HASTELLOY® C-2000® alloy

Principal Features

A copper-bearing Ni-Cr-Mo material with exceptional resistance to sulfuric acid
HASTELLOY® C-2000® alloy (UNS N06200) is unique among the versatile nickel-chromium-molybdenum materials in having a deliberate copper addition. This provides greatly enhanced resistance to sulfuric acid. It also has a high chromium content, to maximize its resistance to oxidizing chemicals and process streams contaminated with ferric ions and dissolved oxygen.

Like other nickel alloys, it is ductile, easy to form and weld, and possesses exceptional resistance to stress corrosion cracking in chloride-bearing solutions (a form of degradation to which the austenitic stainless steels are prone). It is able to withstand a wide range of oxidizing and non-oxidizing chemicals, and exhibits outstanding resistance to pitting and crevice attack in the presence of chlorides and other halides.

Typical chemical process industry (CPI) applications include reactors and heat exchangers.

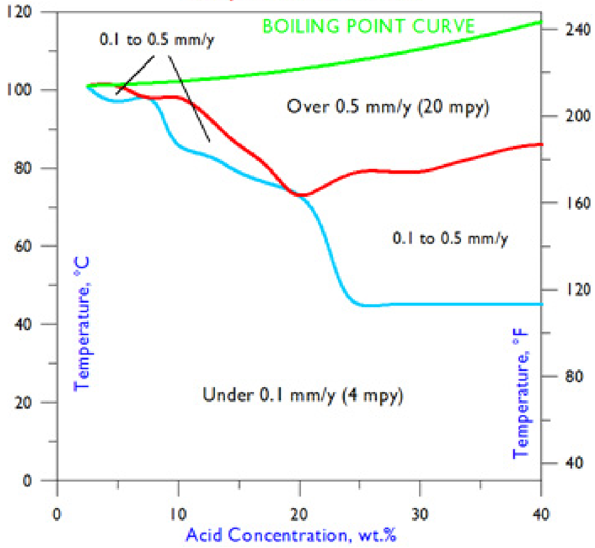
Nominal Composition

	Weight %
Nickel:	59 Balance
Cobalt:	2 max.
Chromium:	23
Molybdenum:	16
Copper:	1.6
Iron:	3 max.
Manganese:	0.5 max.
Aluminum:	0.5 max.
Silicon:	0.08 max.
Carbon:	0.01 max.

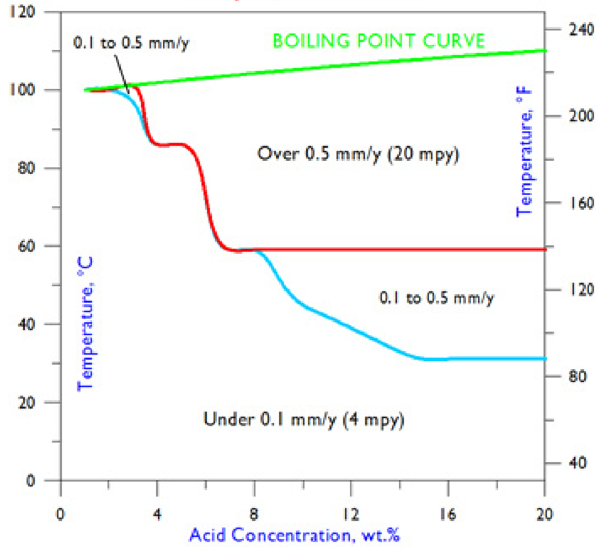
Iso-Corrosion Diagrams

Each of these iso-corrosion diagrams was constructed using numerous corrosion rate values, generated at different acid concentrations and temperatures. The blue line represents those combinations of acid concentration and temperature at which a corrosion rate of 0.1 mm/y (4 mils per year) is expected, based on laboratory tests in reagent grade acids. Below the line, rates under 0.1 mm/y are expected. Similarly, the red line indicates the combinations of acid concentration and temperature at which a corrosion rate of 0.5 mm/y (20 mils per year) is expected. Above the line, rates over 0.5 mm/y are expected. Between the blue and red lines, corrosion rates are expected to fall between 0.1 and 0.5 mm/y.

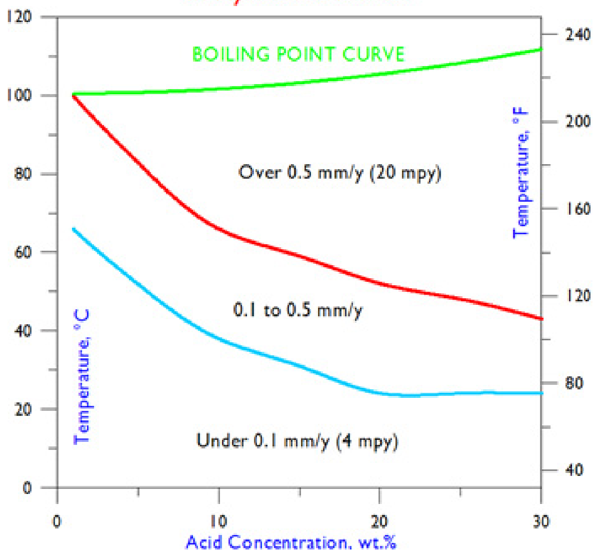
Iso-Corrosion Diagram for C-2000® Alloy in Hydrobromic Acid



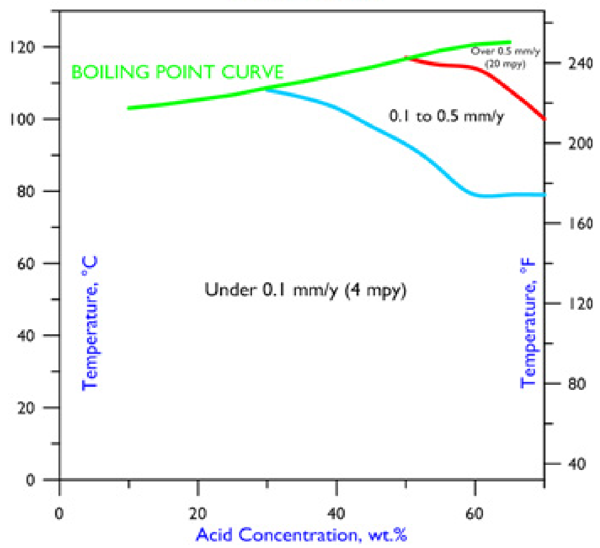
Iso-Corrosion Diagram for C-2000® Alloy in Hydrochloric Acid



