LION® B-2 ALLOY

A nickel-molybdenum alloy with outstanding resistance to hydrochloric and sulfuric acids in the as-welded condition.

Contents

PRINCIPAL FEATURES

Outstanding Corrosion Resistance in the As-Welded Condition

LION® B-2 alloy is a nickel-base wrought alloy with excellent resistance to hydrochloric acid at all concentrations and temperatures. It also withstands hydrogen chloride, sulfuric, acetic and phosphoric acids. The alloy has excellent resistance to pitting, to stress-corrosion cracking and to knife-line and heat-affected zone attack. It resists the formation of grain-boundary carbide precipitates in the weld heat-affected zone, thus making it suitable for most chemical process applications in the as-welded condition.

B-2 alloy is not recommended in the presence of ferric or cupric salts as these salts may cause rapid corrosion failure. Ferric or cupric salts may develop when hydrochloric acid comes in contact with iron or copper.

Therefore, whe Lion B-2 alloy is used in conjunction with iron or copper piping in a system containing hydrochloric acid, the presence of these salts could cause B-2 alloy to fail prematurely.

Exposure of B-2 alloy to temperatures from 1000°F (538°C) to 1600°F (870°C) should be avoided because of a reduction in the ductility of the alloy. In oxidizing gases such as air, B-2 alloy may be used at temperatures up to 1000°F (538°C). In reducing gases or in a vacuum, the alloy may be used from 1600°F (870°C) to substantially higher temperatures.

Limited tests indicate that the corrosion resistance of B-2 alloy in boiling 20 percent hydrochloric acid is not affected by cold reductions of up to 50 percent as compared to tests on the solution heat-treated alloy.

Available in Wrought Form

LION B-2 alloy is available in the form of plate, sheet, strip, billet, bar, wire, covered electrodes, pipe and tubing.

Heat-Treatment

Wrought forms of LIONB-2 alloy are furnished in the solution heat-treated condition unless otherwise specified. B-2 alloy except for bright annealed sheet and strip, is solution heat-treated at 1950°F (1066°C) and rapid quenched. Bright annealed products are heat-treated at 2100°F (1149°C) and cooled in hydrogen.

ASME Boiler and Pressure Vessel Code

LIONB-2 alloy plate, sheet, strip, bar tubing and pipe are covered by ASME specifications SB-333, SB-335, SB-619, SB-622 and SB-626 under UNS number N10665.

NOMINAL CHEMICAL COMPOSITION, PERCENT

Ni[a]	Co	Cr	Mo	Fe	Si	Mn	C
69	1.0**	1.0**	28.0	2.0**	0.10**	1.0**	0.01**

*The undiluted deposited chemical composition of B-2 alloy covered electrodes has 0.02 percent maximum carbon, 0.20 percent maximum silicon, 1.75 percent maximum manganese, 0.03 percent maximum phosphorus and 0.015 percent maximum sulfur.
**Maximum
[a] As-balance

AVERAGE PHYSICAL PROPERTIES

Physical Properties	Temp., °F	British Units	Temp., °C	Metric Units
Density	72	0.333 lb./in.^{3}	22	9.22 g/cm^3
Electrical Resistivity	32	54.1 microhm-in.	0	1.37 microhm-m
	212	54.3 microhm-in.	100	1.38 microhm-m
	392	54.5 microhm-in.	200	1.38 microhm-m
	572	54.6 microhm-in.	300	1.39 microhm-m
	752	54.8 microhm-in.	400	1.39 microhm-m
	932	55.6 microhm-in.	500	1.41 microhm-m
	1112	57.6 microhm-in.	600	1.46 microhm-m

