# HASTELLOY® C-276 alloy

# **Principal Features**

**50 years of proven performance in a wide range of aggressive chemicals** HASTELLOY® C-276 alloy (UNS N10276) was the first wrought, nickel-chromiummolybdenum material to alleviate concerns over welding (by virtue of extremely low carbon and silicon contents). As such, it was widely accepted in the chemical process and associated industries, and now has a 50-year-old track record of proven performance in a vast number of corrosive chemicals.

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). With its high chromium and molybdenum contents, it is able to withstand both oxidizing and non-oxidizing acids, and exhibits outstanding resistance to pitting and crevice attack in the presence of chlorides and other halides. Furthermore, it is very resistant to sulfide stress cracking and stress corrosion cracking in sour, oilfield environments.

HASTELLOY<sup>®</sup> C-276 alloy is available in the form of plates, sheets, strips, billets, bars, wires, pipes, tubes, and covered electrodes. Typical chemical process industry (CPI) applications include reactors, heat exchangers, and columns.

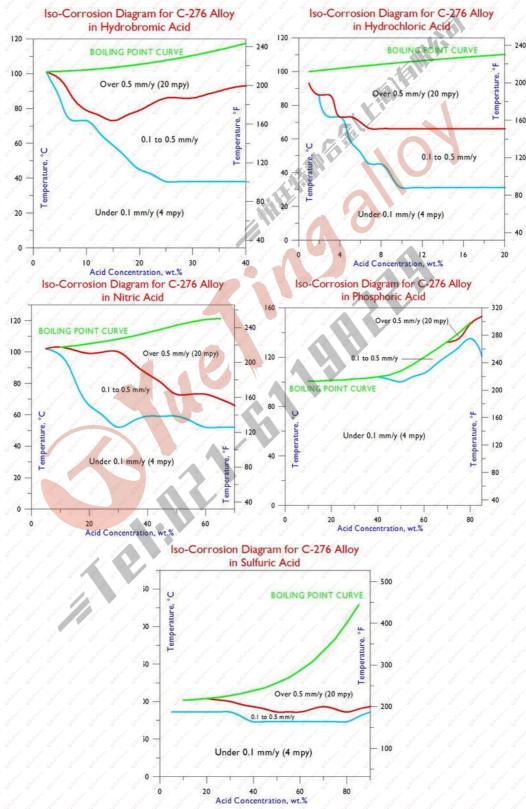
Weig	ht %
Nickel:	57 Balance
Cobalt:	2.5 max.
Chromium:	16
Molybdenum:	16
Iron:	5
Tungsten:	4
Manganese:	1 max.
Vanadium:	0.35 max.
Silicon:	0.08 max.
Carbon:	0.01 max.
Copper:	0.5 max.

# **Nominal Composition**

### **Iso-Corrosion Diagrams**

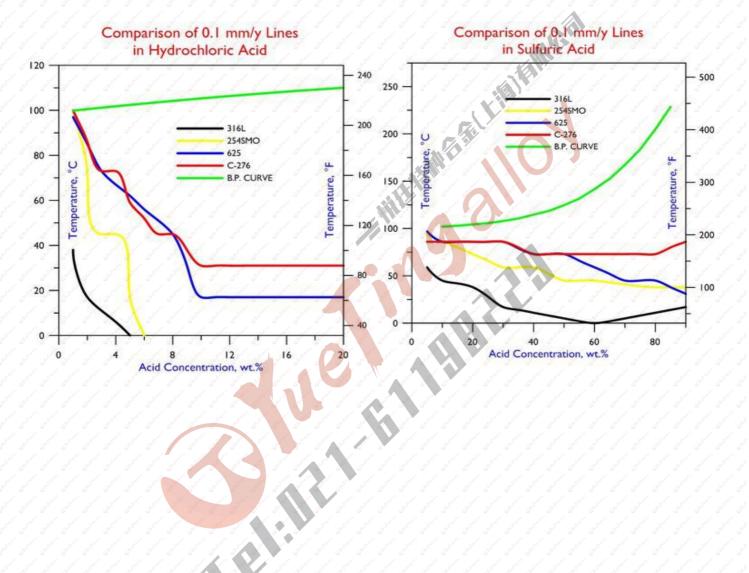
Each of these iso-corrosion diagrams was constructed using numerous corrosion rate values, generated at different acid concentrations and temperatures. The blue line represents those combinations of acid concentration and temperature at which a corrosion rate of 0.1 mm/y (4 mils per year) is expected, 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.