Iso-Corrosion Diagram for C-2000® Alloy in Hydrofluoric Acid

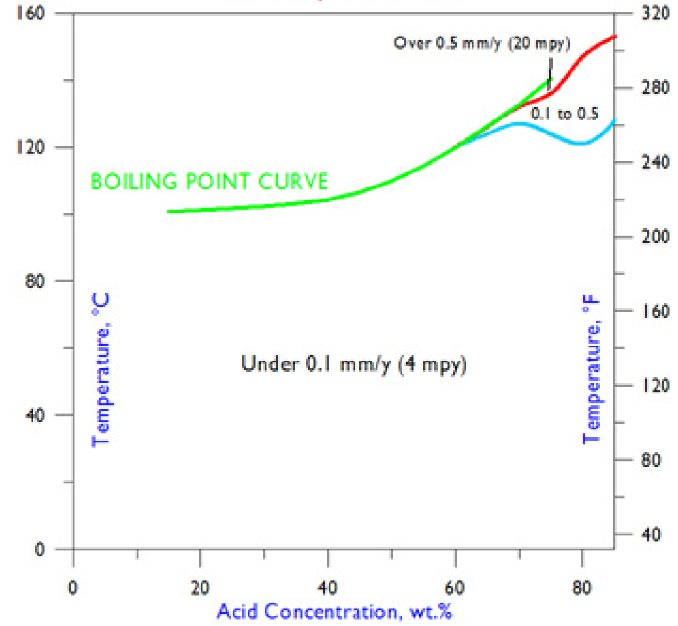


Iso-Corrosion Diagram for C-2000® Alloy in Nitric Acid

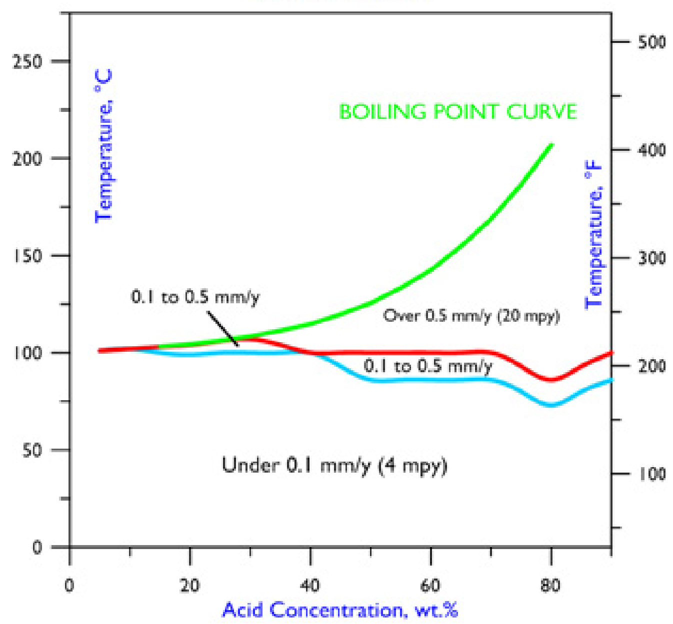


Iso-Corrosion Diagrams Continued

Iso-Corrosion Diagram for C-2000® Alloy in Phosphoric Acid



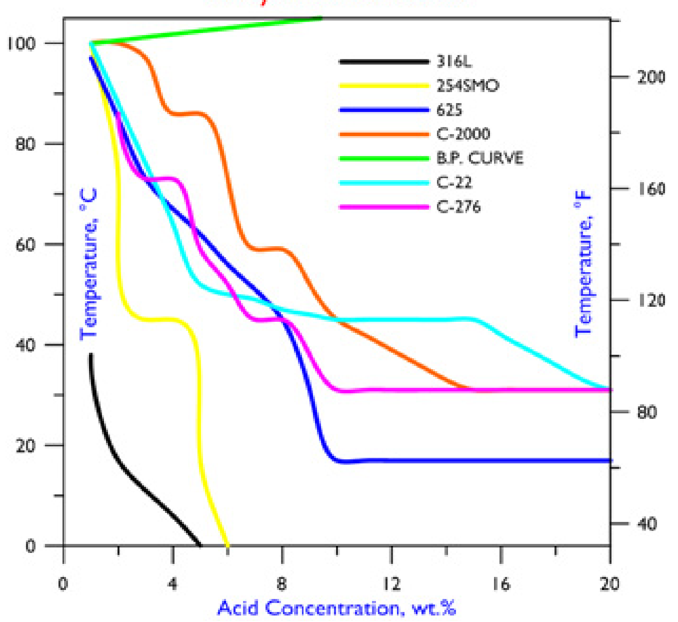
Iso-Corrosion Diagram for C-2000® Alloy in Sulfuric Acid



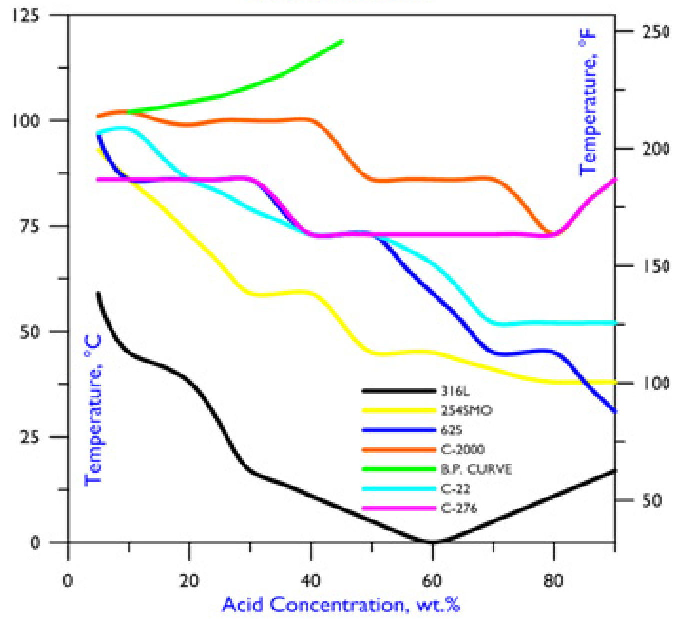
Comparative 0.1 mm/y Line Plots

To compare the performance of HASTELLOY® C-2000® alloy with that of other materials, it is useful to plot the 0.1 mm/y lines. In the following graphs, the lines for C-2000® alloy are compared with those of C-22® alloy, C-276 alloy, 625 alloy, 254SMO alloy, and 316L stainless steel, in hydrochloric and sulfuric acids. Note the superiority of C-2000 alloy in hydrochloric acid at concentrations up to 10%, and in sulfuric acid at concentrations up to 80%. The hydrochloric acid concentration limit of 20% is the azeotrope, above which corrosion tests are less reliable.