AVERAGE PHYSICAL PROPERTIES

Physical Properties	Temp., °F	British Units	Temp., °C	Metric Units
Mean Coefficient of Thermal Expansion	68-200	5.7 microinches/in.-°F	20-93	10.3×10^{-6}m/m·K
	68-400	6.0 microinches/in.-°F	20-204	10.8×10^{-6}m/m·K
	68-600	6.2 microinches/in.-°F	20-316	11.2×10^{-6}m/m·K
	68-800	6.4 microinches/in.-°F	20-427	11.5×10^{-6}m/m·K
	68-1000	6.5 microinches/in.-°F	20-538	11.7×10^{-6}m/m·K
Thermal Conductivity	32	77 Btu-in./ft.^{2}-hr.-°F	0	11.1 W/m·K
	212	85 Btu-in./ft.^{2}-hr.-°F	100	12.2 W/m·K
	392	93 Btu-in./ft.^{2}-hr.-°F	200	13.4 W/m·K
	572	102 Btu-in./ft.^{2}-hr.-°F	300	14.6 W/m·K
	752	111 Btu-in./ft.^{2}-hr.-°F	400	16.0 W/m·K
	932	120 Btu-in./ft.^{2}-hr.-°F	500	17.3 W/m·K
	1112	130 Btu-in./ft.^{2}-hr.-°F	600	18.7 W/m·K
Thermal Diffusivity	32	0.005 in.^{2}/sec.	0	3.2×10^{-6}m^2/s
	212	0.005 in.^{2}/sec.	100	3.4×10^{-6}m^2/s
	392	0.006 in.^{2}/sec.	200	3.6×10^{-6}m^2/s
	572	0.006 in.^{2}/sec.	300	3.8×10^{-6}m^2/s
	752	0.006 in.^{2}/sec.	400	4.0×10^{-6}m^2/s
	932	0.007 in.^{2}/sec.	500	4.2×10^{-6}m^2/s
	1112	0.007 in.^{2}/sec.	600	4.5×10^{-6}m^2/s
Specific Heat	32	0.089 Btu/lb.-°F	0	373 J/kg·K
	212	0.093 Btu/lb.-°F	100	389 J/kg·K
	392	0.097 Btu/lb.-°F	200	406 J/kg·K
	572	0.101 Btu/lb.-°F	300	423 J/kg·K
	752	0.103 Btu/lb.-°F	400	431 J/kg·K
	932	0.106 Btu/lb.-°F	500	444 J/kg·K
	1112	0.109 Btu/lb.-°F	600	456 J/kg·K

AVERAGE FORMABILITY

Form	Condition	Average Olsen Cup Depth, in.	mm
Sheet, 0.063 in. (1.6mm) thick	Heat-treated at: 1950°F (1066°C), rapid quenched	0.57	14.5

AVERAGE DYNAMIC MODULUS OF ELASTICITY

Form	Condition	Test Temp., °F (°C)	Dynamic Modulus of Elasticity, 10^6 psi (GPa)
Plate, 1/2 in. (12.7mm) thick	Heat-treated at 1950°F (1066°C), rapid quenched	Room	31.4 (217)
		600 (316)	29.3 (202)
		800 (427)	28.4 (196)
		1000 (538)	27.4 (189)

AVERAGE TENSILE DATA

Form	Condition	Test Temp., °F (°C)	Ultimate Tensile Strength, Ksi (MPa)	Yield Strength at 0.2% offset, Ksi (MPa)	Elongation in 2 in. (50.8mm), percent	Hardness, Rockwell
Sheet, (bright annealed)	Heat-treated at 2100°F (1149°C), hydrogen cooled	Room	132.5 (914)	57.5 (396)	55	B-98
Sheet and Plate, 0.100 to 0.350 in. (2.5 to 8.9 mm) thick	Heat-treated at 1950°F (1066°C), rapid quenched	Room*	129.7 (894)	59.8 (412)	61	B-95
		400 (204)*	123.2 (849)	50.8 (350)	59	—
		600 (316)*	119.3 (823)	47.5 (328)	60	—
		800 (427)*	116.9 (806)	44.9 (310)	60	—
Plate, 0.360 to 2 in. (9.1 to 51 mm) thick	Heat-treated at 1950°F (1066°C), rapid quenched	Room[1]	130.9 (902)	59.0 (407)	61	B-94
		400 (204)[2]	126.2 (871)	52.3 (361)	60	—
		600 (316)[2]	121.8 (840)	48.8 (336)	60	—
		800 (427)[2]	119.3 (823)	46.3 (319)	61	—
Plate, 1/4 in. (6.4 mm) thick	As manual gas tungsten arc welded	Room	124.0 (855)	—	—	—
	Manual gas tungsten arc welded[3]	Room	118.5 (817)	—	—	—

*Average of 73 tests. [1]Average of 33-34 tests. [2]Average of 18 tests. [3]Heat-treated at 1950°F (1066°C), rapid quenched.

