Technical Datasheet CARPENTER TECHNOLOGY

CarTech® 440C Stainless

Identification

UNS Number

- S44004

Type Analysis

Single figures are nominal except where noted.

Carbon	0.95 to 1.20 %	**Manganese (Maximum)**	1.00 %
Phosphorus (Maximum)	0.040 %	**Sulfur (Maximum)**	0.030 %
Silicon (Maximum)	1.00 %	**Chromium**	16.00 to 18.00 %
Molybdenum (Maximum)	0.75 %	**Iron**	Balance

General Information

Description

CarTech 440C stainless is a high-carbon chromium steel designed to provide stainless properties with maximum hardness. It has been used primarily as a bearing steel, and is used in the hardened plus tempered condition. When heat-treated, CarTech 440C stainless attains the highest hardness of any stainless steel (about Rockwell C 60).

Applications

This stainless steel principally has been used in bearing assemblies, including bearing balls and races. In addition, it should be considered for cutlery, needle valves, ball check valves, valve seats, pump parts, ball studs, bushings, and wear-resistant textile components.

Elevated Temperature Use

Carpenter Stainless Type 440C is not usually recommended for elevated temperature applications since corrosion resistance is reduced when used in the annealed condition or hardened and tempered above about 800ºF (427ºC).

Corrosion Resistance

Carpenter Stainless Type 440C resists corrosion in normal domestic environments and very mild industrial environments, including many petroleum products and organic materials.

This grade is used in the hardened plus tempered condition. Optimum corrosion resistance is obtained by hardening from 2000ºF (1093ºC) to ensure better carbide solution.

However, care should be taken to minimize time at 2000ºF (1093ºC) to avoid excessive grain coarsening. For best corrosion resistance, the tempering temperature should be below about 800ºF (427ºC).

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)	Restricted
Humidity	Good		

Properties

Physical Properties

Specific Gravity	7.62	
Density	0.2750	lb/in³
Mean Specific Heat (32 to 212°F)	0.1100	Btu/lb/°F
Mean CTE (32 to 212°F)	5.60	x 10 $^{-6}$ in/in/°F
Thermal Conductivity (212°F)	168.0	BTU-in/hr/ft²/°F
Modulus of Elasticity (E)	29.0	x 10 ^{3} ksi
Electrical Resistivity (70°F)	361.0	ohm-cir-mil/ft

Typical Mechanical Properties

Typical Room Temperature Mechanical Properties
Hardened 1900°F (1038°C), oil quench, tempered 600°F (316°C)

0.2% Yield Strength		Ultimate Tensile Strength		% Elongation in 2" (50.8mm)	% Reduction of Area	Brinell Hardness
ksi	MPa	ksi	MPa			
275	1896	285	1965	2	10	580

Heat Treatment

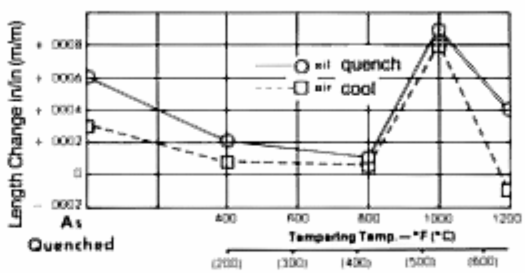
Annealing

For maximum softness, this steel should be heated uniformly to 1550/1600ºF (843/871ºC). Soak and cool very slowly in the furnace. Brinell hardness approximately 223. Intermediate or process annealing treatment-heat uniformly to 1350/1400ºF (732/760ºC). Air cool. Brinell hardness about 255.

Hardening

Heat to 1850/1950ºF (1010/1066ºC); soak; quench in warm oil or cool in air. Do not overheat. When overheated, full hardness cannot be obtained. See comments under corrosion resistance.

Typical Longitudinal Size Change
After hardening 1900°C (1038°C) and tempering one hour



Tempering

Hardness of approximately Rockwell C 60 will be obtained. To remove peak stresses and yet retain maximum hardness, temper at least one hour at 300/350ºF (149/177ºC).