### **Comparative Plots**

To compare the performance of HASTELLOY® C-276 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-276 alloy are compared with those of two popular, austenitic stainless steels (316L and 254SMO), and a lower-molybdenum nickel alloy (625), in hydrochloric and sulfuric acids. At hydrochloric acid concentrations above about 5%, C-276 alloy provides a quantum improvement over the stainless steels, and offers much greater resistance to higher concentrations of both acids than alloy 625. The concentration limit of 20% hydrochloric acid is the azeotrope, beyond which high temperature corrosion tests are less reliable.



# Selected Corrosion Data

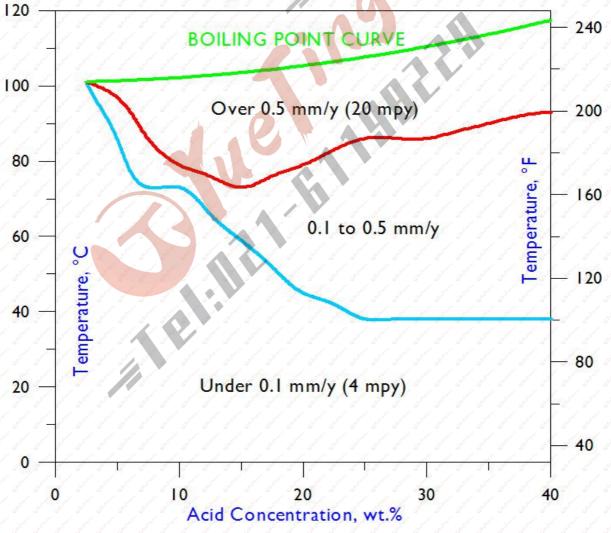
Conc.	50°F	75°F	100°F	125°F	150°F	175°F	200°F	225°F	Se Se Se Se
Wt.%	10°C	24°C	38°C	52°C	66°C	79°C	93°C	107°C	Boiling
2.5	States - States - States	Station States Statement	artan States - States State	Statement Statement Statement	Statement Statement	Station Station Station St	and Statement Statement Statem	Statement Statement Statement	0.13
st st 5	States States States	Shallon Shellon Shellon	entrane Station - Station Stat	Station Station Station	Station Station Station	0.01	0.15	Station Station Station	0.78
7.5	States - States States	Station Station Station	and States - States - States	States - States States	0.01	0.14	0.73	Station Station Station	Station Station - Station
/ / 10	States States	Station Station Station	entre chara contra	Starter - Jarren Starter	0.02	0.51	0.89	States States States	Station Station - Station
15	State State State	States States	and share - Share Share	0.01	0.34	0.57	and a start a star	Star Star Star	State State State
20	Start Start Start	Steel Steel State	< 0.01	0.25	0.37	0.51	1	Star Star Star	Start Start Start
25	Start Start Start	Start Start Start	0.11	0.2	0.29	0.45	0.75	Start Start Start	Start Start Start
30	anter anter anter	and the state of t	0.12	0.2	0.28	0.44	0.75	and a start and a start	and a strength of the strength
40	Gr Gr Gr	attend attended	0.08	0.13	0.21	0.3	0.53	and a start	

#### Hydrobromic Acid

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 15-02, 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-276 Alloy in Hydrobromic Acid

