Technical Datasheet

CarTech® C-276 Alloy

Identification

UNS Number

• N10276

Type Analysis

Single figures are nominal except where noted.

Carbon (Maximum)	0.02 %	**Manganese (Maximum)**	1.00 %
Phosphorus (Maximum)	0.030 %	**Sulfur (Maximum)**	0.030 %
Silicon (Maximum)	0.08 %	**Chromium**	14.50 to 16.50 %
Nickel	Balance	**Molybdenum**	15.00 to 17.00 %
Cobalt (Maximum)	2.50 %	**Vanadium (Maximum)**	0.35 %
Tungsten	3.00 to 4.50 %	**Iron**	4.00 to 7.00 %

General Information

Description

CarTech C-276 alloy is a nickel-molybdenum-chromium-tungsten alloy with excellent general corrosion resistance and good fabricability. The alloy should be considered for use in environments where resistance to hot contaminated mineral acids, organic and inorganic chloride-contaminated media, chlorine, formic and acetic acids, acetic anhydride, sea water and brine solutions is desired.

CarTech C-276 alloy has resisted the formation of grain boundary precipitates in the weld heat-affected zone, making it a candidate for most chemical and petrochemical processing applications in the as-welded condition. The alloy has resisted both general and localized corrosion, including pitting, crevice corrosion, and stress corrosion cracking.

CarTech C-276 alloy is readily fabricated by welding, using methods similar to those utilized for nickel-based alloys.

Corrosion Resistance

Carpenter Alloy C-276 is balanced to provide excellent corrosion resistance to a variety of chemical process environments. This alloy has provided resistance to hot contaminated mineral acids, organic and inorganic chloride contaminated media, hypochlorite, chlorine dioxide solutions, formic and acetic acids, acetic anhydride, sea water and brine solutions.

Corrosion rates shown in the hyperlink entitled "Typical General Corrosion Rates" are for annealed material and may be affected by variables such as aeration, corrosive impurities, velocity, heat transfer, crevices or deposits.

Isocorrosion diagrams shown in the hyperlinks entitled "Resistance to Sulfuric Acid" and "Resistance to Phosphoric Acid" demonstrate typical resistance to general corrosion. Such diagrams do not address other forms of attack, such as localized corrosion or velocity effects.

Localized Corrosion

Carpenter Alloy C-276 has excellent resistance to general, pitting, stress-corrosion cracking and crevice attack, and is balanced to maintain corrosion resistance in the weld heat-affected zone.

Accelerated tests assess the intergranular corrosion resistance of Carpenter Alloy C-276 in as little as 24 hours.

Mixed Acid-Oxidating Salt Test (ASTM G28, Method B)

This test is specially designed for corrosion-resistant materials such as Carpenter Alloy C-276, and is the preferred method of evaluation. Samples are immersed for 24 hours in a mixture of 23% H_2SO_4 + 1% $FeCl_3$ + 1.2% HCl + 1% $CuCl_2$. Carpenter Alloy C-276 is capable of passing with a corrosion rate of 300 mils per year (mpy) or 0.025 inch per month (ipm).

Ferric-Sulfuric Acid Test (ASTM G28, Method A)

Samples are immersed for 24 hours in boiling ferric sulfate - 50% sulfuric acid. The maximum acceptable corrosion rate for Carpenter Alloy C-276 in this test is 480 mils per year (mpy) or 0.04 inch per month (ipm).

Stress Corrosion Cracking Resistance

The high nickel content of Carpenter Alloy C-276 has provided excellent resistance to stress-corrosion cracking. This is demonstrated by its resistance to the boiling magnesium chloride test of ASTM G36.

