% offset		Elongation in 2 inch percent
	oF	oC	Ksi	MPa	ksi	MPa	
Hastelloy C-22 Sheet	RT		116.3 ksi	802	58.5 ksi	403 MPa	57 %
	200 of	93 oC	109.5 ksi	755	53.8 ksi	371 MPa	58 %
	400 of	204 oC	101.6 ksi	701	43.9 ksi	303 MPa	57 %
	600 of	316 oC	97.7 ksi	674	41.8 ksi	288 MPa	62 %
	800 of	427 oC	95.4 ksi	658	41 ksi	283 MPa	67 %
	1000 of	538 oC	90.7 ksi	625	39.7 ksi	274 MPa	61 %
	1200 of	649 oC	84.6 ksi	583	36.1 ksi	249 MPa	65 %
	1400 of	760 oC	76 ksi	524	34.5 ksi	238 MPa	63 %
Hastelloy C-22 Plate	RT		113.9 ksi	785	54.1 ksi	373 MPa	62 %
	200 of	93 oC	107.1 ksi	738	48.8 ksi	336 MPa	65 %
	400 of	204 oC	98.1 ksi	676	40.5 ksi	279 MPa	66 %
	600 of	316 oC	94.55 ksi	652	36.3 ksi	250 MPa	68 %
	800 of	427 oC	91.5 ksi	631	34.6 ksi	239 MPa	68 %
	1000 of	538 oC	87.5 ksi	603	34 ksi	234 MPa	67 %
	1200 of	649 oC	83.2 ksi	574	32.1 ksi	221 MPa	69 %
	1400 of	760 oC	75.6 ksi	521	31 ksi	214 MPa	68 %
Hastelloy C-22 Bar	RT		111 ksi	765	51.9 ksi	358 MPa	70 %
	200 of	93 oC	104.9 ksi	723	45.4 ksi	313 MPa	73 %
	400 of	204 oC	96.2 ksi	663	37.5 ksi	259 MPa	74 %
	600 of	316 oC	91.6 ksi	631	33.8 ksi	233 MPa	79 %
	800 of	427 oC	89.1 ksi	614	30.7 ksi	212 MPa	79 %
	1000 of	538 oC	84.3 ksi	581	28.8 ksi	199 MPa	80 %
	1200 of	649 oC	79.5 ksi	548	28.3 ksi	195 MPa	80 %
	1400 of	760 oC	72.2 ksi	498	29 ksi	200 MPa	77 %

Corrosion Resistance

Hastelloy C-22 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 and acetic anhydride.

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

Corrosion rates of Hastelloy C22 in different corrosive conditions

Environment	Content weight %	Temp, oC,		Average corrosion rate mills per year			
		oC	Of	Alloy C22	Alloy C276	Alloy C4	Alloy 625
Acetic Acid	99 %	Boiling	Boiling	Nominal	Below 1	Nominal	Below 1
Ferric Chloride	10 %	Boiling	Boiling	1 mpy	2 mpy	140 mpy	7325 mpy
Formic acid	88 %	Boiling	Boiling	Below 1	1 mpy	2 mpy	9 mpy
Hydrochloric acid	1 %	Boiling	Boiling	3 mpy	13 mpy	25 mpy	1 mpy
Hydrochloric acid	1.5 %	Boiling	Boiling	14 mpy	32 mpy	64 mpy	353 mpy
Hydrochloric acid	2 %	90 oC	194 of	Nominal	1 mpy	31 mpy	Nominal
Hydrochloric acid	2 %	Boiling	Boiling	61 mpy	51 mpy	82 mpy	557 mpy
Hydrochloric acid	2.5 %	90 oC	194 of	Below 1	12 mpy	34 mpy	72 mpy
Hydrochloric acid	2.5 %	Boiling	Boiling	141 mpy	85 mpy	44 mpy	605 mpy
Hydrochloric acid	10 %	Boiling	Boiling	400 mpy	288 mpy	228 mpy	642 mpy
Hydrochloric acid + 42 g/L Fe ₂ (SO ₄) ₃	1 %	93 oC	200 of	2 mpy	41 mpy	-	238 mpy
Hydrochloric acid + 42 g/L Fe ₂ (SO ₄) ₃	5 %	66 oC	150 of	2 mpy	5 mpy	3 mpy	2 mpy
Hydrochloric acid + 2% HF	5 %	70 oC	158 of	59 mpy	26 mpy	34 mpy	123 mpy
Hydrofluoric acid	2 %	70 oC	158 of	9 mpy	9 mpy	17 mpy	20 mpy
Hydrofluoric acid	5 %	70 oC	158 of	14 mpy	10 mpy	15 mpy	16 mpy
Industrial P ₂ O ₅	38 %	85 oC	185 of	2 mpy	9 mpy	-	1 mpy
Industrial P ₂ O ₅	44 %	116 oC	240 of	21 mpy	100 mpy	-	23 mpy
Industrial P ₂ O ₅	52 %	116 oC	240 of	11 mpy	33 mpy	-	12 mpy
P ₂ O ₅ + 2000 ppm Cl	38 %	85 oC	185 of	1 mpy	12 mpy	-	2 mpy
O ₂ O ₅ + 0.5 % HF	38 %	85 oC	185 of	7 mpy	45 mpy	-	9 mpy
Nitric acid	10 %	Boiling	Boiling	Below 1	7 mpy	7 mpy	Below 1
Nitric acid	65 %	Boiling	Boiling	134 mpy	888 mpy	217 mpy	21 mpy
Nitric acid + 6 % HF	5 %	60 oC	140 of	67 mpy	207 mpy	204 mpy	73 mpy
Nitric acid + 25 % H ₂ SO ₄ + 4 % NaCl	5 %	Boiling	Boiling	12 mpy	64 mpy	97 mpy	713 mpy
Nitric acid + 1 % HCl	5 %	Boiling	Boiling	Below 1	8 mpy	11 mpy	1 mpy
Nitric acid + 2.5 % HCl	5 %	Boiling	Boiling	1 mpy	21 mpy	26 mpy	Below 1
Nitric acid + 15.8 % HCl	8.8 %	52 oC	126 of	4 mpy	33 mpy	114 mpy	Above 10,000
Sulfuric acid	2 %	66 oC	150 of	Nil	Below 1	Nil	Nil
Sulfuric acid	2 %	Boiling	Boiling	5 mpy	6 mpy	6 mpy	6 mpy

