Technical Datasheet

CarTech® 410 Stainless

Identification

UNS Number

- S41000

Type Analysis

Single figures are nominal except where noted.

Carbon (Maximum)	0.15 %	**Manganese (Maximum)**	1.00 %
Phosphorus (Maximum)	0.040 %	**Sulfur (Maximum)**	0.030 %
Silicon (Maximum)	1.00 %	**Chromium**	11.50 to 13.50 %
Iron	Balance		

General Information

Description

CarTech 410 stainless, the basic hardenable martensitic stainless steel, is suitable for highly stressed parts where corrosion resistance, good strength and ductility are needed.

This alloy can be used up to 1200ºF (649ºC) where resistance to scaling and oxidation is required. It has been used for steam turbine buckets, blades, bucket covers, gas turbine compressor blades, nuclear reactor control rod mechanisms, valves, fasteners, shafting, pump parts, petrochemical equipment and machine parts.

Scaling

The safe scaling temperature for continuous service is 1200ºF (649ºC).

Corrosion Resistance

Carpenter Stainless Type 410, in both the annealed and heat-treated conditions, provides good corrosion resistance to mild atmospheres. It resists corrosion in many light industrial and domestic environments as well as potable and mine waters.

The alloy has acceptable resistance to sulfide stress cracking at Rockwell C 22 maximum hardness per NACE MR-01-75, "Sulfide-Stress-Cracking-Resistant Metallic Materials for Oil Field Equipment." Refer to the current document for details on acceptable conditions.

For optimum corrosion resistance, surfaces must be free of scale, lubricants, foreign particles, and coatings applied for drawing and heading. After fabrication of parts, cleaning and/or passivation should be considered.

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	Moderate	Sulfuric Acid	Restricted
Phosphoric Acid	Restricted	Acetic Acid	Restricted
Sodium Hydroxide	Moderate	Salt Spray (NaCl)	Moderate
Sour Oil/Gas	Restricted	Humidity	Moderate

Properties

Physical Properties

Specific Gravity	7.75	
Density	0.2800	lb/in³
Mean Specific Heat (32 to 212°F)	0.1100	Btu/lb/°F

Mean CTE (32 to 1200°F)	6.50	x 10^{-6} in/in/°F
Thermal Conductivity (212°F)	173.0	BTU-in/hr/ft²/°F
Modulus of Elasticity (E)	29.0	x 10^{3} ksi
Electrical Resistivity (70°F)	343.0	ohm-cir-mil/ft

Typical Mechanical Properties

Typical Creep and Stress Rupture Strength

Hardened 1800°F (982°C), oil quench, tempered 1200°F (649°C), one hour

Test Temperature		Stress for Rupture in						Stress for 1% Creep in 10,000 Hours	
		100 Hours		1000 Hours		10,000 Hours			
°F	°C	ksi	MPa	ksi	MPa	ksi	MPa	ksi	MPa
800	427	62	427	56	386	48	331	34	234
900	482	46	317	38	262	32	221	18	124
1000	538	30	207	23	159	17	117	9	62
1100	593	16	110	13	90	10	69	5	34

Typical Creep and Stress Rupture Strength

Annealed condition

Test Temperature		Stress for Rupture in						Stress for 1% Creep in 10,000 Hours	
		100 Hours		1000 Hours		10,000 Hours			
°F	°C	ksi	MPa	ksi	MPa	ksi	MPa	ksi	MPa
800	427	60	414	55	379	52	359	—	—
900	482	47	324	40	276	33	228	—	—
1000	538	32	221	26	179	20	138	9	62
1100	593	17	117	11	76	7	48	4	27
1200	649	8	55	6	41	—	—	2	14

