Technical Datasheet CARPENTER TECHNOLOGY

CarTech® Micro-Melt® 440C Alloy

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 Micro-Melt 440C alloy is a powder metallurgy, high-carbon chromium stainless steel designed to provide stainless properties with maximum hardness. When heat-treated, CarTech Micro-Melt 440C attains the highest hardness of any stainless steel (about HRC 61.5).

Applications

CarTech Micro-Melt 440C alloy has found application in specialty knife blade applications. Its fine carbide distribution and fine-grained microstructure enhance cutting performance as much as 40% better than equivalent cast/wrought steels. Other uses for this stainless steel include bearing assemblies, including bearing balls and races. In addition, the material should be considered for needle valves, ball check valves, valve seats, pump parts, ball studs, bushings and wear-resistant textile components.

Elevated Temperature Use

Micro-Melt 440C alloy 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 800°F (427°C).

Corrosion Resistance

Micro-Melt 440C alloy resists corrosion in normal domestic environments and very mild industrial environments, including many petroleum products and organic materials.

This alloy is used in the hardened plus tempered condition. Corrosion resistance increases with increasing hardening temperature but care should be taken to minimize time at high hardening temperatures to avoid excessive grain growth. For best corrosion resistance, the tempering temperature should be below about 800°F (427°C).

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

Hardened & Tempered Properties – Micro-Melt 440C Alloy

Hardened 1900°F (1038°C), oil quench, tempered 600°F (316°C)

0.2% Yield Strength		Ultimate Tensile Strength		% Elongation	% Reduction In Area	Hardness BHN
ksi	MPa	ksi	MPa			
275	1896	285	1965	2	10	580

Typical Room Temperature Mechanical Properties – Micro-Melt 440C Alloy

0.2% Yield Strength		Ultimate Tensile Strength		% Elongation	% Reduction In Area	Hardness BHN
ksi	MPa	ksi	MPa			
56	386	125	862	13	19	285

Heat Treatment

Annealing

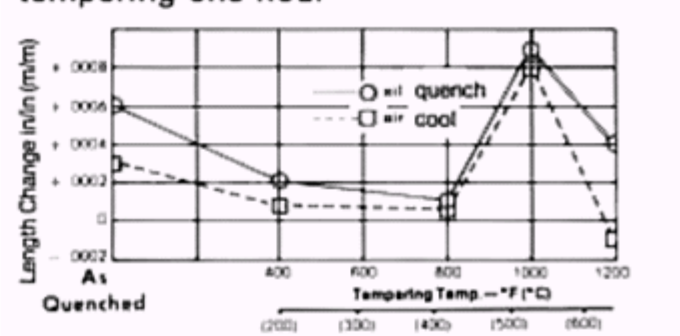
For maximum softness, this steel should be heated uniformly to 1550/1600°F (843/871°C). Soak and cool very slowly in the furnace at a rate of not more than 20°F (11°C) per hour until the furnace is black. The furnace may then be turned off and allowed to cool naturally. The full annealed hardness is 285 HBN.

Hardening

Heat to 1850/1950°F (1010/1066°C); soak; quench in warm oil or cool in air. Do not overheat. When overheated, full hardness cannot be obtained. See comments under corrosion resistance. After quenching, the alloy should be refrigerated at nominally -100°F (-73°C) for 1 hour and warmed to room temperature prior to tempering to minimize retained austenite.

Tempering

A hardness of approximately HRC 60 will be obtained without a refrigeration treatment and approximately HRC 61-62 with a refrigeration treatment as detailed below. To remove peak stresses and yet retain maximum hardness, temper at least one hour at 300/350°F (149/177°C).



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

Workability

Hot Working

This steel should be handled like high-speed tool steel. Preheat to 1400/1500°F (760/816°C), then heat slowly and uniformly to 1900/2100°F (1038/1149°C). Do not forge below 1700°F (927°C), 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 Micro-Melt 440C.

Typical Machining Speeds and Feeds – Micro-Melt 440C Alloy

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	1-1/2	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	1-1/2	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	1-1/2	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, In	High Speed Tools						Carbide Tools					
	Tool Material	Speed (fpm)	Feed – Inches Per Tooth Cutter Diameter, Inches				Tool Material	Speed (fpm)	Feed – Inches Per Tooth Cutter Diameter, Inches			
			1/4	1/2	3/4	1-2			1/4	1/2	3/4	1-2
.050	M2, M7	70	.001	.002	.003	.010	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. Micro-Melt 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 500°F (260°C), welded, and then immediately given a 6-8 hour anneal at 1350/1400°F (732/760°C) with a slow furnace cool. The parts should not be allowed to cool below 500°F (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

Note: While this material meets the following specifications, it may be capable of meeting or being manufactured to meet other general and customer-specific 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
- Strip
- Wire
- Wire-Rod

Edition Date: 12/19/11