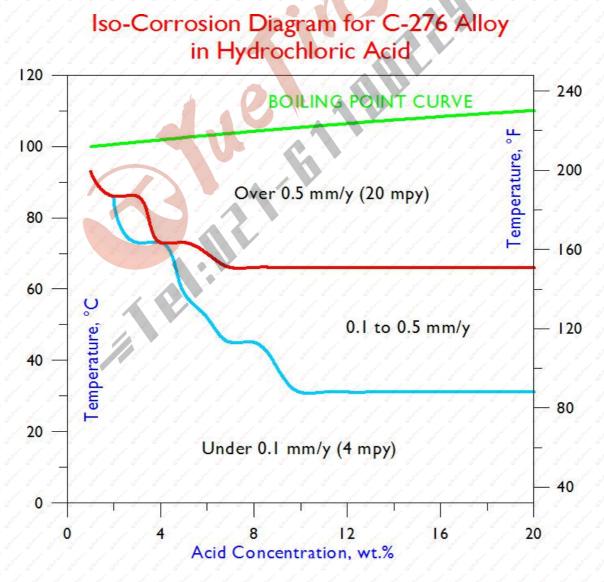


Conc.	50°F	75°F	100°F	125°F	150°F	175°F	200°F	225°F	and and and
Wt.%	10°C	24°C	38°C	52°C	66°C	79°C	93°C	107°C	Boiling
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/ / 2	Station - Contract Station	Station Station Station	destroyed and the second and and	States - States States	0.01	0.02	0.57	Station Station Station	1.26
2.5	States States States	States States States	Charles Share - Shares Sha	State - State State	Starting Starting Starting	0.03	0.89	States States States	1.86
3	State State State	State State State	State State State State	Share Share Share	0.01	0.42	1.18	State State State	2.34
3.5	Start Start Start	Start Start Start	and and and are	Start Start Start	Start Start Start	0.57	1.26	Star Star Star	2.43
4	and and a start and a start and a start	State State State	and and a second and a second and a second a se	and and a second and	0.02	0.67	1.37	Stall Stall Stall	2.92
4.5	Star Star Star	Start Start Start	and and a stranger and a stranger and	Start Start Start	0.37	0.68	1.72	Contra Co	3.34
5	and a start of the	Station states and station	and a second and a second a s	0.02	0.31	0.75	1.25	Station of the station	3.63
7.5	Statement Statement	Statement Statement	0.03	0.31	0.53	0.94		Station Statement	and the second second
10	Shafener Strand Shafener	States States States	0.17	0.32	0.46	1.18	$\cap$	Stationary Statement Stationer	Statement Statement Statement
/ / 15	Station Station Station	Statement Statement Statement	0.19	0.33	0.54	1.21		Shalland Stateman	States of States States
20	Station Station Station	Station Station Station	0.14	0.29	0.55	1.10	Statute - Statute Statu	Station Station Station	States - States

**Hydrochloric Acid** 

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.



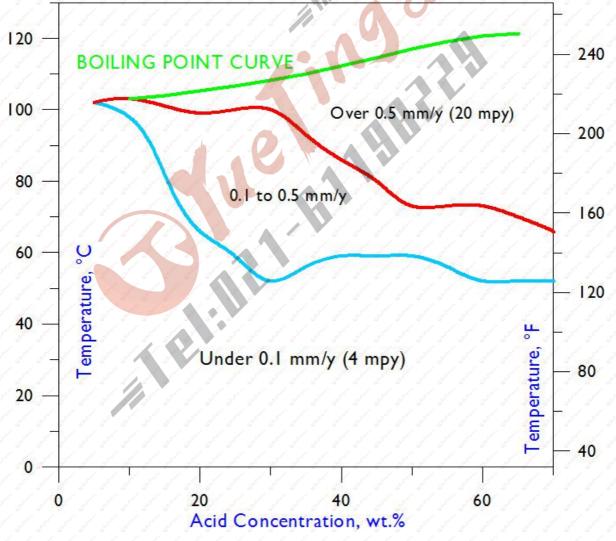
Conc.	50°F	75°F	100°F	125°F	150°F	175°F	200°F	225°F	ST ST ST S
Wt.%	10°C	24°C	38°C	52°C	66°C	79°C	93°C	107°C	Boiling
10	and the state of t	Statement Statement	0.01	and alternation alternation	0.03	Sector Sector Statement	0.06	and the state of t	0.26
20	of Station Station Station	Statement Statement Statement	and and statement statement state	Statement Statement Statement	0.09	Statement Statement Statement St	0.16	Stational Statement Station	0.66
30	States of Trans. States	Station States States	0.02	Staffarra	0.14	0.17	0.41	Shalland States Shalland	1.52
40	Shalland Station Shalland	Station Station Station	and States - States - States	0.05	0.20	0.38	0.88	Station Station Station	4.42
50	States and States	States States States	0.04	0.07	0.30	0.65	1.51	States States States	States States - States S
60	State State State	State State State	0.06	0.10	0.42	0.82	2.03	State State State	18.42
65	Start Start Start	State State State	and Start Start Start	Stern Stern Stern	0.41	Jean Start Start St	2.53	Steel Steel Steel	22.12
70	and the state of the	Star Star Star	0.06	and the second	0.46	1.12	2.62	and and and	Star Star Star S

#### Nitric Acid

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 1-74 and 19-97.

All tests were performed in reagent grade acids under laboratory conditions; field tests are encouraged prior to industrial use.

