HASTELLOY® C-22® alloy

Principal Features

Enhanced versatility and exceptional resistance to chloride-induced pitting

HASTELLOY® C-22® alloy (UNS N06022) is one of the well-known and well-proven nickelchromium-molybdenum materials, the chief attributes of which are resistance to both oxidizing and non-oxidizing chemicals, and protection from pitting, crevice attack, and stress corrosion cracking. Its high chromium content provides much higher resistance to oxidizing media than the family standard, C-276 alloy, and imparts exceptional resistance to chloride-induced pitting, an insidious and unpredictable form of attack, to which the stainless steels are prone.

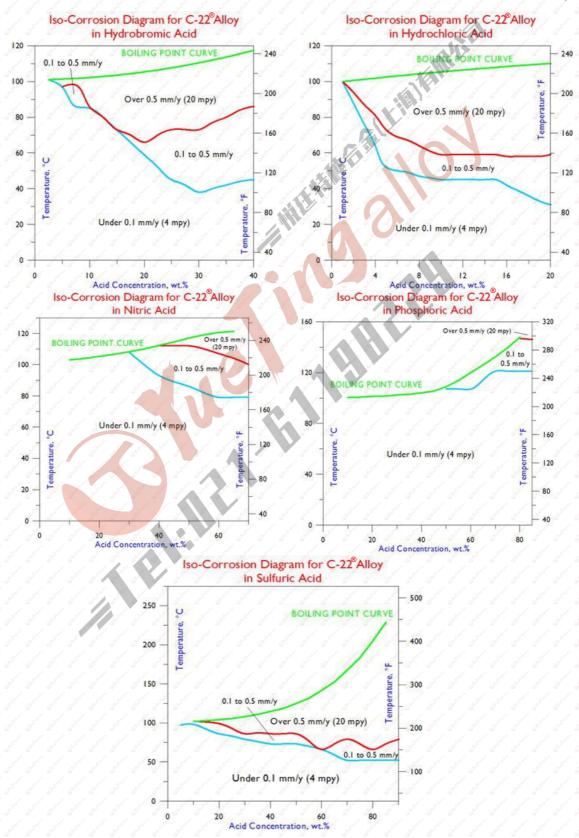
Like other nickel alloys, HASTELLOY® C-22® alloy is very ductile, exhibits excellent weldability, and is easily fabricated into industrial components. It is available in the form of plates, sheets, strips, billets, bars, wires, pipes, tubes, and covered electrodes. Typical chemical process industry (CPI) applications include reactors, heat exchangers, and columns.

Nominal Composition

Weig	ht %
Nickel:	56 Balance
Chromium:	22
Molybdenum:	13
Iron:	3
Cobalt:	2.5 max.
Tungsten:	3
Manganese:	0.5 max.
Silicon:	0.08 max.
Carbon:	0.01 max.
Vanadium:	0.35 max.
Copper:	0.5 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.

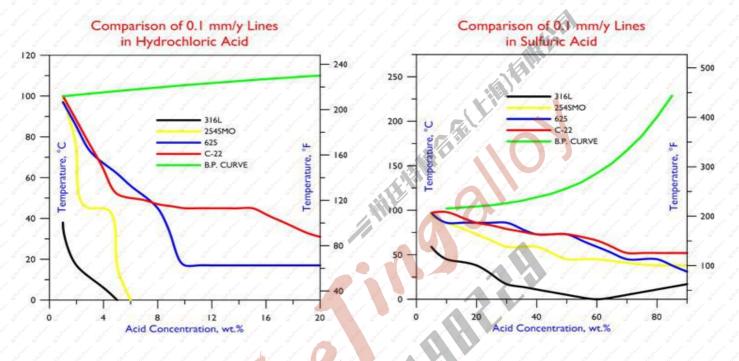


Haynes International - HASTELLOY® C-22® alloy

Comparative 0.1 mm/y Line Plots

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To compare the performance of HASTELLOY® C-22® 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-22® 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. The tests in hydrochloric acid were limited to a concentration of 20% (the azeotrope). At hydrochloric acid concentrations above about 5%, C-22® alloy provides a quantum improvement over the stainless steels, and offers much greater resistance hydrochloric acid than 625 alloy in the concentration range 8 to 20%.