Comparison of 0.1 mm/y Lines in Hydrochloric Acid



Comparison of 0.1 mm/y Lines in Sulfuric Acid



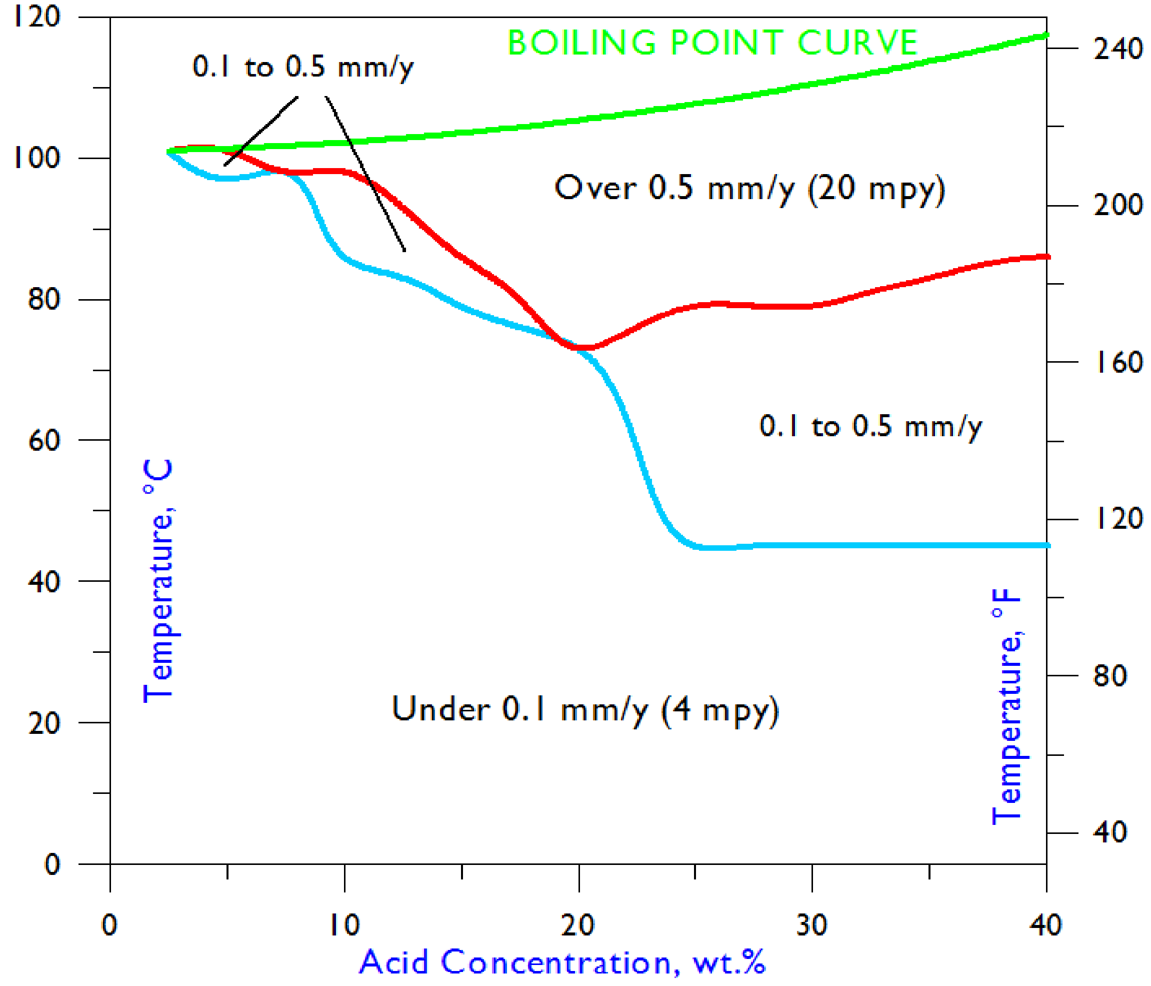
Selected Corrosion Data

Hydrobromic Acid

Conc. Wt.%	50°F 10°C	75°F 24°C	100°F 38°C	125°F 52°C	150°F 66°C	175°F 79°C	200°F 93°C	225°F 107°C	Boiling
2.5	-	-	-	-	<0.01	-	0.01	-	0.01
5	-	-	-	-	<0.01	-	0.01	-	0.15
7.5	-	-	-	-	-	<0.01	<0.01	-	0.58
10	-	-	-	-	<0.01	<0.01	0.34	-	1.71
15	-	-	-	-	-	0.1	0.94	-	-
20	-	-	-	-	<0.01	0.61	0.86	-	2.52
25	-	-	<0.01	0.15	0.3	0.53	0.91	-	-
30	-	-	0.06	0.2	0.29	0.48	0.91	-	-
40	-	-	0.07	0.13	0.18	0.32	0.6	-	-

All corrosion rates are in millimeters per year (mm/y); to convert to mils (thousandths of an inch) per year, divide by 0.0254.
Data are from Corrosion Laboratory Jobs 71-97, 26-99, 49-99, 27-02, and 37-02.
All tests were performed in reagent grade acids under laboratory conditions; field tests are encouraged prior to industrial use.

Iso-Corrosion Diagram for C-2000® Alloy in Hydrobromic Acid



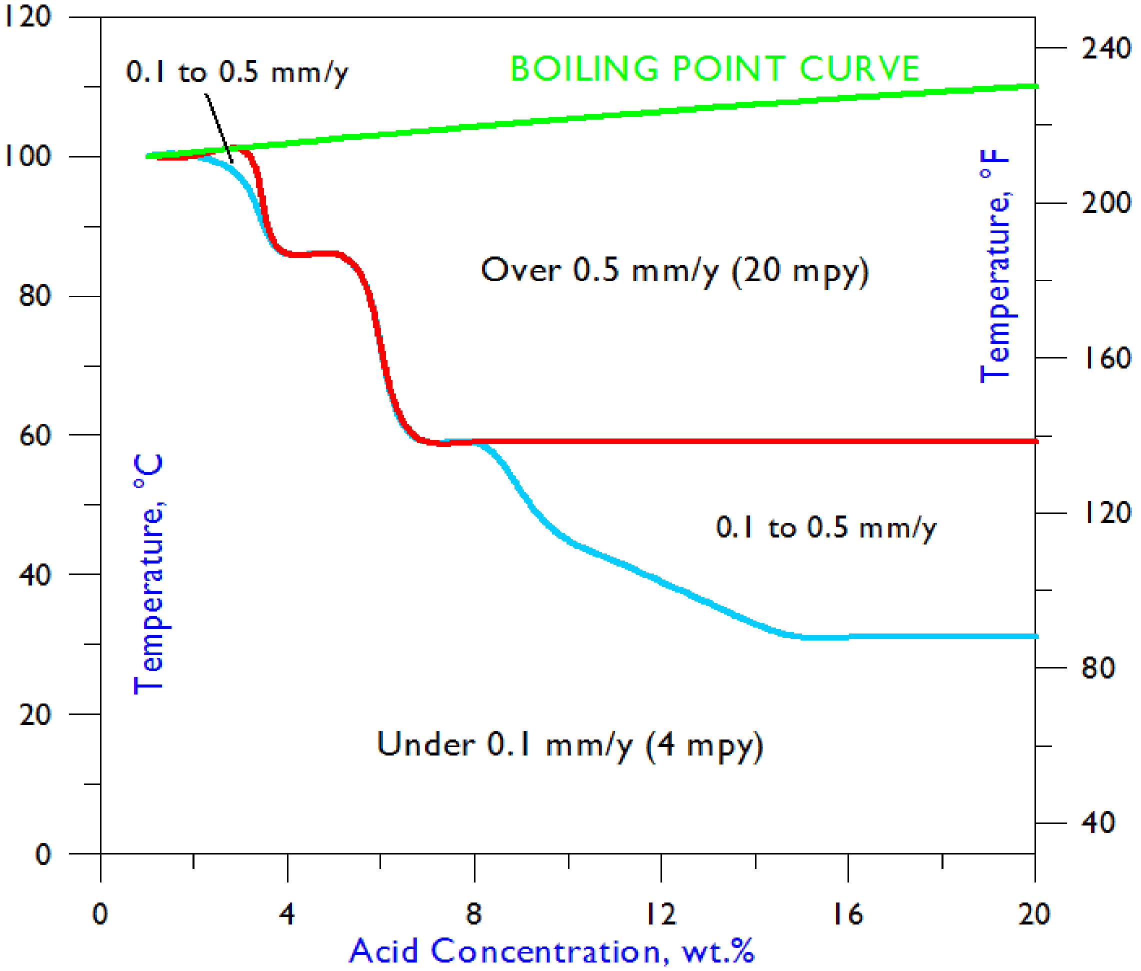
Selected Corrosion Data Continued

Hydrochloric Acid

Conc. Wt.%	50°F 10°C	75°F 24°C	100°F 38°C	125°F 52°C	150°F 66°C	175°F 79°C	200°F 93°C	225°F 107°C	Boiling
1	-	-	-	-	-	-	-	-	0.01
1.5	-	-	-	-	-	-	-	-	0.02
2	-	-	-	-	<0.01	<0.01	<0.01	-	0.09
2.5	-	-	-	-	-	<0.01	0.01	-	0.34
3	-	-	-	-	<0.01	<0.01	0.02	-	0.36
3.5	-	-	-	-	-	0.01	0.65	-	1.61
4	-	-	-	-	<0.01	0.01	1.24	-	2.15
4.5	-	-	-	-	<0.01	0.01	1.48	-	3.98
5	-	-	-	0.01	<0.01	<0.01	1.37	-	4.23
7.5	-	-	<0.01	<0.01	0.57	1.12	-	-	-
10	-	-	<0.01	0.28	0.65	1.54	-	-	-
15	-	-	0.18	0.38	0.7	1.69	-	-	-
20	-	-	0.16	0.36	0.69	1.46	-	-	-

All corrosion rates are in millimeters per year (mm/y); to convert to mils (thousandths of an inch) per year, divide by 0.0254.
Data are from Corrosion Laboratory Jobs 8-95, 11-95, 18-95, 36-95, 3-96, 9-96, 16-96, and 25-96.
All tests were performed in reagent grade acids under laboratory conditions; field tests are encouraged prior to industrial use.

