

Nickel Based Superalloy Hastelloy C-4 (UNS NO6455)



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

Hastelloy C-4 offers resistance to mineral acids, organic and inorganic acids, sea water and brine solutions. It has service temperature up to 1900oF or 1038oC. Outstanding resistance to high temperature corrosion and stress corrosion cracking. Great material for use in chemical processing plants and nuclear fuel processing.

Chemical Composition

Nickel (Ni)	Rem %
Chromium (Cr)	14 to 18 %
Molybdenum (Mo)	14 to 17 %
Iron (Fe)	3 %
Cobalt (Co)	2 %
Manganese	1 %
Carbon (C)	0.015 %
Silicon (Si)	0.08 %
Phosphorous (P)	0.04 %
Sulfur (S)	0.03 %
Titanium (Ti)	0.070 %

Physical Properties

Density	0.312 lb per cubic in or 8.64 g per cubic cm
Modulus of Elasticity	30.8 x 10 ³ ksi (211 x 10 ³ MPa)
Melting temperature	2550oF or 1399oC

Room temperature Mechanical properties	
Ultimate tensile strength	100 ksi or 690 Mpa
Yield strength	40 ksi or 276 MPa
Elongation	40 %
Hardness	100 Rb

Electric Resistivity

Temperature, oF	Temperature, oC	micro-ohm-in	micro-ohm-m
74 of	23 oC	49.1	1.25
212 of	100 oC	49.3	1.25
392 of	200 oC	49.6	1.26
572 of	300 oC	49.9	1.27
752 of	400 oC	50.2	1.28
932 of	500 oC	50.8	1.29
1112 of	600 oC	51.8	1.32

Specific Heat Capacity

Temperature, oF	Temperature, oC	BTU/lb-°F	J/Kg-K
32 oF	0 oC	97	406
212 oF	100 oC	102	427
392 oF	200 oC	107	448
572 oF	300 oC	111	465
752 oF	400 oC	114	477
932 oF	400 oC	117	490
1112 oF	500 oC	120	502

Mean Coefficient of Thermal Expansion

Temperature, oF	Temperature, oC	µin/in-°F	m/m-K
68 of to 200 of	20 oC to 93 oC	6	10.8 x 10(-6)
68 of to 400 of	20 oC to 204 oC	6.6	11.9 x 10(-6)
68 of to 600 of	20 oC to 316 oC	7	12.6 x 10(-6)
68 of to 800 of	20 oC to 427 oC	7.2	13 x 10(-6)
68 of to 1000 of	20 oC to 538 oC	7.4	13.3 x 10(-6)
68 of to 1200 of	20 oC to 649 oC	7.5	13.5 x 10(-6)
68 of to 1400 of	20 oC to 760 oC	8	14.4 x 10(-6)
68 of to 1600 of	20 oC to 871 oC	8.3	14.9 x 10(-6)
68 of to 1800 of	20 oC to 982 oC	8.7	15.7 x 10(-6)

Elastic Modulus

Temperature		Modulus of elasticity	
oC	of	GPa	Psi
Room temp	Room temp	211 GPa	30.8 x 10(6) psi

93 oC	200 of	207 GPa	30.2 x 10(6) psi
205 oC	400 of	201 GPa	29.3 x 10(6) psi
315 oC	600 of	194 GPa	28.3 x 10(6) psi
425 oC	800 of	187 GPa	27.3 x 10(6) psi
540 oC	1000 of	179 GPa	26.2 x 10(6) psi
650 oC	1200 of	171 GPa	25 x 10(6) psi
760 oC	1400 of	162 GPa	23.7 x 10(6) psi
780 oC	1600 of	152 Gpa	22.2 x 10(6) psi
980 oC	1800 of	141 Gpa	20.6 x 10(6) psi

Thermal Diffusivity

Temperature		Diffusion coefficient
oC	oF	10(-6) m2 per sec
23 oC	74 oF	2.8
100 oC	212 oF	3.1
200 oC	390 oF	3.3
300 oC	570 oF	3.7
400 oC	750 oF	4
500 oC	930 oF	4.3
600 oC	1100 oF	4.7

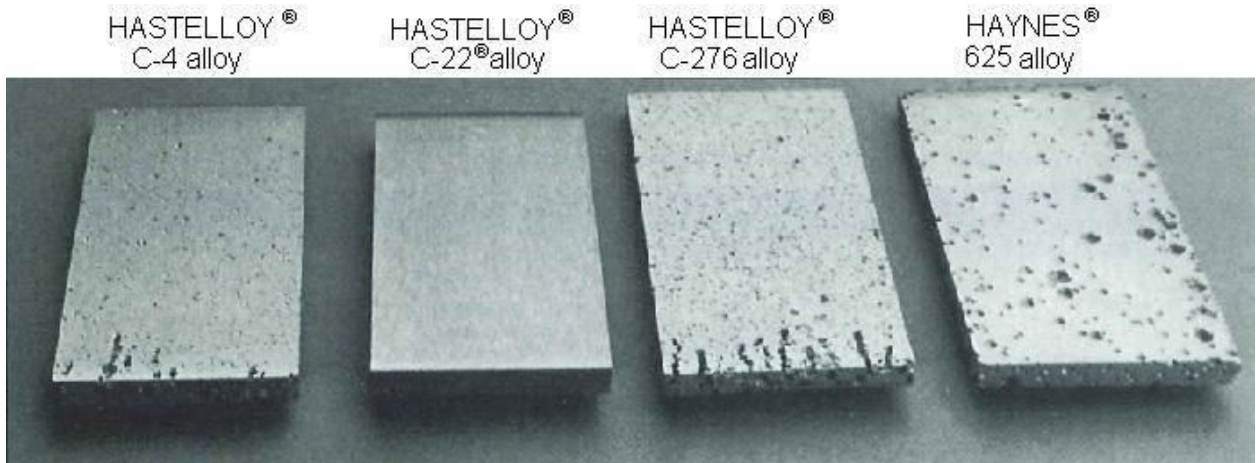
Thermal Conductivity

Temperature		W/m.K	Btu.ft.h.oF
23 oC	74 of	10 W/m.K	5.8 Btu.ft.h.oF
100 oC	212 of	11.4 W/m.K	6.6 Btu.ft.h.oF
200 oC	390 of	13.2 W/m.K	7.7 Btu.ft.h.oF
300 oC	570 of	14.9 W/m.K	8.7 Btu.ft.h.oF
400 oC	750 of	16.6 W/m.K	9.7 Btu.ft.h.oF
500 oC	930 of	18.4 W/m.K	10.7 Btu.ft.h.oF
600 oC	1100 of	20.4 W/m.K	11.8 Btu.ft.h.oF

Corrosion Resistance

Hastelloy C-4 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. An analysis is made in the rigorous conditions that are even more severe 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

An average corrosion rate **Hastelloy C-4** 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

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. Hastelloy C-4 remains untouched for 1000 hours.

Hastelloy C-4 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 oxy acetylene and submerged arc techniques are not preferred due to the risk of corrosion.

Available Forms

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