Selected Corrosion Data

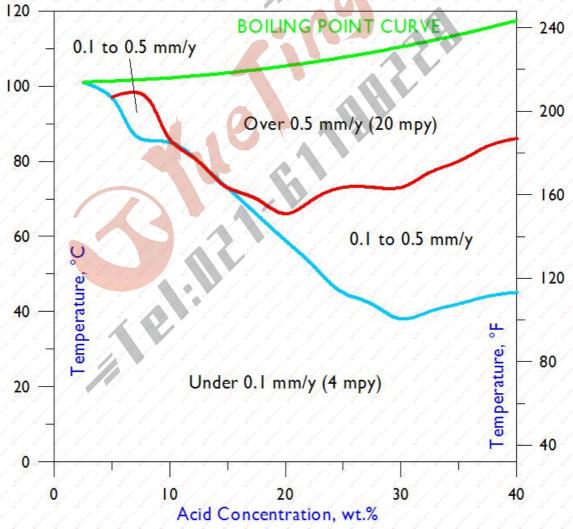
Conc.	50°F	75°F	100°F	125°F	150°F	175°F	200°F	225°F	to the state of th
Wt.%	/t.% 10°C 24°C	38°C	52°C	66°C	79°C	93°C	107°C	Boiling	
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30	Service Service Service	State State State	0.11	0.23	0.29	0.59	1.12	Contraction Contraction	and and a stranger
40	anter anter anter	antinent anti-	0.07	0.13	0.21	0.34	0.66	· or or or	attended attended attended

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-22 Alloy in Hydrobromic Acid



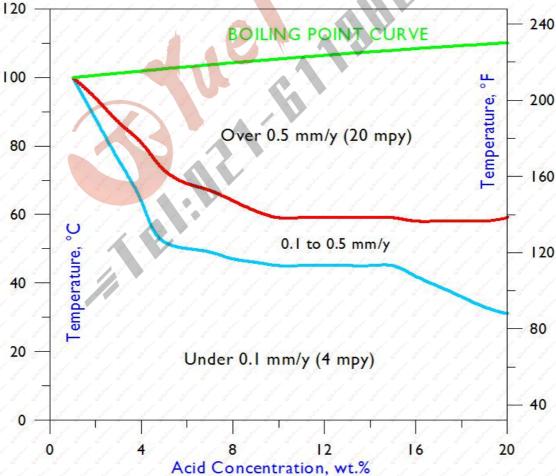
Conc.	50°F	75°F	100°F	125°F	150°F	175°F	200°F	225°F	Antiparti definanti definanti
Wt.%	10°C	24°C	38°C	52°C	66°C	79°C	93°C	107°C	Boiling
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7.5	States and States	Statement Statement	and and and a start of	and a state of the	Station States Station			Shallow Stream Station	and a set of the set o
/ /10	States of States	Statement Statement Statement	0.01	0.28	0.98	1.99	4.39	States States States	11.68
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20	Station Station Station	Station Station Station	0.2	0.32	0.9	1.72	3.38	Station Station Station	9.73

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 442-82 and 176-83.

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

Iso-Corrosion Diagram for C-22 Alloy in Hydrochloric Acid



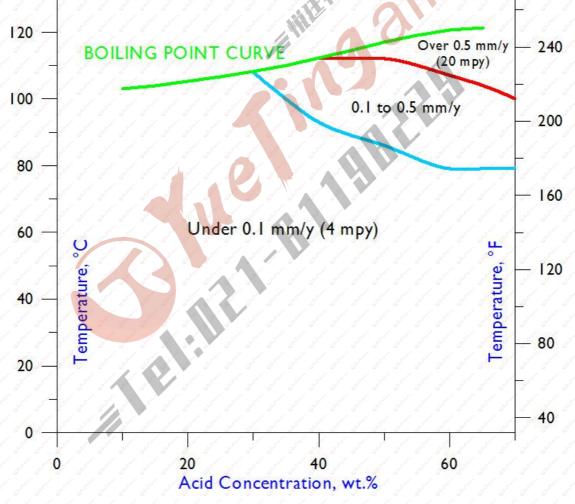
Conc.	50°F	75°F	100°F	125°F	150°F	175°F	200°F	225°F	Strand States
Wt.%	10°C	24°C	38°C	52°C	66°C	66°C 79°C		107°C	Boiling
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50 🗸	Starten Starten	States States States	Starting Starting - Starting Sta	States - States States	States States States	0.05	0.14	0.33	0.59
60	State State State	State State State	and the state of the state	Start Start Start	0.06	0.08	0.19	0.57	1.09
70	and and a start and	State State State	and and a start of	Start Start Start	0.05	0.11	0.33	0.71	2.53

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 443-82 and 47-04.