# Iso-Corrosion Diagram for C-276 Alloy in Nitric Acid



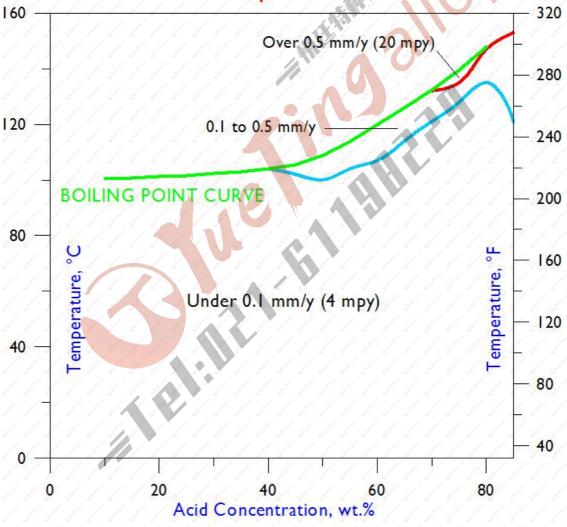
Conc.	125°F	150°F	175°F	200°F	225°F	250°F	275°F	300°F	Strand Strand
Wt.%	52°C	66°C	79°C	93°C	107°C	121°C	135°C	149°C	Boiling
50	an alternation and alternation	Statement Statement	0.01	0.02	Statement Statement	Sector State	and Station - State of States	and a stand of the stand of the stand	0.18
60	States States States	Statement Statement Statement	0.01	0.02	0.08	Section Statement Statement St	and Staffagen Staffagen Staffag	Station States States	0.28
70	Station Station Station	Station States Station 3	0.01	0.02	0.08	0.08	are station states states	Station Station Station	0.13
75	States - States States	Station Station Station	aller Charles - Charles - Ch	Sar Station - Station Station	Station Station Station	Jeanne Station - Station St	Station Station Station	Station Station Station	1.29
80	States and States	States States States	0.01	0.02	States States States	0.09	0.12	States States States	0.31
85	States States States	Statut Statut Statut	and States - States St	Share Share Share	State State State	0.09	0.17	0.29	1.68

#### **Phosphoric Acid**

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.

### Iso-Corrosion Diagram for C-276 Alloy in Phosphoric Acid



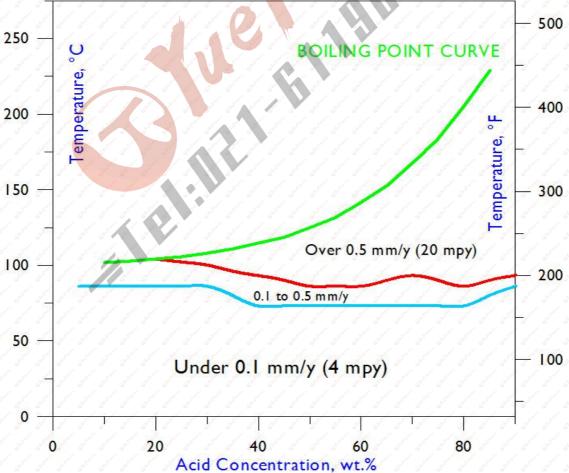
					and the stream	Sanan	IC ACIU	Strate Strate Strate				
Conc.	75°F	100°F	125°F	150°F	175°F	200°F	225°F	250°F	275°F	300°F	350°F	and strand strand
Wt.%	24°C	38°C	52°C	66°C	79°C	93°C	107°C	121°C	135°C	149°C	177°C	Boiling
1	saturation and	and and a	and and a straight	same and same	and a start	and and a	tarran - tarran	and a star of the star	and a stranger	ation and a street		for the second second
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4	suffer and suffered	Antran - Antran A	and statement statement	and the second second	and the second second	the second second second	an and a section of the section of t	and the second second	and the second second	aller and and aller	Telland - Telland	and and a second
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10	statul - statul	and a strand and a strand and a	and a start and a start and	and the state of the state of the state	0.03	0.14	and the second second	had maked a start a start of	terrar - terrar		atologica - destant	0.18
20	station - station	- testinger	and state	- test married - Test married - start	0.05	0.4	and the stand of the stand of the stand	had many and a second and the first	and - show	-	alatan - datan	0.49
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50	station - station	dertand - dertand	and states - states and	0.02	0.26	0.62	1.13	2.33	- /	all set and	Antran - Julian	3.64
60	Antrare Antrare	Julian - Julian Ju	and starter starter	0.02	0.3	0.67	1.03	2.87	sere - sere		Anton - Anton	13.08
70	Station - Station	dellar dellar	and state	0.05	0.16	0.5	1.06	13.68	E	and Hand	Antone - Antone	for a station of the station of the
80	Station - Station	Station Station St	and states - states	0.04	0.14	0.6	2.73	5.66		and and and	atellar - Jellar	Sandar Station - Stationer
90	Station - Station	Antonia - Terrana	and states - states	0.03	0.05	0.46	1.64	4.79	and particular	Start Start Start	station - talion	and stated - stated
96	starting - starting	anteren anteren	and stated statement	and the state of the state	0.04	0.18	0.95			aline and a star	Julian - Julian	and and - and

#### **Sulfuric Acid**

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.