Sulfuric acid	5 %	79 oC	174 of	Below 1	1 mpy	1 mpy	Below 1
Sulfuric acid	5 %	Boiling	Boiling	9 mpy	12 mpy	16 mpy	16 mpy
Sulfuric acid	10 %	Boiling	Boiling	12 mpy	19 mpy	25 mpy	37 mpy
Sulfuric acid	20 %	66 oC	150 of	Below 1	Below 1	Below 1	Below 1
Sulfuric acid	20 %	79 oC	174 of	1 mpy	3 mpy	2 mpy	13 mpy
Sulfuric acid	20 %	Boiling	Boiling	33 mpy	39 mpy	36 mpy	91 mpy
Sulfuric acid	30 %	66 oC	150 of	Below 1	1 mpy	Below 1	Below 1
Sulfuric acid	30 %	79 oC	174 of	3 mpy	4 mpy	3 mpy	27 mpy
Sulfuric acid	30 %	Boiling	Boiling	64 mpy	55 mpy	73 mpy	227 mpy
Sulfuric acid	40 %	38 oC	100 of	Below 1	Below 1	Above 1	Below 1
Sulfuric acid	40 %	66 oC	150 of	Below 1	1 mpy	9 mpy	1 mpy
Sulfuric acid	40 %	79 oC	174 of	9 mpy	10 mpy	15 mpy	35 mpy
Sulfuric acid	50 %	38 oC	100 of	Below 1	Nil	Below 1	1 mpy
Sulfuric acid	50 %	66 oC	150 of	1 mpy	4 mpy	13 mpy	25 mpy
Sulfuric acid	50 %	79 oC	174 of	16 mpy	12 mpy	25 mpy	58 mpy
Sulfuric acid	60 %	38 oC	100 of	Below 1	Below 1	1 mpy	Below 1
Sulfuric acid	70 %	38 oC	100 of	Nil	Nil	2 mpy	Below 1
Sulfuric acid	80 %	38 oC	100 of	Nil	Below 1	Below 1	Below 1
Sulfuric acid + 0.1% HCl	5 %	boiling	Boiling	26 mpy	33 mpy	49 mpy	151 mpy
Sulfuric acid + 0.5% HCl	5 %	boiling	Boiling	61 mpy	49 mpy	91 mpy	434 mpy
Sulfuric acid + 1% HCl	10 %	70 oC	158 of	Below 1	11 mpy	24 mpy	121 mpy
Sulfuric acid + 1% HCl	10 %	90 oC	194 of	94 mpy	45 mpy	66 mpy	326 mpy
Sulfuric acid + 2% HCl	10 %	boiling	boiling	225 mpy	116 mpy	192 mpy	869 mpy
Sulfuric acid + 2% HF	10 %	boiling	boiling	29 mpy	22 mpy	26 mpy	55 mpy
Sulfuric acid + 200 ppm Cl-	25 %	70 oC	158 of	11 mpy	12 mpy	37 mpy	110 mpy
Sulfuric acid + 200 ppm Cl-	25 %	Boiling	Boiling	215 mpy	186 mpy	182 mpy	325 mpy
Sulfuric acid + 1.2 % HCl + 1% FeCl3 + 1% CuCl2	11.5 %	Boiling	Boiling	3 mpy	42 mpy	837 mpy	1815 mpy
Sulfuric acid + 1.2 % HCl + 1% FeCl3 + 1% CuCl2	23 %	Boiling	Boiling	8 mpy	55 mpy	2155 mpy	2721 mpy
Sulfuric acid + 42 g/L Fe2(SO4)3	50 %	boiling	boiling	40 mpy	250 mpy	143 mpy	23 mpy

Fabrication

The wrought alloy C-22 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.

Thermal Stability

The weldments of alloy C-276 and C-22 are set into oxidizing sulfuric acid process solution. 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. Hastelloy C-276 is rarely corroded in the other conditions.

Alloy C-22 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 all 20 different samples were analyzed though all were failed. Alloy C-22 gives much more enhanced resistance to corrosion as compare to the original metal.

Available Forms

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