Iso-Corrosion Diagram for C-2000® Alloy in Hydrochloric Acid

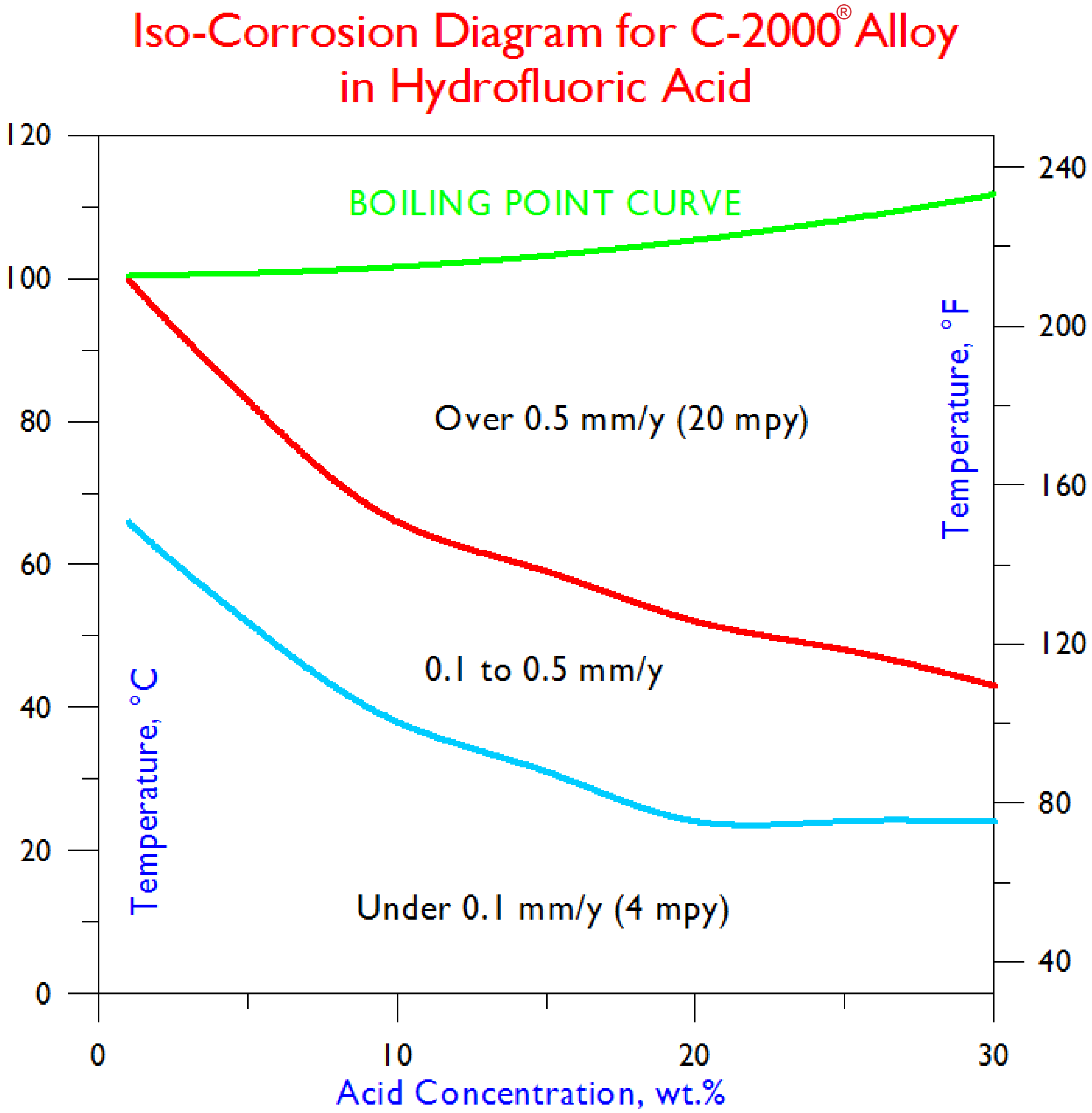


Selected Corrosion Data Continued

Hydrofluoric Acid

Conc. Wt.%	50°F 10°C	75°F 24°C	100°F 38°C	125°F 52°C	150°F 66°C	175°F 79°C	200°F 93°C	225°F 107°C	Boiling
1	-	-	0.01	0.03	0.08	0.18	-	-	-
5	-	-	0.02	0.09	0.33	0.57	-	-	-
10	-	-	0.06	0.22	0.56	0.99	2.27	-	-
20	-	-	0.21	0.48	0.68	0.67	0.74	-	-
30	-	-	0.25	0.62	1.61	1.34	1.46	-	-

All corrosion rates are in millimeters per year (mm/y); to convert to mils (thousandths of an inch) per year, divide by 0.0254.
Data are from Corrosion Laboratory Jobs 3-99, 24-99, and 46-99.
All tests were performed in reagent grade acids under laboratory conditions; field tests are encouraged prior to industrial use.
Hydrofluoric acid is known to cause internal, as well as external, attack of the nickel alloys; these values signify only the amount of external attack encountered during laboratory testing.

