Technical Datasheet

CarTech® 416 Stainless (No.5)

Identification

UNS Number

• S41600

Type Analysis

Single figures are nominal except where noted.

Carbon (Maximum)	0.15 %	**Manganese (Maximum)**	1.25 %
Phosphorus (Maximum)	0.060 %	**Sulfur (Minimum)**	0.150 %
Silicon (Maximum)	1.00 %	**Chromium**	12.00 to 14.00 %
Iron	Balance		

General Information

Description

CarTech 416, originally known as No. 5, was the first free-machining stainless steel. It was found that the addition of sulfur to this high-chromium, corrosion-resisting steel gave it easy machining properties, with speeds comparable to those of 1144 and 8620 Leaded. Type 416 can be cut rapidly and cleanly with regular metal cutting tools. This steel also grinds and polishes freely.

The low frictional properties of CarTech 416 tend to reduce scratching, galling, or seizing in service. Nuts worked freely on their threads which, together with absence of rust in the threads, made disassembly easy. Pump shafts and valve stems worked more smoothly in their packings, and many metal-to-metal contacts withstood more pressure without scratching.

CarTech 416 has been used for shafts, axles, gears and pinions, worms, lead screws, golf club heads, valve trim, bolts and nuts-in fact, any part requiring considerable machining. Where greater corrosion resistance is needed consider Carpenter Project 70+® Type 303 stainless, which is our free-machining 18-8 grade. CarTech 416 stainless is not recommended for vessels containing gases or liquids under high pressure.

Scaling

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

Corrosion Resistance

Carpenter Stainless Type 416 is resistant to corrosion from mild atmospheres, fresh water, steam, ammonia, many petroleum products and organic materials and several mild acid environments. A polished finish is not necessary, but a smoother surface is helpful in providing added corrosion resistance.

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	Restricted	Sulfuric Acid	Restricted
Phosphoric Acid	Restricted	Acetic Acid	Restricted
Sodium Hydroxide	Moderate	Salt Spray (NaCl)	Restricted
Humidity	Moderate		

Properties

Physical Properties

Specific Gravity	7.64

Density	0.2760	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
Electrical Resistivity (70°F)	343.0	ohm-cir-mil/ft

Typical Mechanical Properties

Typical Elevated Temperature Mechanical Properties
Annealed condition

Test Temperature		Short-Time Tensile Tests						Creep Tests	
		0.2% Yield Strength		Ultimate Tensile Strength		% Elongation in 2" (50.8 mm)	% Reduction of Area	Stress for 1% Creep in 10,000 Hours	
°F	°C	ksi	MPa	ksi	MPa			ksi	MPa
70	21	40	276	75	517	30	60	—	—
900	482	35	241	48	331	30	57	—	—
1000	538	31	213	41	283	34	53	9	62
1100	593	25	172	33	228	40	63	4	27
1200	650	18	124	23	159	45	68	2	14
1300	704	12	83	16	110	52	77	1	7
1400	760	8	55	11	76	60	82	—	—

Typical Room Temperature Mechanical Properties
1" (25.4 mm) round bar, hardened 1800°F (982°C), oil quench, tempered one hour

Tempering Temperature		0.2% Yield Strength		Ultimate Tensile Strength		% Elongation in 2" (50.8 mm)	% Reduction of Area	Izod Impact Strength		Hardness	
°F	°C	ksi	MPa	ksi	MPa			ft-lb	J	Brinell	Rockwell
300	149	150	1034	195	1344	10	40	20	27	390	C 41
500	260	142	979	185	1276	13	45	20	27	375	C 39
700	371	146	1007	190	1310	13	48	26	35	390	C 41
900	482	130	896	168	1158	14	50	—	—	341	C 36
1000	538	115	793	145	1000	15	50	—	—	300	C 31
1100	593	100	689	125	862	17	53	28	38	262	C 26
1200	650	85	586	110	758	18	55	30	41	225	B 97