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





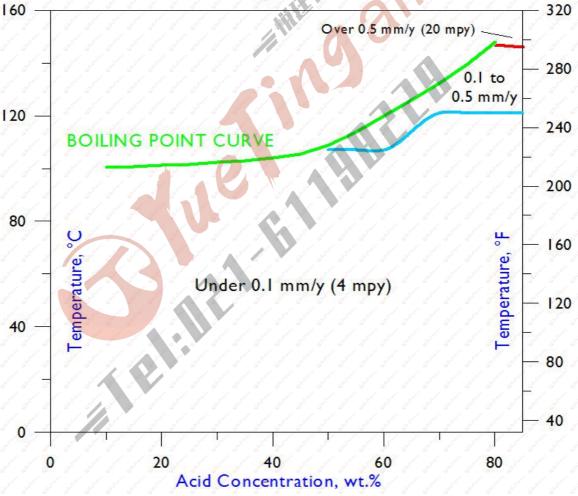
Conc.	125°F	150°F	175°F	200°F	225°F	250°F	275°F	300°F	Strand Start Start
Wt.%	52°C	66°C	79°C	93°C	107°C	121°C	135°C	149°C	Boiling
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70	Station - State Station	Station States Station	ation of the other	States - States States	0.07	0.13	Station Station Station	Station Station Station	0.23
75	States and States	States States States S	and the state of t	States - States States	0.05	0.12	States _ tales States	States States States	0.19
80	States States States	Statut Statut Statut 3	and Shall - Shall Shall	State State State	0.06	0.12	0.16	Contra Charter Charter	0.25
85	and and and and	Staff Staff Staff 3	and share share sh	Start Start Start	0.07	0.12	0.2	Staff Staff Staff	0.66

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 444-82 and 46-04.

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

Iso-Corrosion Diagram for C-22 Alloy in Phosphoric Acid



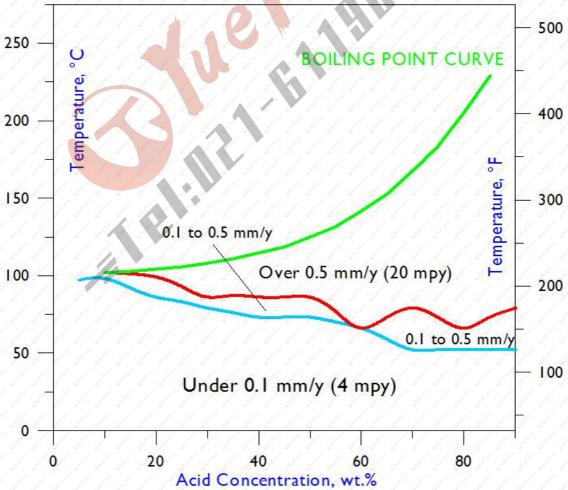
Conc.	75°F	100°F	125°F	150°F	175°F	200°F	225°F	250°F	275°F	300°F	350°F	and star star
Wt.%	24°C	38°C	52°C	66°C	79°C	93°C	107°C	121°C	135°C	149°C	177°C	Boiling
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80	State -	staffager -	0.09	Antaria - Antaria and	1.44	2.16	3.68	3.58		satisfies and satisfies	and the second	at the state of th
90	and the statement	and the second second	Tourn a test and a station	0.34	0.89	1.80	6.27	4.24	and and	the first of the first of the first	and the second second	antinent statut
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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 319-82, 445-82, and 19-14.