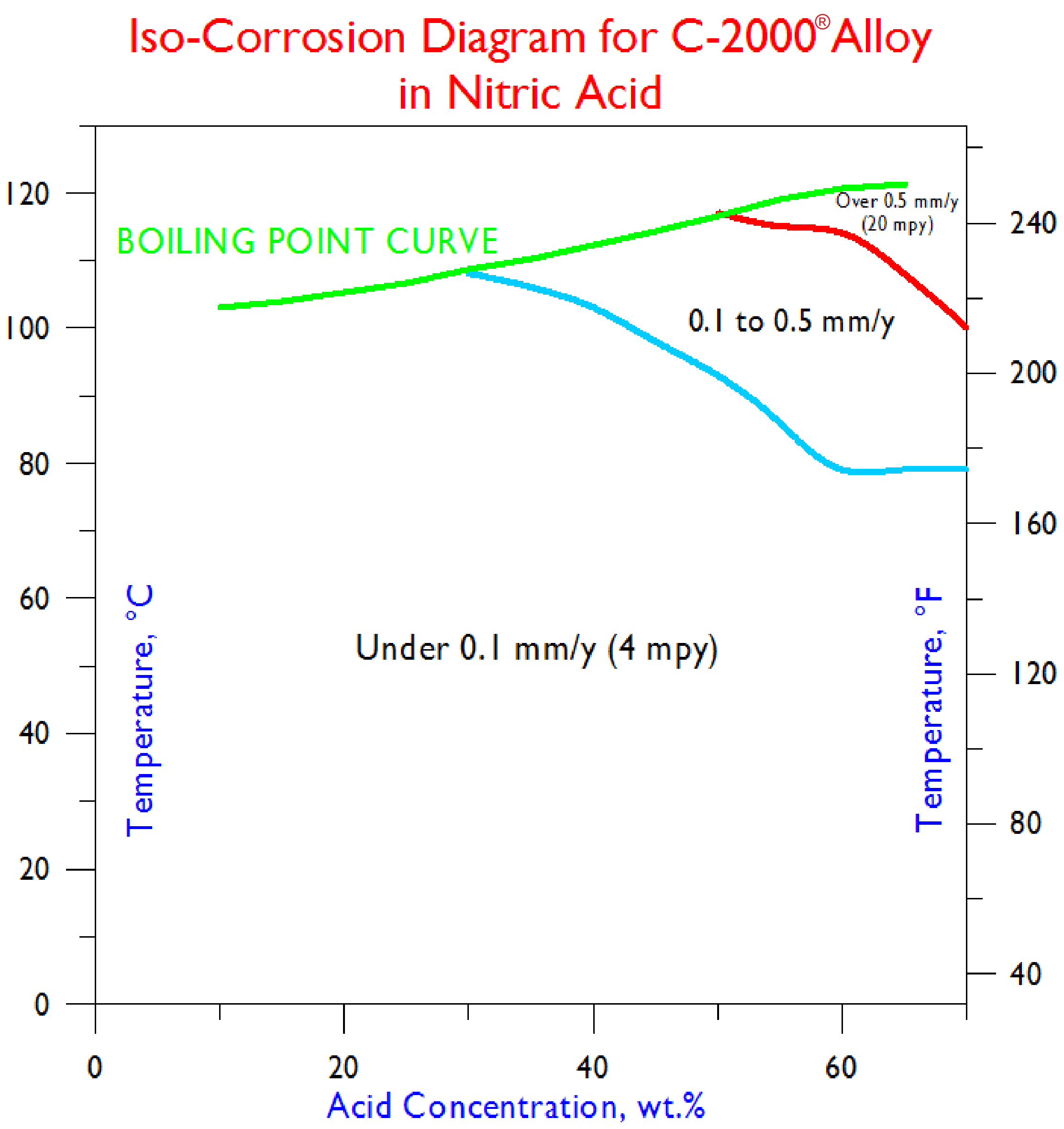


Selected Corrosion Data Continued

Nitric Acid

Conc. Wt.%	50°F 10°C	75°F 24°C	100°F 38°C	125°F 52°C	150°F 66°C	175°F 79°C	200°F 93°C	225°F 107°C	Boiling
10	-	-	-	-	-	-	-	-	-
20	-	-	-	-	-	-	-	-	0.02
30	-	-	-	-	-	-	-	-	-
40	-	-	-	-	-	0.02	0.06	-	0.24
50	-	-	-	-	-	0.05	0.12	-	0.51
60	-	-	-	-	-	0.08	0.19	0.43	0.94
65	-	-	-	-	-	-	-	-	1
70	-	-	-	-	-	0.1	0.29	0.59	1.66

All corrosion rates are in millimeters per year (mm/y); to convert to mils (thousandths of an inch) per year, divide by 0.0254.
Data are from Corrosion Laboratory Jobs 8-95 and 11-97.
All tests were performed in reagent grade acids under laboratory conditions; field tests are encouraged prior to industrial use.

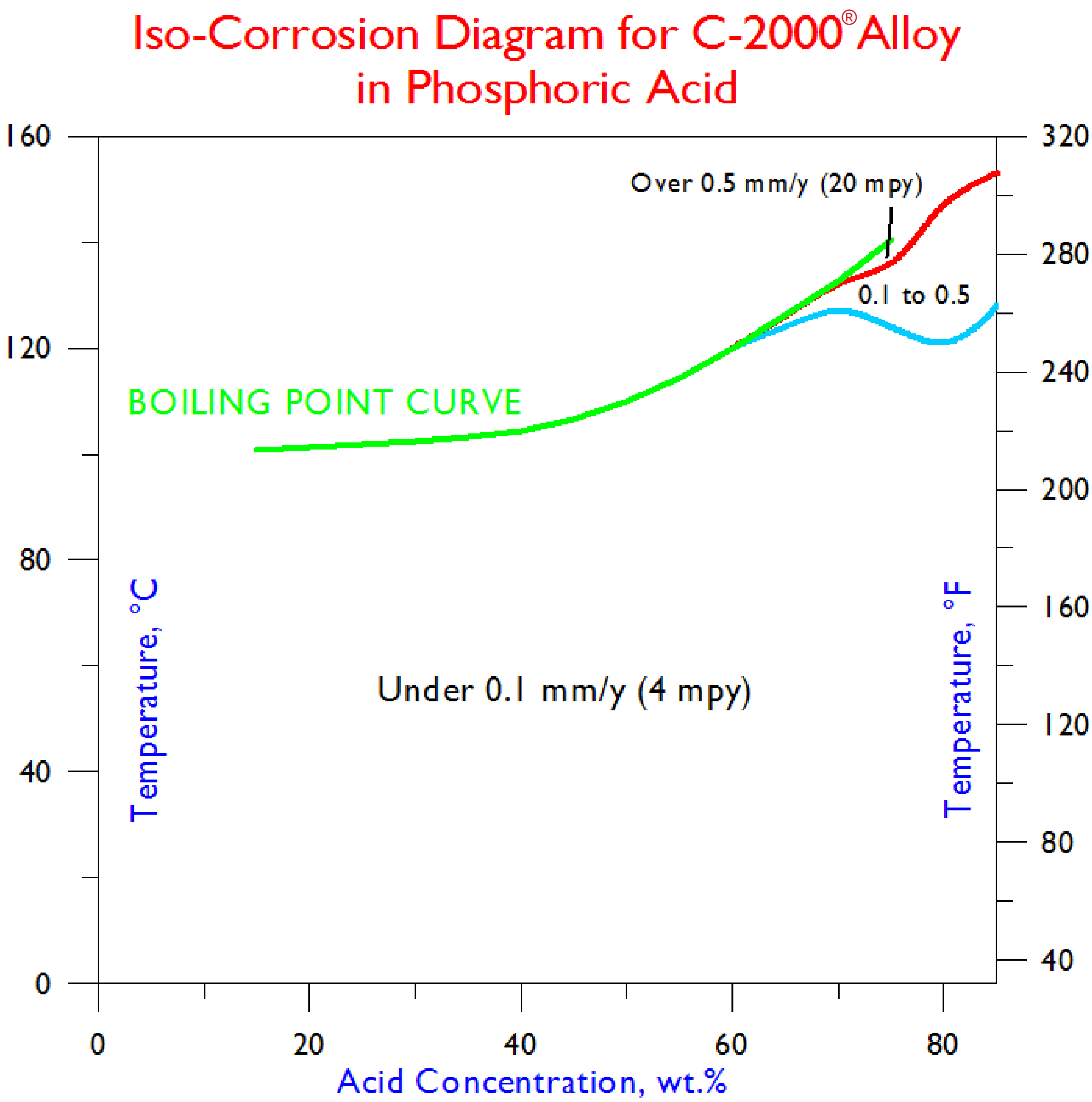


Selected Corrosion Data Continued

Phosphoric Acid

Conc. Wt.%	125°F 52°C	150°F 66°C	175°F 79°C	200°F 93°C	225°F 107°C	250°F 121°C	275°F 135°C	300°F 149°C	Boiling
50	-	-	<0.01	0.01	-	-	-	-	0.03
60	-	-	<0.01	0.01	0.02	-	-	-	0.08
70	-	-	<0.01	0.01	0.02	0.07	-	-	0.15
75	-	-	-	-	-	-	-	-	0.84
80	-	-	<0.01	0.01	-	0.08	0.14	-	0.4
85	-	-	-	-	-	0.05	0.17	0.33	7.9

All corrosion rates are in millimeters per year (mm/y); to convert to mils (thousandths of an inch) per year, divide by 0.0254.
Data are from Corrosion Laboratory Jobs 19-95 and 64-96.
All tests were performed in reagent grade acids under laboratory conditions; field tests are encouraged prior to industrial use.