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

	Concentration	100°F	125°F	150°F	175°F	200°F	The statement statement statement
Chemical	wt.%	38°C	52°C	66°C	79°C	93°C	Boiling
Acetic Acid	99/ 6	States States States	Stafford Stafford - Stafford Staf	Statute States States	States - States - States	Star Station Station State	<0.01
Starting Starting Starting Starting Starting Starting	5	Station Station Station	Station Station - Station Stat	0.13	Stellar States States 5	States States - Jacob State	States States States
Chromic Acid	20	Charles Charles Charles	Statute Statute Statute State	0.53	State State State S	State State State	State State State
Formic Acid	88	Statute Statute Statute	State State State	and and a start of the start of	Stand Stand Stand	And States States States	0.04
and a start and a start and a start and a start	2.5	Share Share Share	State State State State	Share Share Share	State State State S	State State State	0.13
	5 / 5	and and and and a second	and	and			0.78
	7.5	and a start of the	and and an and an	0.01	0.14	sent and a set of	and
	10	a an	terrore aternet	0.02	0.51	and and a start and a start of the start of	and
Hydrobromic	15	a a a a a a	0.01	0.34	0.57	5 0 0 0 5 - 5 - 5 - 5 - 5 - 5 - 5 - 5 - 5 - 5 -	a a a a a
Acid	20	< 0.01	0.25	0.37	0.51	And States - States State	and statement statement
	25	0.11	0.2	0.29	0.45	And States - Jalan Stat	or Station Station Station
	30	0.12	0.2	0.28	0.44	Station - Stational Stati	States States States
	40	0.08	0.13	0.21	0.3	Statute Statute Statu	Oter Oter Oter
and a start and a start of the		Stand Stand Stand			1 - 1 - 1 - 1 - 1 - 1 - 1 - 1 - 1 - 1 -	national stands stands	0.33
	1.5	and the second second	- /	A-0			0.7
	2 / / 2	and and and and a second and a se	-	0.01	0.02	<del>li seli seli seli</del> seli seli - seli se	1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
	2.5	and and a start and a start of the start of			0.03	r <del>der der der</del> Sta <sup>nder</sup> "Sta <sup>nder</sup> " <del>–</del> stander" stat	and an and a star and a star and a star a
	3	and a start and a start	<u> </u>	0.01	0.42	Allen all all all	and a statement and a statement
	3.5	and a second			0.57	and a second and	a a a a a a a a a a a a a a a a a a a
Hydrochloric	s and and a 4 and a set	Statute States	and - and and	0.02	0.67	Star Charles - Charles Charl	of and and a state of the
Acid	4.5	3ª 27		0.37	0.68	Stand Station - Station Stati	Statement Statement Statement
	5 J J J J J		0.02	0.31	0.75	State State - State State	State State
	7.5	0.03	0.31	0.53	0.94	NA SHARE SHARE SHARE	Charles Charles Charles
	10	0.17	0.32		1.18	an san san san	
	15	0.19	0.33		1.21	and and a set of the s	and the second sec
	20	0.14	0.29	0.55	1.1	<u> </u>	and the second second
and a star at a star a	5		0.34	and and a star and a star and a star a st	and a second	n dr. dr. dr. Sall - Sall - Sall	and the second second
Hydrofluoric	10	V- /	0.41	a a a a a a a a a a a a a a a a a a a	and an an a	Ander State	a a a a
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State State State State State	10 5	Station Station Station	Statute Statute Statute Stat	0.03	Station Station Station S	0.06	0.26
	20	Charlen Charlen	Station Station - Station Stat	0.09	States States States 3	0.16	0.66
	30	a Statement Statement Statement	Statement Statement	0.14	0.17	0.41	Statement Statement
	40	Stander Stander Stander	2 m <sup>2</sup> 3 m <sup>2</sup> - 3 m <sup>2</sup> 3 m	0.2	0.38	0.88	Stand Stand
Nitric Acid	50	a and a set		0.3	0.65	1.51	
	60	States States States	1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	0.42	0.82	2.03	and the second sec
	65	and and a second and		0.41	and and a second se	2.53	and and and and a second and a s
	70	alter alter alter	ar ar ar ar ar	0.46	and the strength of	2.62	and the second s