Typical Stress Rupture Strength
Annealed condition

Test Temperature		Stress for Rupture in					
°F	°C	100 hrs.		1,000 hrs.		10,000 hrs.	
		ksi	MPa	ksi	MPa	ksi	MPa
800	427	60	414	55	379	52	358
900	482	47	324	40	276	33	227
1000	538	32	221	26	179	20	138
1100	593	17	117	11	76	7	48
1200	650	8	55	6	41	—	—

Heat Treatment

Annealing

Heat uniformly to 1200/1400°F (650/760°C); soak, then remove from furnace and cool in air. Brinell hardness approximately 187. For maximum softness anneal from a temperature of 1500/1650°F (816/900°C) and cool in furnace. Brinell hardness 155.

Hardening

Heat to 1700/1850ºF (927/1010ºC), soak at heat, quench in oil.

Tempering

Temper to secure the hardness and mechanical properties desired.

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

Although this grade can be forged, it is not recommended for severe upsetting operations. To forge, heat uniformly to 2100/2250ºF (1149/1232ºC); then forge and cool in air. Cool large forgings slowly in dry lime or ashes. Trim hot if possible; otherwise, anneal and trim cold. Do not forge below 1700ºF (927ºC).

Cold Working

Carpenter Stainless Type 416 will withstand some cold work, but it is not recommended for cold upsetting. (A special modification of Type 416 is available for cold heading operations.) Some manufacturers do cold head Type 416 successfully. The primary application for this steel has been in parts that are machined to shape. Type 416Se, in which selenium replaces sulfur as the free-machining additive, has displayed superior cold-working characteristics along with good machinability.

Machinability

Carpenter Stainless Type 416 cuts very freely because of the addition of sulfur. In automatic screw machines, it machines like SAE 1120 with cutting speeds of 135 to 155 surface feet per minute (0.68 to 0.79 m/s). At a higher hardness, such as Rockwell C34, Carpenter Stainless No. 5 is still commercially machinable.

Following are typical feeds and speeds for Carpenter Stainless Type 416.

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) Uncoated	Speed (fpm) Coated	Feed (ipr)
.150	M2	160	.015	C6	555	650	.015
.025	M3	170	.007	C7	605	800	.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
M2		100	.0015	.002	.0025	.002	.0015	.001	.001
	C6	340	.004	.005	.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	125	C2	145	.003	.008	.013	.018	.022	.025

Drilling

Tool Material	Speed (fpm)	High Speed Tools: Feed (inches per revolution) Nominal Hole Diameter (inches)							
		1/16	1/8	1/4	1/2	3/4	1	1 ½	2
M1, M10	95-110	.001	.003	.006	.010	.014	.017	.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	10-20	15-30	25-40	35-45

Milling, End-Peripheral

Depth of Cut (inches)	High Speed Tools						Carbide Tools					
	Tool Material	Speed (fpm)	Feed (ipt) Cutter Diameter (in) 1/4	1/2	3/4	1-2	Tool Material	Speed (fpm)	Feed (ipt) Cutter Diameter (in) 1/4	1/2	3/4	1-2
.050	M2, M7	125	.001	.002	.004	.005	C6	350	.001	.002	.005	.007

Tapping

High Speed Tools	
Tool Material	Speed (fpm)
M1, M7, M10	20-45

Broaching

High Speed Tools		
Tool Material	Speed (fpm)	Chip Load (ipt)
M2, M7	25	.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 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 416 is not recommended for welding.

Other Information

Applicable Specifications

- AMS 5610
- ASTM A582
- MIL-W-52263
- QQ-S-764

Forms Manufactured

- Bar-Hexagons
- Bar-Rounds
- Billet
- Wire
- Wire-Rod

Technical Articles

- A Guide to Etching Specialty Alloys for Microstructural Evaluation
- Alloy Variation Solves Metal Flow Problem in Staking components for Emission Controls
- How to Passivate Stainless Steel Parts
- Passivating and Electropolishing Stainless Steel Parts
- Unique Properties Required of Alloys for the Medical and Dental Products Industry

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