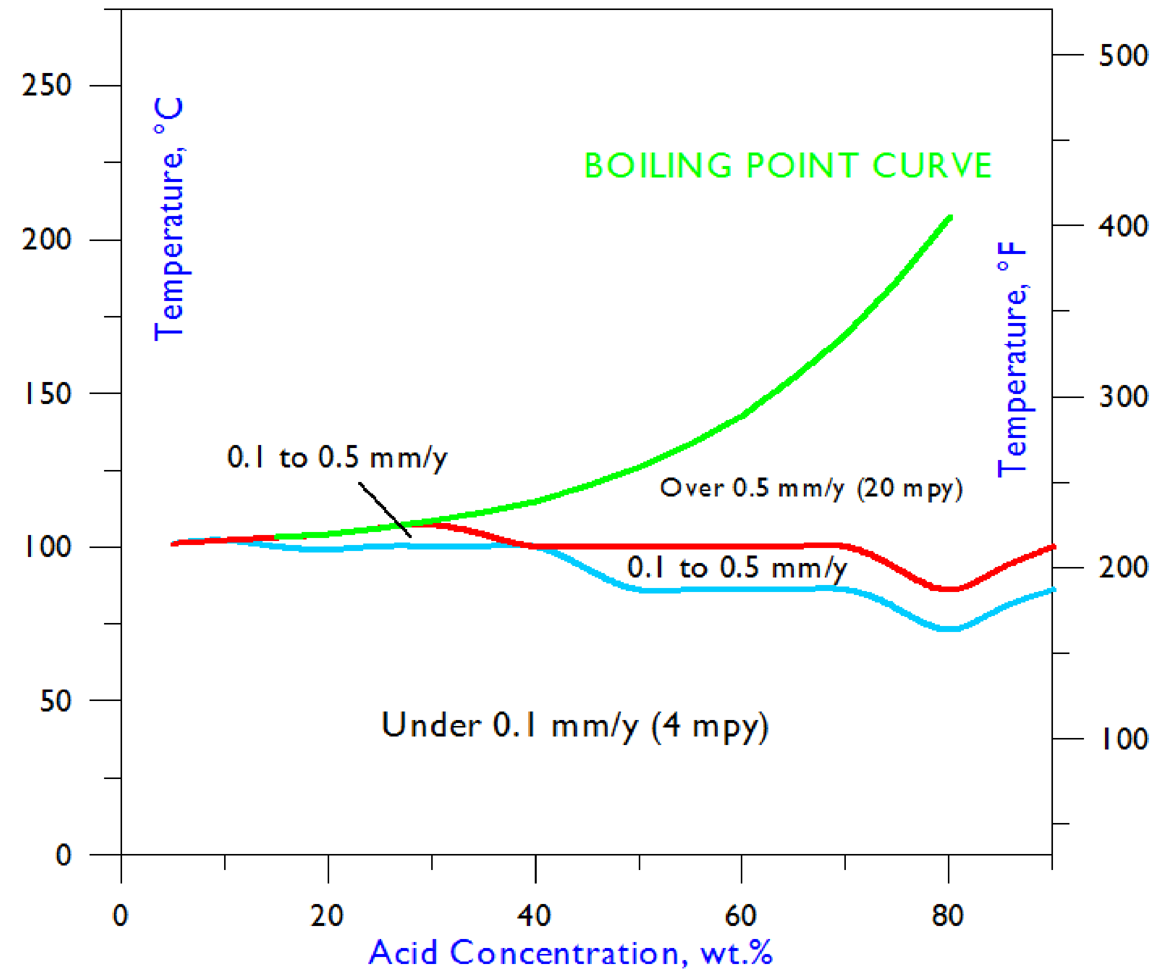
Selected Corrosion Data Continued

Sulfuric Acid

Conc. Wt.%	75°F 24°C	100°F 38°C	125°F 52°C	150°F 66°C	175°F 79°C	200°F 93°C	225°F 107°C	250°F 121°C	275°F 135°C	300°F 149°C	350°F 177°C	Boiling
1	-	-	-	-	-	-	-	-	-	-	-	-
2	-	-	-	-	-	-	-	-	-	-	-	-
3	-	-	-	-	-	-	-	-	-	-	-	-
4	-	-	-	-	-	-	-	-	-	-	-	-
5	-	-	-	-	-	-	-	-	-	-	-	-
10	-	-	-	-	<0.01	0.02	-	-	-	-	-	0.09
20	-	-	-	-	0.01	0.03	-	-	-	-	-	0.18
30	-	-	-	-	0.01	0.04	-	-	-	-	-	0.42
40	-	-	-	-	0.01	0.05	0.72	-	-	-	-	1.13
50	-	-	-	<0.01	0.02	0.16	0.68	1.71	-	-	-	3.35
60	-	-	-	<0.01	0.02	0.37	0.84	2.81	-	-	-	9.27
70	-	-	-	0.01	0.07	0.42	1.4	4.32	-	-	-	-
80	-	-	-	0.06	0.28	0.99	1.62	2.37	-	-	-	-
90	-	-	-	0.02	0.07	0.37	1.17	2.24	-	-	-	-
96	-	-	-	-	0.05	0.19	0.63	-	-	-	-	-

All corrosion rates are in millimeters per year (mm/y); to convert to mils (thousandths of an inch) per year, divide by 0.0254.
Data are from Corrosion Laboratory Jobs 8-95, 11-95, 18-95, 43-95, 9-96, 15-96, and 20-96.
All tests were performed in reagent grade acids under laboratory conditions; field tests are encouraged prior to industrial use.

Iso-Corrosion Diagram for C-2000® Alloy in Sulfuric Acid



Selected Corrosion Data (Reagent Grade Solutions, mm/y)

Chemical	Concentration wt.%	100°F 38°C	125°F 52°C	150°F 66°C	175°F 79°C	200°F 93°C	Boiling
Acetic Acid	99	-	-	-	-	-	<0.01
Chromic Acid	10	-	-	0.1	-	-	-
	20	-	-	0.61	-	-	-
Formic Acid	88	-	-	-	-	-	0.01
Hydrobromic Acid	2.5	-	-	<0.01	-	0.01	0.01
	5	-	-	<0.01	-	0.01	0.15
	7.5	-	-	-	<0.01	<0.01	0.58
	10	-	-	<0.01	<0.01	0.34	1.71
	15	-	-	-	0.1	0.94	-
	20	-	-	<0.01	0.61	0.86	-
	25	<0.01	0.15	0.3	0.53	0.91	-
	30	0.06	0.2	0.29	0.48	0.91	-
	40	0.07	0.13	0.18	0.32	0.6	-
Hydrochloric Acid	1	-	-	-	-	-	0.01
	2	-	-	<0.01	<0.01	<0.01	0.09
	2.5	-	-	-	<0.01	0.01	0.34
	3	-	-	<0.01	<0.01	0.02	0.36
	3.5	-	-	-	0.01	0.65	1.61
	4	-	-	<0.01	0.01	1.24	-
	4.5	-	-	<0.01	0.01	1.48	-
	5	-	0.01	<0.01	<0.01	1.37	-
	7.5	<0.01	<0.01	0.57	1.12	-	-
	10	<0.01	0.28	0.65	1.54	-	-
	15	0.18	0.38	0.7	1.69	-	-
	20	0.16	0.36	0.69	1.46	-	-
Hydrofluoric Acid*	1	0.01	0.03	0.08	0.18	-	-
	5	0.02	0.09	0.33	0.57	-	-
	10	0.06	0.22	0.56	0.99	2.27	-
	20	0.21	0.48	0.68	0.67	0.74	-
	30	0.25	0.62	1.61	1.34	1.46	-
Nitric Acid	20	-	-	-	-	-	0.02
	30	-	-	-	-	-	0.09
	40	-	-	-	0.02	0.06	0.24
	50	-	-	-	0.05	0.12	0.51
	60	-	-	-	0.08	0.19	0.94
	65	-	-	-	-	-	1
	70	-	-	-	0.1	0.29	1.66

Selected Corrosion Data (Reagent Grade Solutions, mm/y)

Chemical	Concentration wt. %	100°F 38°C	125°F 52°C	150°F 66°C	175°F 79°C	200°F 93°C	Boiling
Phosphoric Acid	50	-	-	-	<0.01	0.01	0.03
	60	-	-	-	<0.01	0.01	0.08
	70	-	-	-	<0.01	0.01	0.15
	75	-	-	-	-	-	0.84
	80	-	-	-	<0.01	0.01	-
Sulfuric Acid	10	-	-	-	<0.01	0.02	0.09
	20	-	-	-	0.01	0.03	0.18
	30	-	-	-	0.01	0.04	0.42
	40	-	-	-	0.01	0.05	1.13
	50	-	-	<0.01	0.02	0.16	-
	60	-	-	<0.01	0.02	0.37	-
	70	-	-	0.01	0.07	0.42	-
	80	-	-	0.06	0.28	0.99	-
	90	-	-	0.02	0.07	0.37	-
	96	-	-	-	0.05	0.19	-

*Hydrofluoric acid can also induce internal attack of nickel alloys; these values represent only external attack.