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

Iso-Corrosion Diagram for C-22 Alloy in Sulfuric Acid



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

and the second s	Concentration	100°F	125°F	150°F	175°F	200°F	AND STRATEGIC STRATEGICS
Chemical	wt.%	38°C	52°C	66°C	79°C	93°C	Boiling
Acetic Acid	99	International States States	Statement Statement Statement State	State of State of State	Sharana Sharana Sharana	Sharen Sharen Sharen Sh	0
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	7.5	Statute Statute State	Share Share Share Sh	Statut Statut Statut	0.01	Statut Statut Statut Statut	Start Start Start
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Hydrobromic	15	and and and a second and	0.01	< 0.01	0.88		and and the second second
Acid	20	and State State	0.01	0.46	0.8	Sen Charles Con C	and Contraction Contraction
	25	<0.01	0.2	0.29	0.58	and the second s	and and and a state of the stat
	30	0.11	0.23	0.29	0.59	second second second se	and statement statements statement
	40	0.07	0.13	0.21	0.34	and start start of	and Shalland States States
States States States States States	/ ./ ./ ./ ./ ./ .	Contraction - Statement Stated	States States States States	<u></u>	State State Area	0.01	0.06
	and share share 5 share share s	< 0.01	Jane Jane Jane	0.44		States States States States	and Shalland Station Station
Hydrochloric	7.5	Charles States States	1 1 <u>-</u> 1 1	1 . -	are are	Starting Starting Starting Starting	Start Start Start
Acid	10	0.01	0.28	0.98	Statute Statute Statute	Statute States States States	and Shall and State State
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	20	0.2	0.32	0.9		Start Start Start	an a
1 for the for the set	5	0.04	0.15	0.47	0.58	and and a second	and stand to a stand
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	20		Jane Jane Land	0.01	Station Station Station	0.02	0.06
	30	A Brand	3 ⁷⁷ 4 ⁷ - 3 ⁷ 3 ¹	0.01	States States States	0.02	0.13
Standar Standar Standar Standar Standar	40	Strange State	- 5 ⁴ - 5 ⁴ - 5 ⁴	0.02	Share Share Share	0.09	0.26
Nitric Acid	50	- ~		and and and and	Stall Stall Stall	0.14	0.59
	60		and the second sec	0.06	State State State	0.19	1.09
	65		Star Star Star St	and and an and an	Contra Co	and and an and a	and states and states
	70		and the state of t	0.05	State State State	0.33	2.53
and a second and a second as a second	50		a a a a a a a a a a a a a a a a a a a	and Station Station	Statement Statement	Sector State	0.07
	60	and States - States States	State of State State	and Statement Statement Statement	Statute States States	Sharan Sharan Sharan Sh	0.16
Phosphoric	70	Sector States - States States	Shallow Station Station Sta	Station Station Station	States States States	Statement Statement Statement State	0.23
Acid	75	and Station - Joseph Station	Share Share Share Sh	States - States	Statute States States	Station Station Station Station	0.19
	80	and States and States	Charles Charles Charles Charles	States States States	States States States	Starting Starting Starting Starting	0.25
	85	Statute Statute Statu	John John John John John	Statute Statute Statute	Statut Statut	Statute Statute Statute	0.66

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

Chamical	Concentration	100°F	125°F	150°F	175°F	200°F	and the stand of t
Chemical	wt.%	38°C	52°C	66°C	79°C	93°C	Boiling
and a start of the start of the start	10	State of State of State of State	States States States	Strate Statement Statement Statement	0.02	0.04	0.29
	20 / /	States States - States State	Statute 3 that 3 the state	0.01	0.03	0.28	0.83
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	40	Jana Jana - Jana Jan	States States States S	0.01	0.31	0.87	ATTAN CARTAN CARTAN
Sulfuric	50	State State State State	State State State State	0.02	0.4	0.77	and State and and
Acid	60	Start Start Start Start	Start Start Start 3	Stern Stern Stern Stern	0.67	0.95	and Start Start Start
	70	t st st st	and and and and a second	0.28	0.56	0.94	Star Star Star
and and a second a second a second a second a	80	antender antender antender ante	and the second s	area and a stranger and a stranger	1.44	2.16	and the second second second
	90	tertaetti Statatta	and the second second	0.34	0.89	1.8	and the second sec
	96	and a start - and a start and	and the second second	0.1		1.1	all married and the formation of the formation of the formation

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

Resistance to Pitting & Crevice Corrosion

HASTELLOY[®] C-22[®] alloy exhibits very 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-22[®] and C-276 alloys are as follows:

		g Temperature d 6% FeCl ₃	Critical Crevice Temperature in Acidified 6% FeCl ₃		
Alloy		°C	°F		
316L / / /	59	/ / 15 / /	32	/ / / 0/ / /	
254SMO	140	60	86	/ / / 30 / /	
625	212	100	104	40	
C-276	>302	>150	131	55	
C-22®	>302	>150	176	80	

Other chloride-bearing environments, notably Green Death (11.5% H₂SO₄ + 1.2% HCl + 1% FeCl₃ + 1% CuCl₂) and Yellow Death (4% NaCl + 0.1% Fe₂(SO₄)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-22[®] alloy is 120°C (considerably higher than that of C-276, i.e. boiling). In Yellow Death, C-22[®] alloy has not exhibited pitting, even at the maximum test temperature (150°C). The Critical Crevice Temperature of C-22[®] alloy in Yellow Death is 75°C (as compared with 60°C for C-276 alloy).

