Technical Datasheet

CARPENTER

Carpenter CTS™ XHP Alloy

Identification

U.S. Patent Number

- 5,370,750

Type Analysis

Carbon	1.60 %	**Manganese**	0.50 %
Silicon	0.40 %	**Chromium**	16.00 %
Nickel	0.35 %	**Molybdenum**	0.80 %
Vanadium	0.45 %	**Iron**	79.90 %

General Information

Description

Carpenter CTS™ XHP alloy is powder metallurgy, air-hardening, high carbon, high chromium, corrosion-resistant alloy. It can be considered either a high hardness 440C stainless steel or a corrosion-resistant D2 tool steel.

CTS XHP alloy possesses corrosion resistance equivalent to 440C stainless steel and can attain a maximum hardness of 64 HRC. In addition, the composition of CTS XHP alloy has been balanced so that it can attain a minimum hardness of 60 HRC when air cooled from hardening temperatures of 1850 to 2000°F (1010°C to 1093°C). CTS XHP alloy is thus more forgiving during heat treatment than similar alloys.

Applications

Carpenter CTS XHP can be used for specialty knives where the alloy's fine carbide distribution can be used to produce a keenly sharp cutting edge. The material can be easily ground to the thin profiles required for cutting tools. CTS XHP knife blades can be finely polished to high luster or produced with a uniform matte finish.

Corrosion Resistance

Carpenter CTS XHP alloy possesses corrosion resistance equivalent to Type 440C stainless. CTS XHP alloy resists corrosion in normal domestic environments and very mild industrial environments, including many petroleum products and organic materials.

For optimum corrosion resistance, surfaces must be free of scale and foreign particles and finished parts should be passivated.

Detailed test data can be furnished upon request.

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

Carpenter CTS™ XHP Alloy

Mean CTE	
77 to 212°F	5.65 x 10 -6 in/in/°F
77 to 392°F	6.02 x 10 -6 in/in/°F
77 to 572°F	6.24 x 10 -6 in/in/°F
77 to 752°F	6.40 x 10 -6 in/in/°F
77 to 932°F	6.53 x 10 -6 in/in/°F
77 to 1112°F	6.63 x 10 -6 in/in/°F
77 to 1292°F	6.71 x 10 -6 in/in/°F
77 to 1472°F	6.87 x 10 -6 in/in/°F

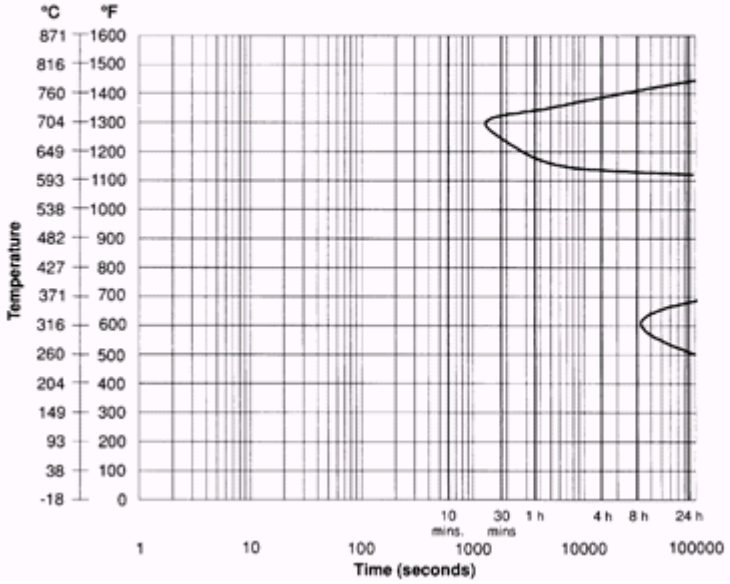
Mean coefficient of thermal expansion— CTS-XHP Alloy

Annealed condition

Room Temperature		Average Coefficient	
77°F to	25°C to	10^{-6} / °F	10^{-6} / °C
212	100	5.65	10.17
392	200	6.02	10.83
572	300	6.24	11.23
752	400	6.40	11.52
932	500	6.53	11.76
1112	600	6.63	11.93
1292	700	6.71	12.13
1472	800	6.87	12.37

Isothermal transformation (I-T) diagram— CTS-XHP Alloy

Austenitize at 1925°F (1052°C) for 25 mins., quenched to I-T temperature, then brine quenched to room temperature.