Resistance to Pitting and Crevice Corrosion

HASTELLOY® C-2000® alloy exhibits high resistance to chloride-induced pitting and crevice attack, forms of corrosion to which the austenitic stainless steels are particularly prone. To assess the resistance of alloys to pitting and crevice attack, it is customary to measure their Critical Pitting Temperatures and Critical Crevice Temperatures in acidified 6 wt.% ferric chloride, in accordance with the procedures defined in ASTM Standard G 48. These values represent the lowest temperatures at which pitting and crevice attack are encountered in this solution, within 72 hours. For comparison, the values for 316L, 254SMO, 625, C-276, and C-2000® alloys are as follows. Note that C-2000® alloy exhibits higher resistance to crevice attack than even C-276 alloy.

Alloy	Critical Pitting Temperature in Acidified 6% $FeCl_3$		Critical Crevice Temperature in Acidified 6% $FeCl_3$	
	°F	°C	°F	°C
316L	59	15	32	0
254SMO	140	60	86	30
625	212	100	104	40
C-276	>302	>150	131	55
C-2000®	**293**	**145**	**176**	**80**

Other chloride-bearing environments, notably Green Death (11.5% H_2SO_4 + 1.2% HCl + 1% $FeCl_3$ + 1% $CuCl_2$) and Yellow Death (4% NaCl + 0.1% $Fe_2(SO_4)_3$ + 0.021M HCl), have been used to compare the resistance of various alloys to pitting and crevice attack (using tests of 24 hours duration). In Green Death, the lowest temperature at which pitting has been observed in C-2000 alloy is 100°C. In Yellow Death, C-2000 alloy has not exhibited pitting, even at the maximum test temperature (150°C).The Critical Crevice Temperature of C-2000 alloy in Yellow Death is 95°C.

Resistance to Stress Corrosion Cracking

One of the chief attributes of the nickel alloys is their resistance to chloride-induced stress corrosion cracking. A common solution for assessing the resistance of materials to this extremely destructive form of attack is boiling 45% magnesium chloride (ASTM Standard G 36), typically with stressed U-bend samples. As is evident from the following results, the three nickel alloys, C-276, C-2000® and 625, are much more resistant to this form of attack than the comparative, austenitic stainless steels. The tests were stopped after 1,008 hours (six weeks).

Alloy	Time to Cracking
316L	2 h
254SMO	24 h
625	No Cracking in 1,008 h
C-276	No Cracking in 1,008 h
C-2000®	**No Cracking in 1,008 h**

Resistance to Seawater Crevice Corrosion

Seawater is probably the most common aqueous salt solution. Not only is it encountered in marine transportation and offshore oil rigs, but it is also used as a coolant in coastal facilities. Listed are data generated as part of a U.S. Navy study at the LaQue Laboratories in Wrightsville Beach, North Carolina (and published by D.M. Aylor et al, Paper No. 329, CORROSION 99, NACE International, 1999). Crevice tests were performed in both still (quiescent) and flowing seawater, at 29°C, plus or minus 3°C. Two samples (A & B) of each alloy were tested in still water for 180 days, and likewise in flowing water. Each sample contained two possible crevice sites. The results indicate that C-2000® alloy is very resistant to crevice corrosion in seawater.

Alloy	Quiescent		Flowing	
	No. of Sites Attacked	Maximum Depth of Attack, mm	No. of Sites Attacked	Maximum Depth of Attack, mm
316L	A:2, B:2	A:1.33, B:2.27	A:2, B:2	A:0.48, B:0.15
254SMO	A:2, B:2	A:0.76, B:1.73	A:2, B:2	A:0.01, B:<0.01
625	A:1, B:2	A:0.18, B:0.04	A:2, B:2	A:<0.01, B:<0.01
C-276	A:1, B:1	A:0.10, B:0.13	A:0, B:0	A:0, B:0
C-2000®	**A:0, B:0**	**A:0, B:0**	**A:0, B:0**	**A:0, B:0**

Corrosion Resistance of Welds

To assess the resistance of welds to corrosion, Haynes International has chosen to test all-weld-metal samples, taken from the quadrants of cruciform assemblies, created using multiple gas metal arc (MIG) weld passes. Predictably, the inhomogeneous nature of weld microstructures leads generally to higher corrosion rates (than with homogeneous, wrought products). Nevertheless, HASTELLOY® C-2000® alloy exhibits excellent resistance to the key, inorganic acids, even in welded form, as shown in the following table:

Chemical	Concentration	Temperature		Corrosion Rate			
				Weld Metal		Wrought Base Metal	
	wt.%	°F	°C	mpy	mm/y	mpy	mm/y
H_2SO_4	30	150	66	0.2	0.01	<0.1	<0.01
H_2SO_4	50	150	66	0.3	0.01	<0.1	<0.01
H_2SO_4	70	150	66	2.4	0.06	0.2	0.01
H_2SO_4	90	150	66	2.9	0.07	0.6	0.02
HCl	5	100	38	0.1	<0.01	0.1	<0.01
HCl	10	100	38	2.1	0.05	<0.1	<0.01
HCl	15	100	38	2.4	0.06	7	0.18
HCl	20	100	38	8	0.2	6.3	0.16
HNO_3	30	Boiling		3.8	0.1	3.5	0.09

Physical Properties

Physical Property	British Units		Metric Units	
Density	RT	0.307 lb/in^3	RT	8.50 g/cm^3
Electrical Resistivity	RT	50.6 µohm.in	RT	1.28 µohm.m
	200°F	50.8 µohm.in	100°C	1.29 µohm.m
	400°F	51.2 µohm.in	200°C	1.30 µohm.m
	600°F	51.6 µohm.in	300°C	1.31 µohm.m
	800°F	52.2 µohm.in	400°C	1.32 µohm.m
	1000°F	52.9 µohm.in	500°C	1.34 µohm.m
	1200°F	53.0 µohm.in	600°C	1.35 µohm.m
Thermal Conductivity	RT	63 Btu.in/h.ft^2.°F	RT	9.1 W/m.°C
	200°F	74 Btu.in/h.ft^2.°F	100°C	10.8 W/m.°C
	400°F	88 Btu.in/h.ft^2.°F	200°C	12.6 W/m.°C
	600°F	99 Btu.in/h.ft^2.°F	300°C	14.1 W/m.°C
	800°F	114 Btu.in/h.ft^2.°F	400°C	16.1 W/m.°C
	1000°F	133 Btu.in/h.ft^2.°F	500°C	18.0 W/m.°C
	1200°F	162 Btu.in/h.ft^2.°F	600°C	21.6 W/m.°C
Mean Coefficient of Thermal Expansion	77-200°F	6.9 µin/in.°F	25-100°C	12.4 µm/m.°C
	77-400°F	6.9 µin/in.°F	25-200°C	12.4 µm/m.°C
	77-600°F	7.0 µin/in.°F	25-300°C	12.6 µm/m.°C
	77-800°F	7.2 µin/in.°F	25-400°C	12.9 µm/m.°C
	77-1000°F	7.4 µin/in.°F	25-500°C	13.2 µm/m.°C
	77-1200°F	7.6 µin/in.°F	25-600°C	13.3 µm/m.°C
Thermal Diffusivity	RT	0.10 ft^2/h	RT	0.025 cm^2/s
	200°F	0.11 ft^2/h	100°C	0.029 cm^2/s
	400°F	0.13 ft^2/h	200°C	0.033 cm^2/s
	600°F	0.14 ft^2/h	300°C	0.036 cm^2/s
	800°F	0.16 ft^2/h	400°C	0.040 cm^2/s
	1000°F	0.17 ft^2/h	500°C	0.043 cm^2/s
	1200°F	0.19 ft^2/h	600°C	0.047 cm^2/s
Specific Heat	RT	0.102 Btu/lb.°F	RT	428 J/kg.°C
	200°F	0.104 Btu/lb.°F	100°C	434 J/kg.°C
	400°F	0.106 Btu/lb.°F	200°C	443 J/kg.°C
	600°F	0.109 Btu/lb.°F	300°C	455 J/kg.°C
	800°F	0.113 Btu/lb.°F	400°C	468 J/kg.°C
	1000°F	0.121 Btu/lb.°F	500°C	486 J/kg.°C
Dynamic Modulus of Elasticity	RT	30.0 x 10^6 psi	RT	207 GPa
	600°F	27.5 x 10^6 psi	300°C	191 GPa
	800°F	25.6 x 10^6 psi	400°C	180 GPa
	1000°F	24.8 x 10^6 psi	500°C	173 GPa
	1200°F	23.5 x 10^6 psi	600°C	166 GPa
Melting Range	2422-2476°F	-	1328-1358°C	-