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

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

and defined defined defined to the set	Concentration	100°F	125°F	150°F	175°F	200°F	and a station of the state of the state
Chemical	wt. %	38°C	52°C	66°C	79°C	93°C	Boiling
and Statement Statement Statement Statement	50 / /	States - Care States	Station Station - Station Station	States States States States	0.01	0.02	States of States
and Statement Statement Statement Statement St	60	States States States	sharan Sharan - Sharan Shar	Sharan Sharan Sharan S	0.01	0.02	States States States
Phosphoric	70	States States States	States States - States State	State State State 3	0.01	0.02	States States States
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	85	Start Start Start	and and and and and	Strington Strington	Start Start Start		Star Star
and a stational atalogue atalogue atalogue atalogue	10	and the state of t	and the second sec	a the fragment of the fragment of	0.03	0.14	0.18
	20	atternant standard standard	Statement Statement - Statement Statement	and a second second second	0.05	0.4	0.49
	30	Statement Statement	Station Station Station State	and Statement Statement Statement St	0.06	0.42	0.83
	40 / 40	Station Station Station	Section Section State	Share Shere Share	0.19	0.48	State State State
Sulfuric	50 / /	States States States	Station Station - Station Station	0.02	0.26	0.62	States States States
Acid	60	Startan Startan Startan	Station Charles - Station Other	0.02	0.3	0.67	States States States
	70	a alterna alterna alterna a	Server States - States State	0.05	0.16	0.5	State State State
	80	a State State State		0.04	0.14	0.6	Start Start Start
	90	and and a second and a second	-	0.03	0.05	0.46	Start Start Start
	96	Star Star Star	-		0.04	0.18	Ser Ser Ser

### Resistance to Pitting and Crevice Corrosion

HASTELLOY® C-276 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, and C-276 alloys are as follows:

		g Temperature ed 6% FeCl <sub>3</sub>	Critical Crevice Temperatur in Acidified 6% FeCl <sub>3</sub>		
Alloy	°F	۵ ۵ <b>°C</b> ۵ ۵	of the strategy of the strateg	0°C 0	
316L	59	15	32	0	
254SMO	140	60	86	30	
625	212	100	104	40	
C-276	>302	>150	131	55	

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-276 alloy is the boiling point. In Yellow Death, C-276 alloy has not exhibited pitting, even at the maximum test temperature (150°C). The Critical Crevice Temperature of C-276 alloy in Yellow Death is 60°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 two nickel alloys, C-276 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

### 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.

Share Starte Starte Start	and and and a Q	uiescent	Flowing			
Alloy	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		

# **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 to higher corrosion rates (than with homogeneous, wrought products). Nevertheless, HASTELLOY® C-276 alloy exhibits excellent resistance to the key, inorganic acids, even in welded form, as shown in the following table:

	Concentration	Temperature		Corrosion Rate				
	States States States States States States	The france Stationers Stationers S	Strater Statement Statement State	Weld Metal		Wrought I	Base Metal	
Chemical	wt.%	۴F	°C	mpy	mm/y	mpy	mm/y	
H <sub>2</sub> SO <sub>4</sub>	30	150	66	1.2	0.03	<0.1	< 0.01	
H <sub>2</sub> SO <sub>4</sub>	50	150	66	1.2	0.03	0.8	0.02	
H <sub>2</sub> SO <sub>4</sub>	70	150	66	5.1	0.13	2	0.05	
H <sub>2</sub> SO <sub>4</sub>	90	150	66	4.3	0.11	1.2	0.03	
HCI	10	100	38	8.7	0.22	6.7	0.17	
HCI	15	100	38	7.9	0.2	7.5	0.19	
HCI	20	100	38	6.3	0.16	5.5	0.14	