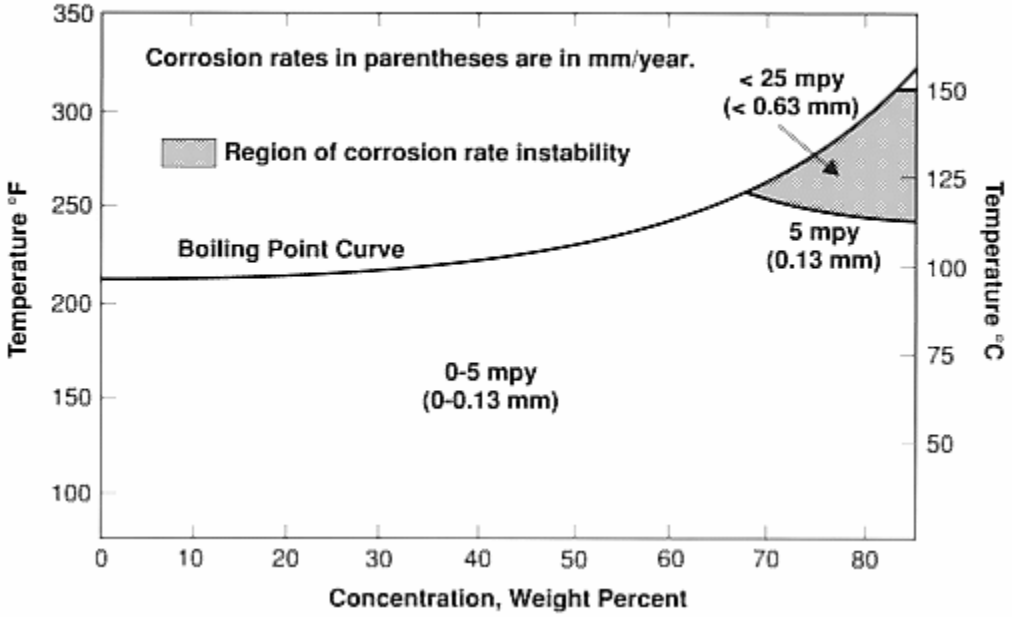
Pitting Resistance

Carpenter Alloy C-276 has demonstrated excellent resistance to pitting and crevice corrosion in the ferric chloride test of ASTM G48. This excellent resistance has also been shown in the chemical process industry, as well as flue gas desulfurization and pulp/paper applications.

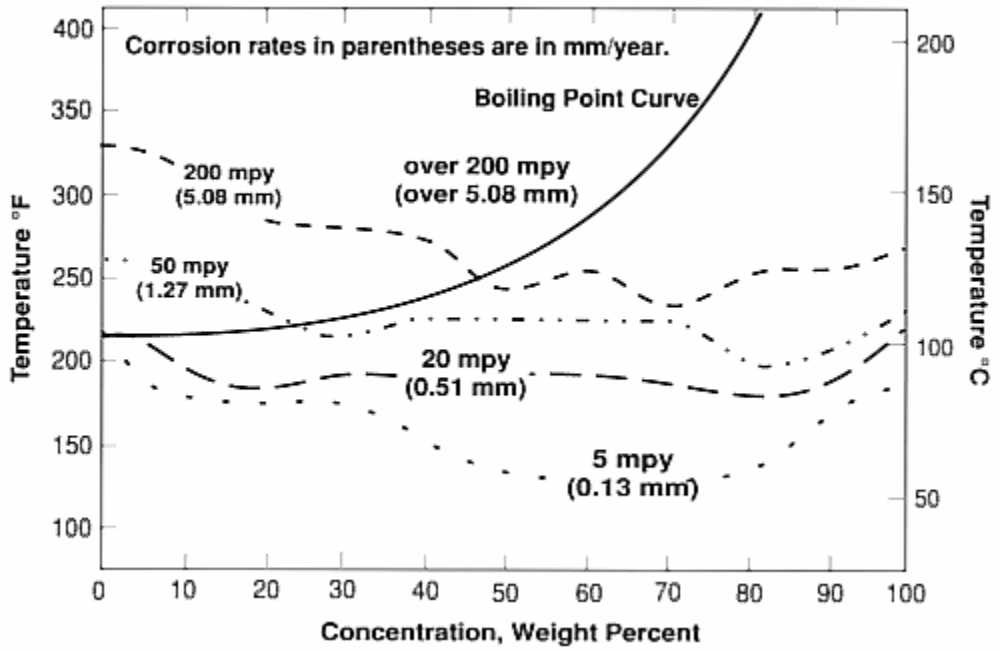
Important Note: *The following 4-level rating scale is intended for comparative purposes only. Corrosion testing is recommended; factors which affect corrosion resistance include temperature, concentration, pH, impurities, aeration, velocity, crevices, deposits, metallurgical condition, stress, surface finish and dissimilar metal contact.*

Nitric Acid	Good	Sulfuric Acid	Excellent
Phosphoric Acid	Excellent	Acetic Acid	Excellent
Sodium Hydroxide	Excellent	Salt Spray (NaCl)	Excellent
Sea Water	Excellent	Sour Oil/Gas	Excellent
Humidity	Excellent		

Resistance to Phosphoric Acid—Carpenter Alloy C-276



Resistance to Sulfuric Acid—Carpenter Alloy C-276



Typical General Corrosion Rates*—Carpenter Alloy C-276

Environment	Concentration (% by weight)	Test Temperature		Penetration Rate (per year)					
				Unwelded**		As-welded***		Welded and heat-treated**	
		°F	°C	mils	mm	mils	mm	mils	mm
Formic Acid	20	Boiling		4.8	0.12	3.5	0.09	3.60	0.09
Hydrochloric Acid	10	150	66	21.	0.53	20.	0.51	21.	0.53
Hydrochloric Acid	10	167	75	40.	1.02	50.	1.27	—	—
Hydrochloric Acid	10+0.5 NaOCl	167	75	46.	1.17	50.	1.27	—	—
Hydrochloric Acid	3.5+8 Fe Cl_3	190	88	—	—	5.	0.13	—	—
Sulfuric Acid	10	Boiling		15.	0.38	14.	0.36	18.	0.46
Sulfuric Acid	85	167	75	17.	0.43	17.	0.43	—	—

* Determined in laboratory tests. It is recommended that samples be tested under actual plant conditions.
** Solution heat-treated.
*** Gas tungsten-arc welded.