Typical Mechanical Properties

Hardened & Tempered Properties

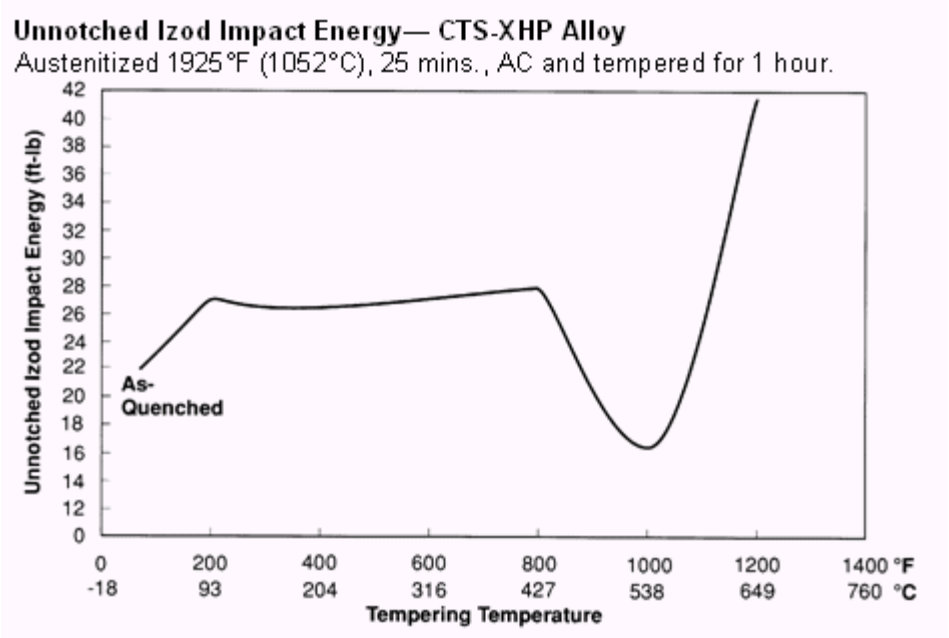
Compression Test Results— Carpenter CTS XHP Alloy

Compressive yield strength is 347.0 ksi, compressive modulus is 32.6 x 10^6 psi, heat treat is 1925°F (1052°C) (25 mins.) O.Q. + -100°F (-73°C) (1h) A.W. + 350°F (177°C) (1h) A.C.

Carpenter CTS™ XHP Alloy

Typical Annealed Tensile Properties— CTS-XHP Alloy

Yield Strength		Ultimate Tensile Strength		% Elongation	% Reduction In Area	Hardness BHN
ksi	MPa	ksi	MPa			
68.3	471	125.3	864	10.2	16.0	230/255



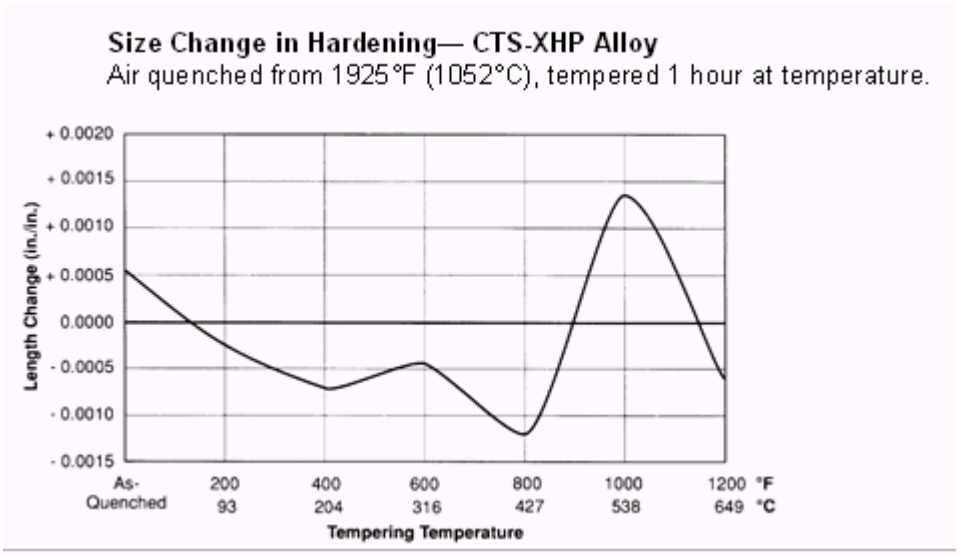
Heat Treatment

Decarburization

Carpenter CTS XHP alloy, like all high carbon tool steels, is subject to decarburization during thermal processing and precautions must be taken to control this condition.