# **Physical Properties**

Physical Property	Briti	sh Units	Metric Units		
Density	RT	0.321 lb/in <sup>3</sup>	RT	8.89 g/cm <sup>3</sup>	
Electrical Resistivity	/ / RT / /	48.4 µohm.in	/ / RT/ / ,	1.23 µohm.m	
	200°F	48.7 µohm.in	100°C	1.24 µohm.m	
	400°F	49.0 µohm.in	200°C	1.25 µohm.m	
	600°F	49.5 µohm.in 300°C		1.26 µohm.m	
	800°F	49.8 µohm.in 400°C		1.26 µohm.m	
	1000°F	50.6 µohm.in	500°C	1.28 µohm.m	
	and a stranger and a stranger and a stranger	and and a strand and a strand	000°C	1.30 µohm.m	
<del>- 5 - 5 - 5 - 5 - 5 - 5 - 5 - 5</del> I - S - S - S - S - S - S - S - S	100°F	71 Btu.in/h.ft <sup>2</sup> .°F	50°C	10.5 W/m.°C	
	200°F	77 Btu.in/h.ft <sup>2</sup> .°F	100°C	11.2 W/m.°C	
Thermal	400°F	90 Btu.in/h.ft <sup>2</sup> .°F	200°C	12.9 W/m.°C	
Conductivity	600°F	104 Btu.in/h.ft <sup>2</sup> .°F	300°C	14.7 W/m.°C	
	800°F	117 Btu.in/h.ft <sup>2</sup> .°F	400°C	16.5 W/m.°C	
	1000°F	132 Btu.in/h.ft <sup>2</sup> .°F	500°C	18.3 W/m.°C	
	75-200°F	6.2 µin/in.°F	24-100°C	11.2 µm/m.°C	
	75-400°F	6.7 µin/in.°F	24-200°C	12.0 µm/m.°C	
Mean Coefficient of	77-600°F	7.1 μin/in.°F	24-300°C	12.7 µm/m.°C	
Thermal Expansion	77-800°F	7.3 µin/in.°F	24-400°C	13.1 µm/m.°C	
	77-1000°F	7.4 µin/in.°F	24-500°C	13.3 µm/m.°C	
	77-1100°F 🥌	7.8 µin/in.°F	24-600°C	13.8 µm/m.°C	
Magnetic Permeability	200 oersted	1.0002	15.9 kA/m	1.0002	
Specific Heat	RT	0.102 Btu/lb.°F	of of RT of o	427 J/kg.°C	
Dynamic Modulus of Elasticity	RT	29.8 x 10 <sup>6</sup> psi	RT	205 GPa	
	400°F	28.3 x 10 <sup>6</sup> psi	200°C	195 GPa	
	600°F	27.3 x 10 <sup>6</sup> psi	300°C	189 GPa	
	800°F	26.4 x 10º psi	400°C	183 GPa	
	1000°F	25.5 x 10º psi	500°C	178 GPa	
Melting Range	2415-2500°F	and a second state of the	1323-1371°C	and a start of the	
Poisson's Ratio		a particular a part	RT	0.31	

RT= Room Temperature

# **Impact Strength**

and the start start start start start start	Start Sta	feel Stall Stall Stall Stall Stall	Thickness		Impact Strength	
Type of Test	Test Temperature	Form	in	mm	ft.lbf	J Stranger
Charpy V-Notch	RT	Plate	0.394	10	348	472
Charpy V-Notch	RT	Plate	0.472	12	351	476

\*RT= Room Temperature

# Tensile Strength and Elongation

Test Temperature		Thickness		0.2%Offset Yield Strength		Ultimate Tensile Strength		Elongation	
Form	°F	°C	in	mm	ksi	MPa	ksi	MPa	%
Sheet	RT	RT	0.078	/ 2/ /	51.6	356	114.9	792	61
Sheet	400	204	0.078	2	42	290	100.6	694	59
Sheet	600	316	0.078	/ 2/ /	35.9	248	98.8	681	68
Sheet	800	427	0.078	2	32.7	225	94.3	650	67
Sheet	400	204	0.094	2.4	39.9	275	101	696	58
Sheet	600	316	0.094	2,4	33.5	231	97.6	673	64
Sheet	800	427	0.094	2.4	29.7	205	93.5	645	64
Sheet	400	204	0.063-0.187	1.6-4.7	42.1	290	100.8	695	56
Sheet <sup>2</sup>	600	316	0.063-0.187	1.6-4.7	37.7	260	97	669	64
Sheet <sup>2</sup>	800	427	0.063-0.187	1.6-4.7	34.8	240	95	655	65
Sheet <sup>2</sup>	1000	538	0.063-0.187	1.6-4.7	33.8	233	88.9	613	60
Plate <sup>3</sup>	400	204	0.188-1.0	4.8-25.4	38.2	263	98.9	682	61
Plate <sup>3</sup>	600	316	0.188-1.0	4.8-25.4	34.1	235	94.3	650	66
Plate <sup>3</sup>	800	427	0.188-1.0	4.8-25.4	32.7	225	91.5	631	60
Plate <sup>3</sup>	1000	538	0.188-1.0	4.8-25.4	32.8	226	87.2	601	59
Plate	RT	RT		25.4	52.9	365	113.9	785	59
Plate	600	316		25.4	36.2	250	96.3	664	63
Plate	800	427		25.4	30.5	210	94.8	654	61