Impact Strength

Product From	Test Temperature		Impact Strength	
	°F	°C	ft-lbf	J
Plate	RT	RT	362	491
Plate	-320	-196	419	568
Bar	RT	RT	369	500
Bar	-320	-196	423	574

Impact strengths were generated using Charpy V-notch samples, machined from mill annealed material.

Tensile Strength & Elongation

Form	Thickness/ Bar Diameter		Test Temperature		0.2% Offset Yield Strength		Ultimate Tensile Strength		Elongation
	in	mm	°F	°C	ksi	MPa	ksi	MPa	%
Sheet	0.063	1.6	RT	RT	52	359	109	752	64
Sheet	0.063	1.6	200	93	46	317	107	738	66
Sheet	0.063	1.6	400	204	38	262	96	662	65
Sheet	0.063	1.6	600	316	34	234	92	634	68
Sheet	0.063	1.6	800	427	31	214	89	614	76
Sheet	0.063	1.6	1000	538	30	207	82	565	75
Sheet	0.063	1.6	1200	649	30	207	77	531	62
Plate	0.5	12.7	RT	RT	50	345	110	758	68
Plate	0.5	12.7	200	93	46	317	105	724	68
Plate	0.5	12.7	400	204	35	241	97	669	72
Plate	0.5	12.7	600	316	31	214	92	634	70
Plate	0.5	12.7	800	427	28	193	88	607	72
Plate	0.5	12.7	1000	538	28	193	83	572	69
Plate	0.5	12.7	1200	649	28	193	76	524	78
Bar	1	25.4	RT	RT	52	359	110	758	67
Bar	1	25.4	200	93	44	303	103	710	68
Bar	1	25.4	400	204	38	262	92	634	70
Bar	1	25.4	600	316	33	228	90	621	70
Bar	1	25.4	800	427	30	207	87	600	71
Bar	1	25.4	1000	538	27	186	82	565	72
Bar	1	25.4	1200	649	26	179	77	531	77

RT= Room Temperature

Hardness

Form	Hardness, HRBW	Typical ASTM Grain Size
Sheet	87	3 - 5
Plate	88	1 - 4
Bar	84	0 - 4

All samples tested in solution-annealed condition.
HRBW = Hardness Rockwell “B”, Tungsten Indentor.

Welding & Fabrication

HASTELLOY® C-2000® alloy is very amenable to the Gas Metal Arc (GMA/MIG), Gas Tungsten Arc (GTA/TIG), and Shielded Metal Arc (SMA/Stick) welding processes. Matching filler metals (i.e. solid wires and coated electrodes) are available for these processes, and welding guidelines are given in the “Welding and Fabtication” brochure.

Wrought products of HASTELLOY® C-2000® alloy are supplied in the Mill Annealed (MA) condition, unless otherwise specified. This solution annealing procedure has been designed to optimize the alloy’s corrosion resistance and ductility. Following all hot forming operations, the material should be re-annealed, to restore optimum properties. The alloy should also be re-annealed after any cold forming operations that result in an outer fiber elongation of 7% or more. The annealing temperature for HASTELLOY® C-2000® alloy is 1149°C (2100°F), and water quenching is advised (rapid air cooling is feasible with structures thinner than 10 mm (0.375 in). A hold time at the annealing temperature of 10 to 30 minutes is recommended, depending on the thickness of the structure (thicker structures need the full 30 minutes). More details concerning the heat treatment of HASTELLOY® C-2000® alloy are given in the “Welding and Fabrication” brochure.

HASTELLOY® C-2000® alloy can be hot forged, hot rolled, hot upset, hot extruded, and hot formed. However, it is more sensitive to strain and strain rates than the austenitic stainless steels, and the hot working temperature range is quite narrow. For example, the recommended start temperature for hot forging is 1232°C (2250°F) and the recommended finish temperature is 954°C (1750°F). Moderate reductions and frequent re-heating provide the best results, as described in the “Welding and Fabrication” brochure. This reference also provides guidelines for cold forming, spinning, drop hammering, punching, and shearing. The alloy is stiffer than most austenitic stainless steels, and more energy is required during cold forming. Also, HASTELLOY® C-2000® alloy work hardens more readily than most austenitic stainless steels, and may require several stages of cold work, with intermediate anneals.

While cold work does not usually affect the resistance of HASTELLOY® C-2000® alloy to general corrosion, and to chloride-induced pitting and crevice attack, it can affect resistance to stress corrosion cracking. For optimum corrosion performance, therefore, the re-annealing of cold worked parts (following an outer fiber elongation of 7% or more) is important.

Specifications

Specifications

HASTELLOY® C-2000® alloy (N06200, W86200)	
Sheet, Plate & Strip	SB 575/B 575 P= 43
Billet, Rod & Bar	SB 574/B 574 B 472 P= 43
Coated Electrodes	SFA 5.11/ A 5.11 (ENiCrMo-17) DIN 2.4699 (EL-NiCr23Mo16Cu) F= 43
Bare Welding Rods & Wire	SFA 5.14/ A 5.14 (ERNiCrMo-17) DIN 2.4698 (SG-NiCr23Mo16Cu) F= 43
Seamless Pipe & Tube	SB 622/B 622 P= 43
Welded Pipe & Tube	SB 619/B 619 SB 626/B 626 P= 43
Fittings	SB 366/B 366 SB 462/B 462 P= 43
Forgings	SB 564/B 564 SB 462/B 462 P= 43
DIN	17744 No. 2.4675 NiCr23Mo16Cu
TÜV	Werkstoffblatt 539 Kennblatt 9679 Kennblatt 9678 Kennblatt 9677
Others	NACE MR0175 ISO 15156

Codes

HASTELLOY® C-2000® alloy (N06200, W86200)			
ASME	Section I	-	
	Section III	Class 1	-
		Class 2	-
		Class 3	-
	Section VIII	Div. 1	800°F (427°C)[1]
		Div. 2	-
	Section XII	-	
	B16.5	800°F (427°C)[2]	
	B16.34	800°F (427°C)[3]	
	B31.1	-	
	B31.3	800°F (427°C)[1]	
VdTÜV (doc #)		844°F (450°C)[4], #539	

[1]Approved material forms: Plate, Sheet, Bar, Forgings, fittings, welded pipe/tube, seamless pipe/tibe
[2]Approved material forms: Plate, Forgings, fittings, Bolting
[3]Approved material forms: Plate, Bar, Forgins, seamless pipe/tube
[4]Approved material forms: Plate, Sheet, Bar, Forgings

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