Properties

Physical Properties

Density	0.3210	lb/in³
Mean Specific Heat	0.1020	Btu/lb/°F
Mean CTE		
75 to 200°F	6.20	x 10 $^{-6}$ in/in/°F
75 to 400°F	6.70	x 10 $^{-6}$ in/in/°F
75 to 600°F	7.10	x 10 $^{-6}$ in/in/°F
75 to 800°F	7.30	x 10 $^{-6}$ in/in/°F
75 to 1000°F	7.40	x 10 $^{-6}$ in/in/°F
75 to 1200°F	7.80	x 10 $^{-6}$ in/in/°F
75 to 1400°F	8.30	x 10 $^{-6}$ in/in/°F
75 to 1600°F	8.80	x 10 $^{-6}$ in/in/°F
75 to 1700°F	8.90	x 10 $^{-6}$ in/in/°F

Mean coefficient of thermal expansion

Test Temperature		10^{-6}/°F	10^{-6}/K
75°F to	24°C to		
200	93	6.2	11.2
400	204	6.7	12.0
600	316	7.1	12.8
800	427	7.3	13.2
1000	538	7.4	13.4
1200	649	7.8	14.1
1400	760	8.3	14.9
1600	871	8.8	15.9
1700	927	8.9	16.0

Thermal Conductivity

-270°F	50.00	BTU-in/hr/ft²/°F
-100°F	60.00	BTU-in/hr/ft²/°F
0°F	65.00	BTU-in/hr/ft²/°F
100°F	71.00	BTU-in/hr/ft²/°F
200°F	77.00	BTU-in/hr/ft²/°F
400°F	90.00	BTU-in/hr/ft²/°F
600°F	104.0	BTU-in/hr/ft²/°F
800°F	117.0	BTU-in/hr/ft²/°F
1000°F	132.0	BTU-in/hr/ft²/°F
1200°F	145.0	BTU-in/hr/ft²/°F
1400°F	159.0	BTU-in/hr/ft²/°F
1600°F	173.0	BTU-in/hr/ft²/°F
1800°F	185.0	BTU-in/hr/ft²/°F
2000°F	195.0	BTU-in/hr/ft²/°F

Thermal conductivity

Test Temperature		Btu-in/ft²•h•°F	W/m•K
°F	°C		
-270	-168	50	7.2
-100	-73	60	8.6
0	-18	65	9.4
100	38	71	10.2
200	93	77	11.1
400	204	90	13.0
600	316	104	15.0
800	427	117	16.9
1000	538	132	19.0
1200	649	145	20.9
1400	760	159	22.9
1600	871	173	24.9
1800	982	185	26.7
2000	1093	195	28.1

Modulus of Elasticity (E) (75°F)	29.8	x 10^{3} ksi
Electrical Resistivity (75°F)	782.2	ohm-cir-mil/ft
Melting Range	2420 to 2500	°F

Typical Mechanical Properties

Typical Room Temperature Tensile Properties—Carpenter Alloy C-276
Tested bars solution treated and water quenched.

Condition	0.2% Yield Strength		Ultimate Tensile Strength		% Elongation in 4D	% Reduction of Area
	ksi	MPa	ksi	MPa		
Typical	55	379	110	758	60	70
ASTM B574 (min)	41	283	100	690	40	—

Heat Treatment

Annealing

To anneal (solution treatment) Carpenter Alloy C-276, heat to 2050/2100°F (1121/1149°C) for 1 hour per inch of thickness and water quench.

Stress relief heat treatments are not effective and a full anneal should be used.

Hardening

Carpenter Alloy C-276 cannot be hardened by heat treatment. It can only be hardened by cold working.

Workability

Hot Working

For forging, heat uniformly to 2200°F (1204°C). The best corrosion resistance is obtained if the forgings are given a final anneal.

Machinability

Carpenter Alloy C-276 can be machined with conventional techniques. Tungsten carbide-tipped tools are suggested with the tools engaged in the cut at all times.

Weldability

Gas tungsten-arc welding, gas metal-arc welding, shielded metal-arc (coated electrode) welding, or resistance welding may be used. Minimum heat input consistent with adequate penetration reduces the chance of hot-cracking. Oxyacetylene welding should be avoided due to possibility of carburization.

Carpenter Alloy C-276 can be used in the as-welded condition in most chemical and petrochemical process equipment.

Other Information

Descaling (Cleaning)

A clean surface is required to obtain optimum corrosion resistance. High temperature oxide may be removed with a molten salt pre-treatment followed by a water quench and subsequent immersion in hydrochloric acid and finally nitric-hydrofluoric acid. Thorough rinsing is used between each acid treatment and at completion.

Applicable Specifications

- ASME SB574
- ASME SB575
- ASTM B574
- ASTM B575

Forms Manufactured

- Bar-Rounds
- Strip
- Weld Wire
- Wire
- Wire-Rod

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