AVERAGE AGED DUCTILITY, SHEET*

Aging Temp., °F (°C)	Aging Time, min.	Elongation in 2 in. (50.8 mm), percent
1300 (704)	1	48
	5	39
	10	27
	30	13
1350 (732)	1	48
	5	14
	10	17
	30	7
1400 (760)	1	44
	5	14
	10	3
	30	2
1450 (788)	1	45
	5	11
	10	4
	30	3

*0.180 in. (4.6 mm) in thickness.

AVERAGE CORROSION DATA IN BOILING ACIDS*

Media	Concentration, percent by weight	Average Corrosion Rate per year mils	mm
Acetic Acid	10	0.5	<0.02
	30	0.4	0.01
	50	0.4	0.01
	70	0.3	<0.01
	99 (Glacial)	0.3	<0.01
Formic Acid	10	0.3	<0.01
	20	0.6	<0.02
	30	0.7	<0.02
	40	0.7	<0.02
	60	0.5	<0.02
	89	0.5	<0.02
Hydrochloric Acid	1	0.8	0.02
	2	3	0.08
	5	5	0.13
	10	7	0.18
	15	11	0.28
	20	15	0.38
	20	20**	0.51**
Phosphoric Acid (Chemically Pure)	10	2	0.05
	30	3	0.08
	50	6	0.15
	85	25	0.63
Sulfuric Acid	2	0.5	<0.02
	5	3	0.08
	10	2	0.05
	20	0.7	<0.02
	30	0.7	<0.02
	40	0.9	<0.03
	50	1	0.03
	50	2**	0.05**
	50	1***	0.03***
	60	2	0.05
	70	9	0.23

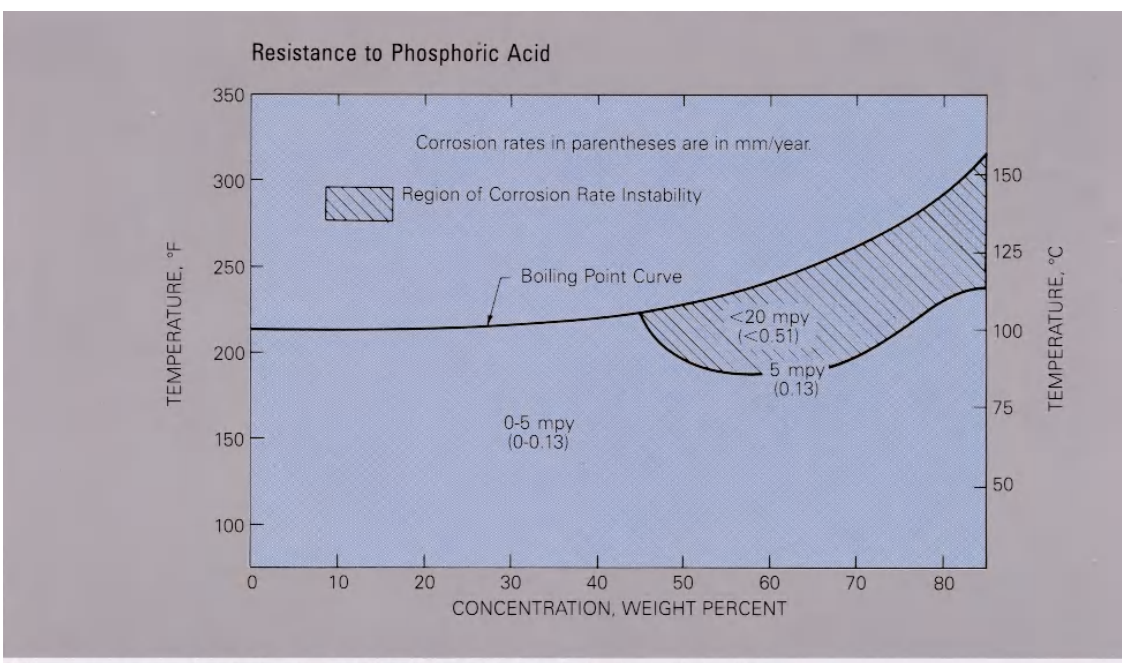
*Determined in laboratory tests of 120 hours duration. It is recommended that samples be tested under actual plant conditions. All test specimens were heat-treated at 1950°F (1066°C), water quenched unless otherwise noted.
**As gas tungsten arc welded.
***Aged 48 hours at 1000°F (538°C).

