CARPENTER TECHNOLOGY

DATASHEET

440C

Applicable specifications: AMS 5618, AMS 5630, AMS 5880, ASTM A276, ASTM A314, ASTM A473, ASTM A493, ASTM A580, ASTM A756, QQ-S-763

Associated specifications: UNS S44004

Type analysis

Single figures are nominal except where noted.

Iron	Balance	**Chromium**	16.00–18.00 %	**Carbon**	0.95–1.20 %
Manganese	Max 1.00 %	**Silicon**	Max 1.00 %	**Molybdenum**	Max 0.75 %
Phosphorus	Max 0.040 %	**Sulfur**	Max 0.030 %		

Forms manufactured

Bar-Rounds	**Billet**	**Strip**	**Wire**	**Wire-Rod**

Description

440C 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, 440C attains the highest hardness of any stainless steel (about HRC 60).

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 800°F (427°C).

Key Properties:

- Superior hardness
- Stainless properties

Markets:

- Aerospace
- Consumer
- Defense
- Industrial
- Medical
- Transportation

Applications:

- Needle valves and ball check valves
- Valve seats
- Cutlery
- Bearing assemblies
- Ball studs and bushings
- Wear-resistant textile components

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Corrosion resistance

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 2000°F (1093°C) to ensure better carbide solution.

However, care should be taken to minimize time at 2000°F (1093°C) to avoid excessive grain coarsening. 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 that 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		

Physical properties

PROPERTY	At or From	English Units
SPECIFIC GRAVITY	—	7.62
DENSITY	—	0.2750 lb/in^3
MEAN SPECIFIC HEAT	32 to 212°F (0 to 100°C)	0.1100 Btu/lb/°F
MEAN CTE	32 to 212°F (0 to 100°C)	5.60 x 10^{-6} in/in/°F
THERMAL CONDUCTIVITY	212°F (100°C)	168.0 Btu-in/hr/ft^2/°F
MODULUS OF ELASTICITY	—	29.0 x 10^3 ksi
ELECTRICAL RESISTIVITY	70°F (21°C)	361.0 ohm-cir-mil/ft

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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 IN (50.8 MM)		REDUCTION OF AREA		HARDNESS	
ksi	MPa	ksi	MPa	%		%		BRINELL	
275	1896	285	1965	2		10		580	

Heat treatment

Annealing	For maximum softness, 440C should be heated uniformly to 1550/1600°F (843/871°C). Soak and cool very slowly in the furnace. Brinell hardness approximately 223. Intermediate or process annealing treatment: Heat uniformly to 1350/1400°F (732/760°C). Air cool. Brinell hardness about 255.
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.
Tempering	Hardness of approximately HRC 60 will be obtained. To remove peak stresses and yet retain maximum hardness, temper at least 1 hour at 300/350°F (149/177°C).

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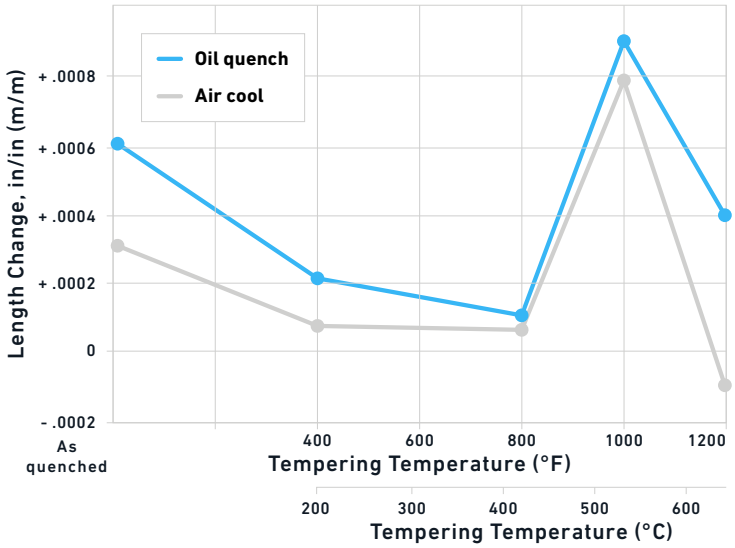
TYPICAL LONGITUDINAL SIZE CHANGE

After hardening 1900°C (1038°C) and tempering 1 hour



TYPICAL HARDNESS

1 IN. (25.4 MM) ROUND, HARDENED 1900°F (1038°C), OIL QUENCH, TEMPERED 1 HOUR		
TEMPERING TEMPERATURE		HARDNESS
°F	°C	HRC
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).

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Workability

Hot working	440C 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. Typical feeds and speeds for 440C appear below.
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. 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,440C 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 to 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.

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Typical feeds and speeds

TURNING — SINGLE-POINT AND BOX TOOLS

DEPTH OF CUT, IN	HIGH-SPEED TOOLS			CARBIDE TOOLS			
	SPEED, FPM	FEED, IPR	TOOL MATERIAL	SPEED, FPM		FEED, IPR	TOOL MATERIAL
				UNCOATED	COATED		
.150	65	.015	T-15	300	350	.015	C-6
.025	75	.007	M-42	350	450	.007	C-7

TURNING — CUT-OFF AND FORM TOOLS

SPEED, FPM	FEED, IPR							TOOL MATERIAL	
	CUT-OFF TOOL WIDTH, IN			FORM TOOL WIDTH, IN				HIGH-SPEED TOOLS	CARBIDE TOOLS
	1/16	1/8	1/4	1/2	1	1-1/2	2		
50	.001	.001	.0015	.001	.001	.001	.0015	T-15	—
175	.003	.003	.0045	.003	.002	.002	.002	—	C-6

ROUGH REAMING

HIGH-SPEED TOOLS		CARBIDE TOOLS		FEED, IPR, REAMER DIAMETER, IN`					
SPEED, FPM	TOOL MATERIAL	SPEED, FPM	TOOL MATERIAL	1/8	1/4	1/2	1	1-1/2	2
57	T-15	75	C-2	.003	.006	.010	.015	.018	.021

DRILLING — HIGH-SPEED TOOLS

SPEED, FPM	FEED, IPR								TOOL MATERIAL
	NOMINAL HOLE DIAMETER, IN								
	1/16	1/8	1/4	1/2	3/4	1	1-1/2	2	
40–50	.001	.003	.005	.007	.009	.011	.014	.018	M-42, T-15

DIE THREADING — HIGH-SPEED TOOLS

SPEED, FPM				TOOL MATERIAL
7 OR LESS, TPI	8 TO 15, TPI	16 TO 24, TPI	25 AND UP, TPI	
5–12	8–15	10–20	15–25	M-42, T-15

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MILLING — END PERIPHERAL

DEPTH OF CUT, IN	HIGH-SPEED TOOLS						CARBIDE TOOLS					
	SPEED, FPM	FEED, IN PER TOOTH CUTTER DIAMETER, IN				TOOL MATERIAL	SPEED, FPM	FEED, IPT CUTTER DIAMETER, IN PER TOOTH				TOOL MATERIAL
		1/4	*1/2*	*3/4*	*1-2*			*1/4*	*1/2*	*3/4*	*1-2*	
.050	70	.001	.002	.003	.004	M-2, M-7	235	.001	.002	.004	.006	C-6

TAPPING — HIGH-SPEED TOOLS

SPEED, FPM	TOOL MATERIAL
8–18	M-1, M-7, M-10 nitrided

BROACHING — HIGH-SPEED TOOLS

SPEED, FPM	CHIP LOAD, IN PER TOOTH	TOOL MATERIAL
10	.002	M-42, T-15

For additional information, please contact your nearest sales office:
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