Annealing

Carpenter CTS XHP alloy should be annealed in a neutral atmosphere. Heat uniformly to 1550/1600°F (843/871°C), then 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. Annealed hardness is 230/255 HBN.



Effect of Refrigeration on As-Hardened Condition— CTS-XHP Alloy
Hardness measurements are averages rounded to nearest 0.5 HRC.
Sample size: 1 in. dia. x 0.5 in. thick.

Heat treatment: 25 minutes at hardening temperature, then air cool or oil quench to room temperature. Leave as-hardened, or refrigerate at -100°F (-73°C) for 1 hour. Air warm to room temperature.

Hardening Temperature		Air Cool only	Air Cool + Refrigeration	Oil Quench Only	Oil Quench + Refrigeration
°F	°C				
1850	1010	62.0	62.5	62.5	63.5
1900	1038	62.5	63.5	63.0	64.0
1950	1066	62.5	64.0	62.5	64.5
2000	1093	58.5	64.0	57.0	64.0

Effect of Refrigeration on Tempered Hardness— CTS-XHP Alloy
Hardness measurements are averages rounded to nearest 0.5 HRC.
Sample size: 1-in. dia. x 0.5 in. thick.

Heat treatment: 25 minutes at hardening temperature. Air cool or oil quench. Leave as-hardened, or refrigerate at -100°F (-73°C) for 1 hour. Air warm. Temper 1 hour at temperature. Air cool.

Tempering Temperature		Air Cool only	Air Cool + Refrigeration	Oil Quench only	Oil Quench + Refrigeration
°F	°C				
1900°F (1038°C) Hardening Temperature					
As-Hardened		62.5	63.5	63.0	64.0
200	93	63.0	64.0	63.0	64.0
250	121	63.0	64.0	63.0	64.0
300	149	62.0	63.0	62.0	63.0
350	177	61.0	62.0	61.0	62.0
400	204	60.5	62.0	60.5	61.0
450	232	60.0	61.0	59.5	60.5
500	260	59.0	60.5	59.0	60.0
600	316	58.0	--	--	-
800	427	58.0			
1950°F (1066°C) Hardening Temperature					
As-Hardened		62.5	64.0	62.5	64.5
200	93	62.5	65.0	62.5	65.0
250	121	62.5	65.0	62.0	65.0
300	149	62.0	64.0	61.5	64.0
350	177	61.0	63.0	60.5	63.0
400	204	60.5	62.5	60.0	62.5
450	232	59.5	61.5	59.0	61.5
500	260	59.0	61.0	57.5	60.5
600	316	57.5	--	--	--
800	427	57.5	--	--	--

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

Workability

Forging

Carpenter CTS XHP alloy forges very much like high-speed steels. 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 heated to about 1550°F (843°C), soak uniformly at this temperature, then shut off the heat and cool slowly in the furnace. Anneal after forging. Cool to room temperature before annealing.

Carpenter CTS™ XHP Alloy

Machinability

The following chart contains suggested speeds and feeds for machining Carpenter CTS XHP 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) Uncoated	Speed (fpm) Coated	Feed (ipr)
.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

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
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) 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	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.

Other Information

Wear Resistance

The wear characteristics in the table below were generated using ASTM G65 Procedure "A", the Standard Practice for conducting Dry Sand/Rubber Wheel Abrasion Tests. The data are presented as volume loss as required by the ASTM Standard. It should be noted therefore that a lower number means better wear resistance.

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Heat Treatments:

CTS-XHP Alloy	1925°F (1052°C) (25 mins.) Air Cool/-100°F (-73°C) (1h) Air Warm/350°F (177°C) (1h) Air Cool
440C	1900°F (1038°C) (25 mins.) Oil Quench/-100°F (-73°C) (1h) Air Warm/350°F (177°C) (1h) Air Cool
D2	1850°F (1010°C) (25 mins.) Air Cool-As Hardened

Material	Hardness, HRC	Average ASTM Volume Loss (mm^3)
CTS-XHP Alloy	62.5	35.1
440C	58.5	66.9
D2	63.5	37.6

Forms Manufactured

- Bar
- Billet
- Strip

Technical Articles

- Blade Alloys 101: What You Need to Know About the Alloys Used for Knife Blades

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