Typical Elevated Temperature Mechanical Properties

Hardened 1750°F (954°C), tempered one hour 50°F (28°C) above test temperature

Test Temperature		0.2% Yield Strength		Ultimate Tensile Strength		% Elongation in 2" (50.8 mm)	% Reduction of Area	Room Temp. Rockwell C Hardness After Test	Brinell Hot Hardness
°F	°C	ksi	MPa	ksi	MPa				
Room		154	1062	212	1462	17	62	45	431
400	204	171	1179	210	1448	14	41	43½	401
600	316	163	1124	208	1434	18	51	43	385
800	427	155	1069	196	1351	17	53	43	370
900	482	140	965	174	1200	15	53	43½	353
1000	538	75	517	79	545	24	79	31	191
1100	593	46	317	50	345	30	88	24	127
1200	649	28	193	32	221	39	92	19	81

Typical Elevated Temperature Tensile Properties

Annealed condition

Test Temperature		0.2% Yield Strength		Ultimate Tensile Strength		% Elongation in 2" (50.8 mm)	% Reduction of Area
°F	°C	ksi	MPa	ksi	MPa		
70	21	40	276	75	517	35	70
900	482	35	241	48	331	31	76
1000	538	31	214	41	283	36	79
1100	593	25	172	33	228	41	84
1200	649	18	124	23	159	47	90
1300	704	12	83	16	110	55	94
1400	760	8	55	11	76	66	96

Typical Elevated Temperature Tensile Properties
¾" (19.05 mm) round bar, hardened 1800°F (982°C), oil quench, tempered 1125°F (607°C), one hour

Test Temperature		0.2% Yield Strength		Ultimate Tensile Strength		% Elongation in 2" (50.8 mm)	% Reduction of Area	Room Temp. Brinell Hardness After Test
°F	°C	ksi	MPa	ksi	MPa			
Room		104	717	123	848	21	69	241
800	427	82	565	95	655	17	70	248
900	482	77	531	85	586	19	72	248
1000	538	65	448	71	490	22	80	248

Typical Elevated Temperature Tensile Properties
¾" (19.05 mm) round bar, hardened 1800°F (982°C), oil quench, tempered 1200°F (649°C), one hour

Test Temperature		0.2% Yield Strength		Ultimate Tensile Strength		% Elongation in 2" (50.8 mm)	% Reduction of Area	Room Temp. Brinell Hardness After Test
°F	°C	ksi	MPa	ksi	MPa			
Room		90	621	109	752	22	68	217
800	427	71	490	84	579	17	63	217
900	482	67	462	75	517	20	71	217
1000	538	55	379	62	427	20	79	217
1100	593	46	317	52	359	32	86	217

Typical Room Temperature Mechanical Properties
Bar, hardened 1850°F (1010°C) 30 minutes, oil quench, tempered 4 hours

Tempering Temperature		0.2% Yield Strength		Ultimate Tensile Strength		% Elongation in 2" (50.8 mm)	% Reduction of Area	Charpy V-Notch Impact Strength		Hardness	
°F	°C	ksi	MPa	ksi	MPa			ft-lb	J	Rockwell C	Brinell
500	260	158	1089	193	1331	17	62	56	76	43	401
700	371	155	1069	188	1296	17	60	49	66	43	401
900	482	147	1014	189	1303	18	58	28	38	42	401
1000	538	133	917	140	965	19	62	24	33	30	285
1100	593	105	724	120	827	20	63	38	52	24	248
1200	649	92	634	106	731	21	65	88	119	20	223