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-22[®], 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	/ / / / / / / / / / / / / / / / / / /
625 / / / /	No Cracking in 1,008 h
C-276	No Cracking in 1,008 h
C-22®	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-22[®] alloy is very resistant to crevice corrosion in seawater.

Index Stationer Stationer Stationer		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		
C-22®	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 allweld-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-22® alloy exhibits excellent resistance to the key, inorganic acids, even in welded form, as shown in the following table:

and all and all and all all all all all all all all all al	Concentration	Tempe	erature	and and are	Corrosion Rate					
	Stand Stand Stand Stand	and the second	States States	Weld	Metal	Wrought E	Base Metal			
Chemical	wt.%	°F	°C	mpy	mm/y	mpy 🖉	mm/y			
H ₂ SO ₄	30	150	66	0.6	0.02	0.4	0.01			
H ₂ SO ₄	50	150	66	9.3	0.24	0.8	0.02			
H ₂ SO ₄	70	150	66	10.3	0.26	11	0.28			
H ₂ SO ₄	90	150	66	18.5	0.47	13.4	0.34			
HCI	5	100	38	<0.1	< 0.01	<0.1	< 0.01			
HCI	10	100	38	<0.1	< 0.01	0.4	0.01			
HCI	15	100	38	11.1	0.28	9.4	0.24			
HCI	20	100	38	10.2	0.26	7.9	0.2			

Physical Properties

Physical Property	Briti	sh Units	Metric	: Units 📝 🖉
Density	RT / /	0.314 lb/in ³	/ _ / RT /	8.69 g/cm ³
Starting Starting Starting Starting Starting Starting Starting	/ / RT / /	44.9 µohm.in	RT	1.14 µohm.m
a and a second and a second a	200°F	48.0 µohm.in	100°C	1.23 µohm.m
and a start a s	400°F	48.8 µohm.in	200°C	1.24 µohm.m
Electrical	600°F	49.3 µohm.in	300°C	1.25 µohm.m
Resistivity	800°F	49.7 µohm.in	400°C	1.26 µohm.m
and a star and a star and a star and a star a st The start a star	1000°F	50.1 µohm.in	500°C	1.27 µohm.m
and a set of	and a set of the set o	and share and share share share share	600°C	1.28 µohm.m
a constant de la constant	100°F	69 Btu.in/h.ft ² .°F	50°C	10.1 W/m.°C
" all a share and a share all and a share all a	200°F	76 Btu.in/h.ft ² .°F	100°C	11.1 W/m.°C
"	400°F	94 Btu.in/h.ft ² .°F	200°C	13.4 W/m.°C
Thermal	600°F	110 Btu.in/h.ft ² .°F	300°C	15.5 W/m.°C
Conductivity	800°F	125 Btu.in/h.ft ² .°F	400°C	17.5 W/m.°C
and a start of the operation of the operation of the operation of the	1000°F	139 Btu.in/h.ft ² .°F	500°C	19.5 W/m.°C
and a second departed departed and a second departed and a second departed and a second depart of the second de	Sector State of the Sector State of the Sector		600°C	21.3 W/m.°C
	RT	0.004 in²/s	RT	0.027 cm ² /s
and	200°F	0.005 in²/s	100°C	0.030 cm ² /s
and and and an	400°F	0.005 in ² /s	200°C	0.035 cm ² /s
Thermal	600°F	0.006 in ² /s	300°C	0.039 cm ² /s
Diffusivity	800°F	0.007 in ² /s	400°C	0.042 cm ² /s
" Sand Sand Sand Sand Sand Sand Sand Sand	1000°F	0.007 in²/s	500°C	0.046 cm ² /s
" Sharen	States States States States		600°C	0.048 cm ² /s
and a start of the	75-200°F	6.9 µin/in.°F	24-100°C	12.4 µm/m.°C
and a start and a start and a start and a start a start a start a	75-400°F	6.9 µin/in.°F	24-200°C	12.4 µm/m.°C
Santa	75-600°F	7.0 µin/in.°F	24-300°C	12.6 µm/m.°C
and and and and and and and and and	75-800°F	7.4 µin/in.°F	24-400°C	13.1 µm/m.°C
Mean Coefficient of	75-1000°F	7.7 µin/in.°F	24-500°C	13.7 µm/m.°C
Thermal Expansion	7 <mark>5-12</mark> 00°F	8.1 µin/in.°F	24-600°C	14.3 µm/m.°C
	75-1400°F	8.5 µin/in.°F	24-700°C	14.9 µm/m.°C
" Sharen Sharen Sharen Sharen Sharen Sharen Sharen Sharen Sh	75-1600°F	8.8 µin/in.°F	24-800°C	15.5 µm/m.°C
an section statement section section statement statement section state	75-1800°F	9.0 µin/in.°F	24-900°C	15.9 µm/m.°C
Share Share Share Share Share Share Share Share	100°F	0.098 Btu/lb.°F	50°C	414 J/kg.°C
and the state of the state of the state	200°F	0.101 Btu/lb.°F	100°C	423 J/kg.°C
and a second and a second a se	400°F	0.106 Btu/lb.°F	200°C	444 J/kg.°C
Specific Heat	600°F	0.111 Btu/lb.°F	300°C	460 J/kg.°C
opcomo nout	800°F	0.114 Btu/lb.°F	400°C	476 J/kg.°C
تكملى المحلى المحلى المحلى المحلى المحلى المحلى المحلى 14 - المحلي المحلي المحلي المحلي المحلي المحلي المحلي	1000°F	0.118 Btu/lb.°F	500°C	485 J/kg.°C
and and a set a			600°C	514 J/kg.°C