Typical Hardness
1" (25.4 mm) round, hardened 1900°F (1038°C), oil quench, and tempered one hour

Tempering Temperature		Rockwell C Hardness
°F	°C	
300	149	60
400	204	59
500	260	57
600	316	56
700	371	56
800	427	56

For maximum corrosion resistance, do not temper above 800°F (427°C).

Workability

Hot Working

This steel should be handled like high-speed tool steel. Preheat to 1400/1500ºF (760/816ºC), then heat slowly and uniformly to 1900/2100ºF (1038/1149ºC). Do not forge below 1700ºF (927ºC), and reheat as often as necessary. Cool in a furnace if possible or in warm dry lime or ashes. Anneal after forging; cool to room temperature before annealing.

Cold Working

If annealed for maximum softness, this steel can be moderately cold formed or headed.

Machinability

For most machining operations, this steel cuts best when in the dead soft annealed condition. Because of its high carbon content it machines somewhat like high-speed steel. Because chips are tough and stringy, chip curlers and breakers are important.

The following are typical feeds and speeds for Carpenter Stainless Type 440C.

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	T15	65	.015	C6	300	350	.015
.025	M42	75	.007	C7	350	450	.007

Turning—Cut-Off and Form Tools

Tool Material		Speed (fpm)	Feed (ipr)						
			Cut-Off Tool Width (inches)				Form Tool Width (inches)		
High Speed Tools	Carbide Tools		1/16	1/8	1/4	1/2	1	1 ½	2
T15		50	.001	.001	.0015	.001	.001	.001	.0015
	C6	175	.003	.003	.0045	.003	.002	.002	.002

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
T15	57	C2	75	.003	.006	.010	.015	.018	.021

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
T15, M42	40-50	.001	.003	.005	.007	.009	.011	.014	.018

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
T15, M42	5-12	8-15	10-20	15-25

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	70	.001	.002	.003	.004	C6	235	.001	.002	.004	.006

Tapping

High Speed Tools	
Tool Material	Speed (fpm)
M1, M7, M10 Nitrided	8-18

Broaching

High Speed Tools		
Tool Material	Speed (fpm)	Chip Load (ipt)
T15, M42	10	.002

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.

Grinding and Polishing

In cutlery applications, grinding and polishing are very important. Carpenter Stainless Steel Type 440C works well in these operations but considerable care must be used not to overheat since both the hardness and corrosion resistance may be lowered.

Weldability

Because of its high-hardness capability, this steel is seldom welded. However, if welding is necessary, the parts should be preheated and maintained at about 500ºF (260ºC), welded, and then immediately given a 6-8 hour anneal at 1350/1400ºF (732/760ºC) with a slow furnace cool. The parts should not be allowed to cool below 500ºF (260°C) between welding and annealing. High welding heat inputs should be used. To obtain mechanical properties in the weld similar to those in the base metal, welding consumables of like composition should be considered. Otherwise, AWS E/ER309 might also be considered.

Other Information

Applicable Specifications

• AMS 5618	• AMS 5630
• AMS 5880	• ASTM A276
• ASTM A314	• ASTM A473
• ASTM A493	• ASTM A580
• ASTM A756	• QQ-S-763

Forms Manufactured

• Bar-Rounds	• Billet
• Wire	• Wire-Rod

Technical Articles

- A Designer's Manual On Specialty Alloys For Critical Automotive Components
- A Guide to Etching Specialty Alloys for Microstructural Evaluation
- 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
- Passivating and Electropolishing Stainless Steel Parts
- Selecting New Stainless Steels for Unique Applications
- Selecting Stainless Steels for Valves
- Selection of High Strength Stainless Steels for Aerospace, Military and Other Critical Applications
- The ABC's of Alloy Selection, Heat Treating and Maintaining Cold Work Tooling
- Unique Properties Required of Alloys for the Medical and Dental Products Industry

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