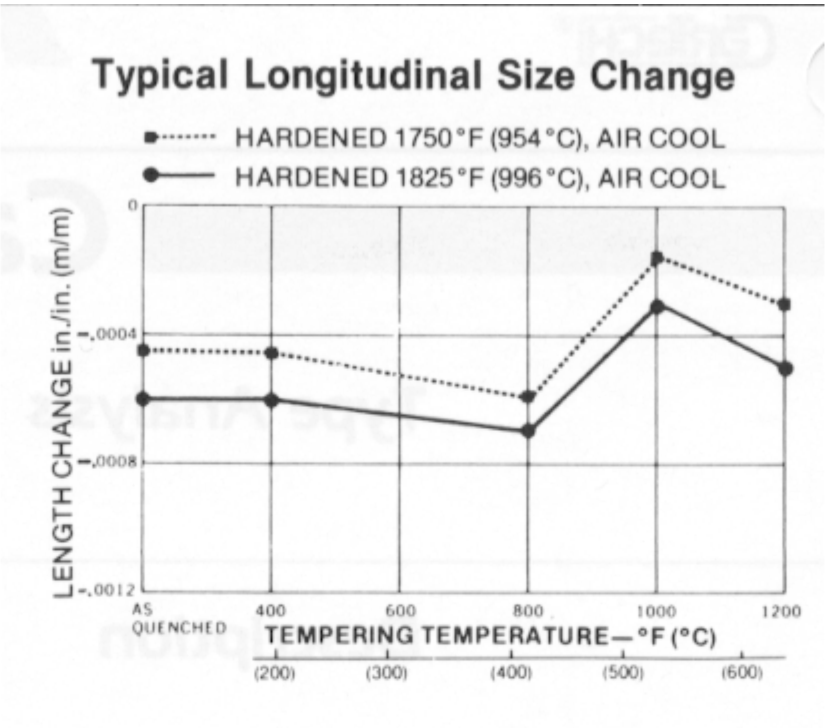
Heat Treatment

Annealing

Heat uniformly to 1200/1400ºF (649/760ºC)-remove charge from furnace and cool in air. Brinell hardness approximately 187. For cleaner cutting in broaching, threading, and other machining operations, it is sometimes desirable to lower the annealing temperature to obtain somewhat higher hardness. For maximum softness, heat to temperatures of 1500/1650ºF (816/899ºC) and cool slowly in the furnace. Brinell hardness approximately 155.

Hardening

Heat to 1750/1850ºF (954/1010ºC), soak at heat, quench in oil. The steel will also harden by cooling in air.



Tempering

Temper to secure hardness and mechanical properties desired. Soak at heat at least one hour, and longer for large pieces-cool in air.

Tempering this alloy in the range of 750/1050ºF (399/566ºC) results in decreased impact strength and also reduced corrosion resistance (the nature and extent of which vary with the media involved). However, tempering in this range is sometimes necessary to obtain the strength and ductility properties required. In many applications and environments, the reduced impact strength is not necessarily detrimental, and the corrosion resistance is only mildly reduced or even unaffected.

Workability

Hot Working

This steel can be readily forged, headed, riveted and upset. It is harder when hot than mild steel and consequently requires more blows or a heavier hammer. Heat uniformly to 2000/2200ºF (1093/1204ºC); then forge and cool in air. Cool large forgings in dry lime or furnace. Trim hot or else anneal and trim cold. Do not forge below 1650ºF (899ºC).

Cold Working

In the annealed condition, Carpenter Stainless Type 410 can be blanked, drawn, formed, and cold headed.

Machinability

Carpenter Stainless Type 410 in the dead soft condition is tough and draggy and the chips tend to build up on the tool. Better finishes are obtained in the cold-drawn or heat-treated condition. Where higher mechanical properties are required, it can be machined at hardnesses up to Rockwell C 35.

Following are typical feeds and speeds for Carpenter Stainless Type 410.