RT= Room Temperature

Physical Properties Continued

Physical Property	British	n Units	Metric l	Jnits
an share share share share share share share share	RT	29.9 x 10 ⁶ psi	RT	206 GPa
	200°F	29.4 x 10 ⁶ psi	200°C	197 GPa
	400°F	28.5 x 10 ⁶ psi	300°C	191 GPa
	600°F	27.6 x 10 ⁶ psi	400°C	185 GPa
Dynamic Modulus of	800°F	26.6 x 10 ⁶ psi	500°C	179 GPa
Elasticity	1000°F	25.7 x 10 ⁶ psi	600°C	174 GPa
	1200°F	24.8 x 10 ⁶ psi	700°C	168 GPa
	1400°F	23.6 x 10 ⁶ psi	800°C	160 GPa
	1600°F	22.4 x 10 ⁶ psi	900°C	152 GPa
	1800°F	21.1 x 10 ⁶ psi	1000°C	144 GPa
Melting Range	2475-2550°F	State State State	1357-1399°C	and Station Station Station Station Station

RT= Room Temperature

Impact Strength

These impact strengths (averages from several tests) were generated using Charpy V-notch samples, machined from plates of thickness 10 mm and 25.4 mm.

Plate Th	ickness	Test Tem	perature	Impact Strength	Number of Tests
/in/	/ mm /		°C	ft.lbf J	and share share share share share share
0.394	/ /10 /	/ _ RT / _	RT	340 461	3° 3° 3° 3° 3° 36 3° 3° 3°
0.394	/ 10 /	-320	-196	418 567	5° 5° 5° 6° 5° 5° 5°
star 1 star	25.4	RT	RT	345 468	d d d d d d 9 d d d
, ³⁴ , 1 , ³⁴ ,	25.4	-320 🍐	-196	421 571	6