1: Average of 25 tests

2: Average of 34-36 tests

3: Average of 9-11 tests

RT= Room Temperature

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# Hardness

Form	Hardness, HRB		
Sheet	.90		
Plate			

The values are averages from numerous tests HRB = Hardness Rockwell "B".

### Welding and Fabrication

HASTELLOY® C-276 alloy is very amenable to the Gas Metal Arc (GMA/MIG), Gas Tungsten Arc (GTA/TIG), and Shielded Metal Arc (SMA/Stick) welding processes. Matchingfiller metals (i.e. solid wires and coated electrodes) are available for these processes, and welding guidelines are given in the "Welding and Fabrication" brochure.

Wrought products of HASTELLOY® C-276 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-276 alloy is 1121°C (2050°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-276 alloy are given in our "Welding and Fabrication" brochure.

HASTELLOY® C-276 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 "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-276 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-276 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 reannealing of cold worked parts (following an outer fiber elongation of 7% or more) is important.

# **Specifications & Codes**

	fications OY® C-276 alloy		
	76, W10276)		
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-4) DIN 2.4887 (EL-NiMo15Cr15W) F= 4		
Bare Welding Rods & Wire	SFA 5.14/ A 5.14(ERNiCrMo-4) DIN 2.4886 (SG- NiMo16Cr16W) F= 43		
Seamless Pipe & Tube	SB 622/B 622 B 983 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. 2.4819 NiMo16Cr15W		
τϋν	Werkstoffblatt 400 Kennblatt 320 Kennblatt 319		
Others	NACE MR0175 ISO 15156		

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" 3" 3" 3" 3" 3" 3" 3" 3" 3" " " - 3" 3" 3" 4" 3" 4" 3" 4" 3" 4" 3"	HASTELLOY® (N10276, V		yet		
	Section I	1000°F (538°C)¹ Code Case 1924 1000°F (538°C)			
and and and and and and and and	Star Star Star Star Star Star In 1997 start start start start st	Class 1	S <sup>II</sup> S <sup>III</sup> S <sup>III</sup> S <sup>III</sup> S <sup>III</sup> S <sup>III</sup> S <sup>III</sup>		
ASME	Section III	Class 2	800°F (427°C) <sup>2</sup>		
		Class 3	800°F (427°C) <sup>2</sup>		
	Section VIII	Div. 1	1250°F (677°C) <sup>3</sup>		
		Div. 2	1250°F (677°C) <sup>3</sup>		
and Statement Statement Statement Statement Statement	Section XII	650°F (343°C) <sup>3</sup>			
and Statement Statement Statement Statement State	B16.5	1250°F (677°C)₄			
and Statement Statement Statement Statement State	B16.34	1250°F (677°C)⁵			
and share share share share share share share	B31.1	1000°F (538°C)6			
a star star star star star star star	B31.3	1250°F (677°C) <sup>7</sup>			
VdTÜV (doc #)	844°F (450°C) <sup>®</sup> , #400				

<sup>1</sup>Approved material forms: Plate, Sheet, Bar, fittings, welded pipe/tube, seamless pipe/tube <sup>2</sup>Approved material forms: Plate, Sheet, Bar, welded pipe/tube, seamless pipe/tube <sup>3</sup>Approved material forms: Plate, Sheet, Bar, Forgings, fittings, welded pipe/tube, seamless pipe/tube

<sup>4</sup>Approved material forms: Plate, Forgings, fittings, Bolting

<sup>5</sup>Approved material forms: Plate, Bar, Forgings, seamless pipe/tube, Bolting

<sup>6</sup>Approved material forms: Plate, Sheet, fittings, welded pipe/tube, seamless pipe/tube <sup>7</sup>Approved material forms: Plate, Sheet, Forgings, fittings, welded pipe/tube, seamless pipe/tube <sup>8</sup>Approved material forms: Plate, Sheet, Bar, Forgings

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