AVERAGE CORROSION DATA IN BOILING 20 PERCENT HCl, COLD REDUCED SHEET

Cold Reduction, percent	Average Corrosion Rate per year, mils	mm	Hardness, Rockwell
(as solution heat-treated)	14	0.36	B-92
10	14	0.36	C-32
20	14	0.36	C-38
30	13	0.33	C-43
40	14	0.36	C-44
50	14	0.36	C-45

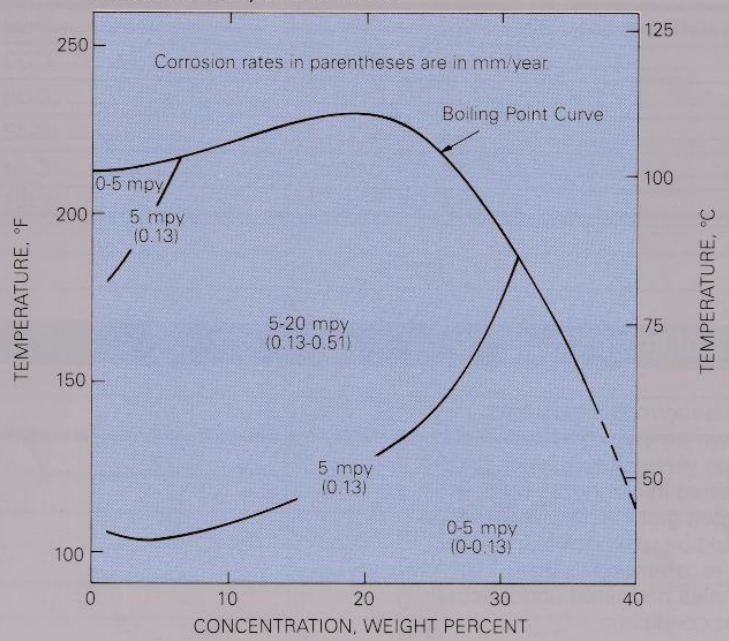
ISOCORROSION DIAGRAMS*

The isocorrosion diagrams shown on this and subsequent pages were plotted using data obtained in laboratory tests in reagent grade acids. These data should be used only as a guide. It is recommended that samples be tested under actual plant conditions.

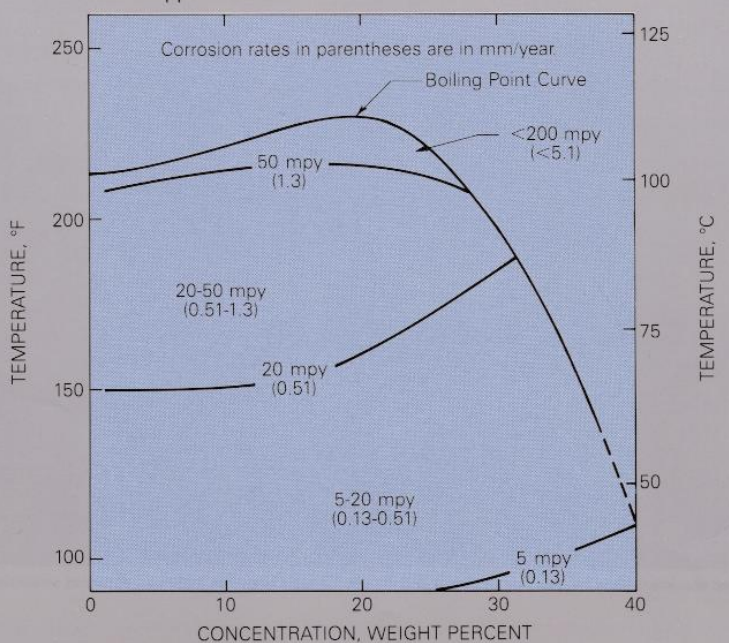


*All test specimens were solution heat-treated at 1950 °F (1066 °C), rapid quenched and in the unwelded condition.