RT= Room Temperature

Те	Te Tempe		Thickness/ Bar Diameter		0.2% Offset Yield Strength		Ultimate Tensile Strength		Elongation
Form	°F	°C	in /	mm	ksi	MPa	ksi	MPa	%
Sheet	RT	RT	0.028-0.125	0.7-3.2	59	407	116	800	57
Sheet	200	93	0.028-0.125	0.7-3.2	54	372	110	758	58
Sheet	400	204	0.028-0.125	0.7-3.2	44	303	102	703	57
Sheet	600	316	0.028-0.125	0.7-3.2	42	286	98	676	62
Sheet	800	427	0.028-0.125	0.7-3.2	41	283	95	655	67
Sheet	1000	538	0.028-0.125	0.7-3.2	40	276	91	627	61 /
Sheet	1200	649	0.028-0.125	0.7-3.2	36	248	85	586	65
Sheet	1400	760	0.028-0.125	0.7-3.2	35	241	76	524	63
Plate	RT	RT	0.25-0.75	6.4-19.1	54	372	114	786	62
Plate	200	93	0.25-0.75	6.4-19.1	49	338	107	738	65
Plate	400	204	0.25-0.75	6.4-19.1	41	283	98	676	66
Plate	600	316	0.25-0.75	6.4-19.1	36	248	95	655	68
Plate	800	427	0.25-0.75	6.4-19.1	35	241	92	634	68
Plate	1000	538	0.25-0.75	6.4-19.1	34	234	88	607	67
Plate	1200	649	0.25-0.75	6.4-19.1	32	221	83	572	69
Plate	1400	760	0.25-0.75	6.4-19.1	31	214	76	524	68
Bar	RT	RT	0.5-2.0	12.7-50.8	52	359	111	765	70
Bar	200	93	0.5-2.0	12.7-50.8	45	310	105	724	73
Bar	400	204	0.5-2.0	12.7-50.8	38	262	96	662	74
Bar	600	316	0.5-2.0	12.7-50.8	34	234	92	634	79
Bar	800	427	0.5-2.0	12.7-50.8	31	214	89	614	/ 79/ /
Bar	1000	538	0.5-2.0	12.7-50.8	29	200	84	579	80
Bar	1200	649	0.5-2.0	12.7-50.8	28	193	80	552	80
Bar	1400	760	0.5-2.0	12.7-50.8	29	200	72	496	77

Tensile Strength & Elongation

Values are averages from numerous tests

RT= Room Temperature

Hardness

The room temperature hardnesses of HASTELLOY® C-22® sheets and plates are approximately 93 HRB and 95 HRB, respectively. The values are averages from numerous tests.

Welding & Fabrication

HASTELLOY[®] C-22[®] 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 our "Welding and Fabrication" brochure.

Wrought products of HASTELLOY® C-22® 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-22® 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-22® alloy are given in our "Welding and Fabrication" brochure.

HASTELLOY® C-22® 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 our "Welding and Fabricaiton" 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-22® alloy work hardens more readily than most austenitic stainless steels, with intermediate anneals.

While cold work does not usually affect the resistance of HASTELLOY® C-22® 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 & Codes

	.OY[®] C-22[®] alloy 22, W86022)
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-10) DIN 2.4638 (EL-NiCr21Mo14W) F= 43
Bare Welding Rods & Wire	SFA 5.14/ A 5.14 (ERNiCrMo-10) DIN 2.4635 (SG- NiCr21Mo14W) 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. 2.4602 NiCr21Mo14W
τüv	Werkstoffblatt 479 Kennblatt 4635 Kennblatt 4636 Kennblatt 4534
Others	NACE MR0175 ISO 15156 ASME Code Case No. 2226-2 Case No. N-621-1

ST ST ST	HASTELI	odes OY® C-22®			
Start Start Start	(NU60	22, W86022	/		
	State State State State State .	1250°F (677°C) ¹			
	Section I	Code Case 2226			
	and and and and and a set of the	125	0°F (677°C)		
	Statut Statut Statut Statut Statut .		800°F (427°C) ¹		
	Starten Starten Starten Starten i	Class 1	Code Case N-		
	Section III	learner Charlen Charlen Charles	621-1		
	Starting Starting Starting Starting Starting	Class 2	1250°F (677°C) ²		
	State State State State State	Class 3	1250°F (677°C) ²		
	Section VIII	Div. 1	1250°F (677°C) ¹		
ASME			800°F (427°C) ³		
		Div. 2	1250°F (677°C) ¹		
			800°F (427°C) ³		
	Section XII	650	650°F (343°C)⁴		
	B16.5	1250°F (677°C)⁵			
	B16.34		1250°F (677°C)6		
	B31.1	800°F (427°C)7			
	B31.3	800°F (427°C) ⁸			
VdTÜV (doc #)		844	°F (450°C) ⁹ , #479		

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

⁴Approved material forms: Plate, Sheet, Bar, fittings, welded pipe/tube, seamless pipe/tube, Bolting ⁵Approved material forms: Plate, Forgings, fittings, Bolting

⁶Approved material forms: Plate, Bar, Forgings, seamless pip/tube, Bolting

⁷Approved material forms: Plate, Sheet, fittings, welded pipe/tube, seamless pipe/tube ⁸Approved material forms: Plate, Sheet, Forgings, fittings, welded pipe/tube, seamless pipe/tube ⁹Approved material forms: Plate, Sheet, Bar, Forgings

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