Turning—Single-Point and Box Tools

Depth of Cut (Inches)	High Speed Tools			Carbide Tools (Inserts)			
	Tool Material	Speed (fpm)	Feed (ipr)	Tool Material	Speed (fpm)		Feed (ipr)
					Uncoated	Coated	
.150	M2	100	.015	C6	450	600	.015
.025	M3	125	.007	C7	550	750	.007

Turning—Cut-Off and Form Tools

Tool Material		Speed (fpm)	Feed (ipr)						
High Speed Tools	Carbide Tools		Cut-Off Tool Width (inches)				Form Tool Width (inches)		
			1/16	1/8	1/4	1/2	1	1 ½	2
M2		90	.001	.001	.002	.0015	.001	.001	.001
	C6	325	.004	.0055	.007	.005	.004	.0035	.0035

Rough Reaming

High Speed		Carbide Tools		Feed (ipr) Reamer Diameter (inches)					
Tool Material	Speed (fpm)	Tool Material	Speed (fpm)	1/8	1/4	1/2	1	1 ½	2
M7	90	C2	110	.003	.006	.010	.014	.018	.022

Drilling

High Speed Tools									
Tool Material	Speed (fpm)	Feed (inches per revolution) Nominal Hole Diameter (inches)							
		1/16	1/8	1/4	1/2	3/4	1	1 ½	2
M7, M10	60-70	.001	.003	.006	.010	.013	.016	.021	.025

Die Threading

FPM for High Speed Tools				
Tool Material	7 or less, tpi	8 to 15, tpi	16 to 24, tpi	25 and up, tpi
M1, M2, M7, M10	5-15	10-25	20-35	25-40

Milling, End-Peripheral

Depth of Cut (inches)	High Speed Tools						Carbide Tools					
	Tool Material	Speed (fpm)	Feed (ipt) Cutter Diameter (in)				Tool Material	Speed (fpm)	Feed (ipt) Cutter Diameter (in)			
			1/4	1/2	3/4	1-2			1/4	1/2	3/4	1-2
.050	M2, M7	110	.001	.002	.003	.004	C6	345	.001	.002	.004	.006

Tapping

High Speed Tools	
Tool Material	Speed (fpm)
M1, M7, M10	15-40

Broaching

High Speed Tools		
Tool Material	Speed (fpm)	Chip Load (ipt)
M2, M7	20	.004

Additional Machinability Notes

When using carbide tools, surface speed feet/minute (sfpm) can be increased between 2 and 3 times over the high-speed suggestions. Feeds can be increased between 50 and 100%.

Figures used for all metal removal operations covered are average. On certain work, the nature of the part may require adjustment of speeds and feeds. Each job has to be developed for best production results with optimum tool life. Speeds or feeds should be increased or decreased in small steps.

Weldability

Carpenter Stainless Type 410 can be satisfactorily welded. When a filler metal is needed, consider one with a similar composition, such as AWS E/ER 410.

Parts should be preheated to at least 350/400ºF (177/204ºC) before welding to prevent cracking, particularly in heavy or intricate sections. Since Carpenter Stainless Type 410 is air-hardening, it should be annealed immediately after welding to make the sections uniformly ductile.

Other Information

Applicable Specifications

- AMS 5613
- ASTM A276
- ASTM A479
- ASTM A493
- ASTM A580
- ASTM F899
- QQ-S-763

Forms Manufactured

- Bar-Flats
- Bar-Rounds
- Bar-Squares
- Billet
- Strip
- Wire
- Wire-Rod

Technical Articles

- A Designer's Manual On Specialty Alloys For Critical Automotive Components
- Alloy Selection for Cold Forming (Part I)
- Alloy Selection for Cold Forming (Part II)
- Blade Alloys 101: What You Need to Know About the Alloys Used for Knife Blades
- How to Passivate Stainless Steel Parts
- How to Select the Right Stainless Steel or High Temperature Alloy for Heading
- New Ideas for Machining Austenitic Stainless Steels
- New Stainless for Fasteners Combines Corrosion Resistance, High Hardness and Cold Formability
- New Torrington Airframe Control Bearings Offer Improved Corrosion Resistance and Longer Dynamic Life
- One of the Word's Most Powerful Revolvers Gets Lift From Aerospace Alloys
- Passivating and Electropolishing Stainless Steel Parts
- Selecting Stainless Steels for Valves
- Unique Properties Required of Alloys for the Medical and Dental Products Industry

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