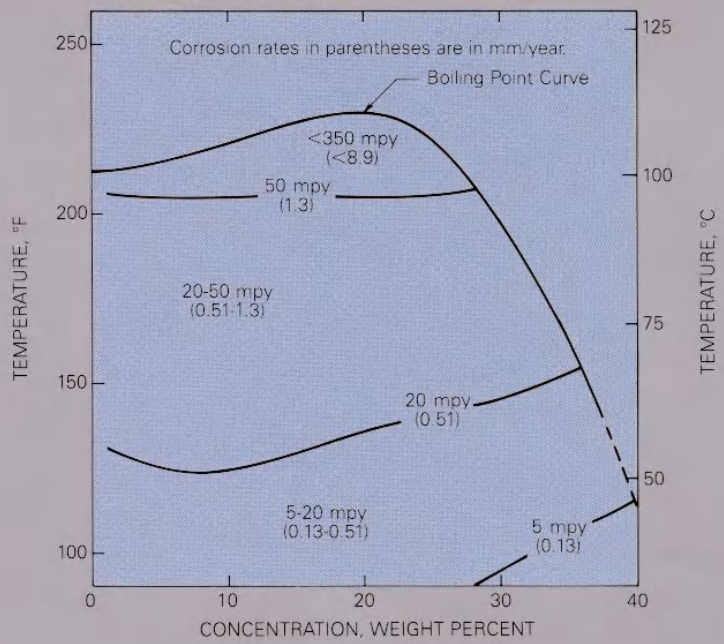
Resistance to Hydrochloric Acid



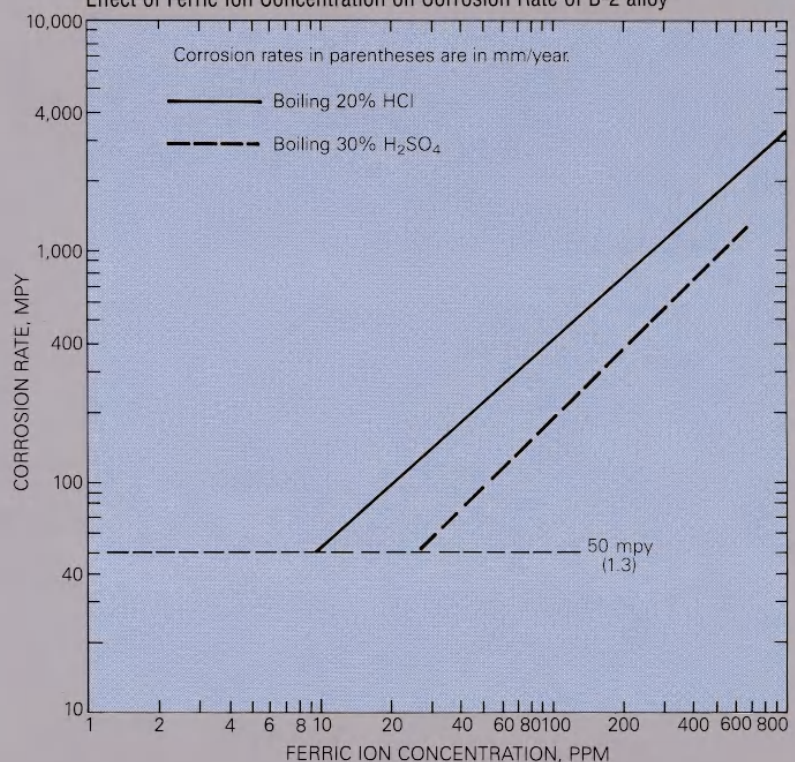
Resistance to Hydrochloric Acid with 50 ppm Ferric Ions



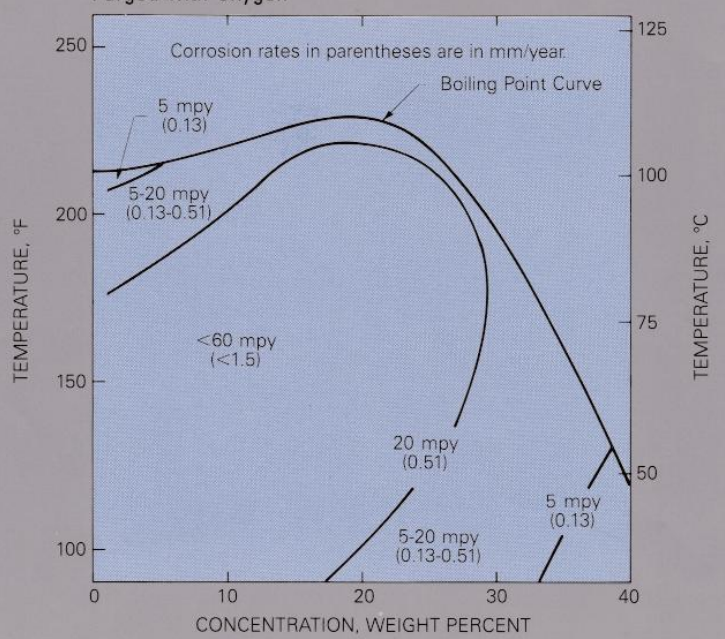
Resistance to Hydrochloric Acid with 100 ppm Ferric Ions



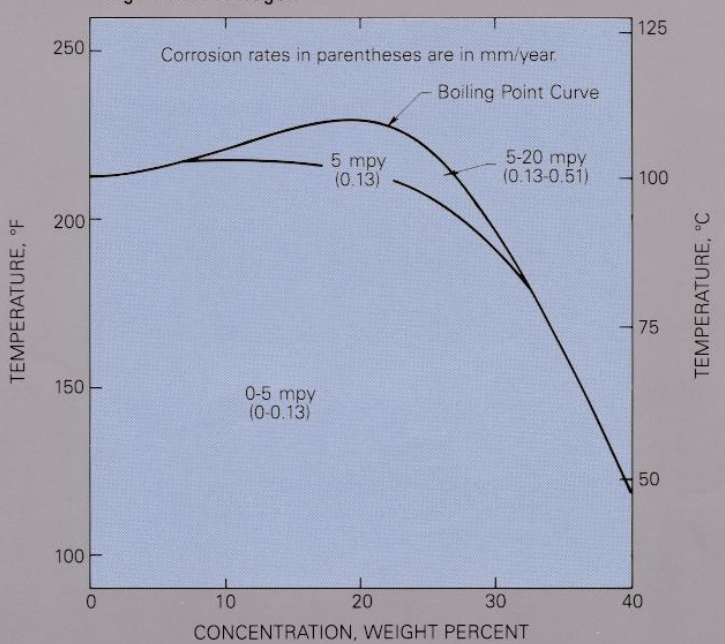
Effect of Ferric Ion Concentration on Corrosion Rate of B-2 alloy



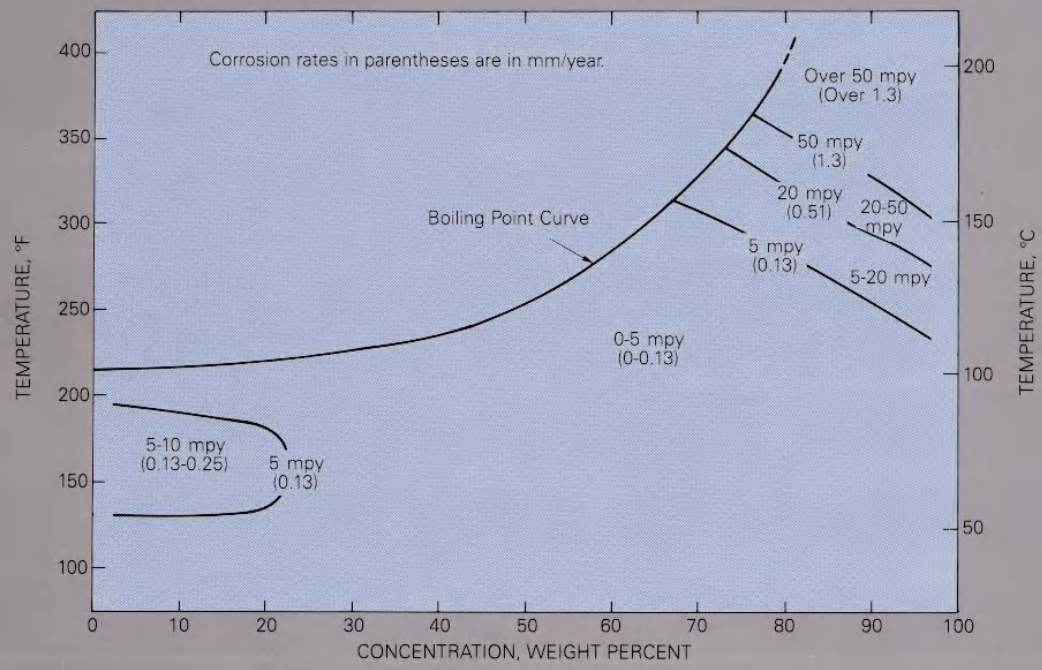
Resistance to Hydrochloric Acid, Purged with Oxygen



Resistance to Hydrochloric Acid, Purged with Nitrogen



Resistance to Sulfuric Acid



Resistance to Sulfuric Acid with 200 ppm Chloride Ions