CARPENTER Specialty Alloys

ALLOY Data

CTS-XHP® Alloy

Patent Number

5,370,750

Type Analysis

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

Description

CTS-XHP® alloy is an air-hardening, high carbon, high chromium, corrosion resistant alloy. It can be considered either a high hardness stainless steel or a corrosion-resistant tool steel. The alloy is manufactured using powder metallurgy and controlled metal working processes.

CTS-XHP alloy possesses corrosion resistance equivalent to high chromium stainless steels but can attain a maximum hardness of 62 HRC, approaching that of D2 tool steel. 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. CTS-XHP alloy is thus more forgiving during heat treatment than similar alloys.

Applications

Applications that may be considered for CTS-XHP alloy include all the applications for stainless steels that may require higher hardness, such as bearing assemblies, needle valves, ball check valves, valve seats, pump parts, ball studs, bushings and wear resistant textile components. CTS-XHP can be used for specialty knives where its fine carbide distribution can be used to produce a keenly sharp cutting edge.

Because of the hardness of CTS-XHP alloy, it may also be considered for use in D2 applications requiring greater corrosion resistance, such as blanking dies, forming dies, extrusion dies, drawing dies, forming rolls, edging rolls, beading rolls, master tools, heading tools, long punches, intricate punches and slitting cutters.

Corrosion Resistance

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.

STAINLESS STEELS 88
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Important Note: *The following 5-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
Sea Water	--	Sour Oil/Gas	--
Humidity	Good		

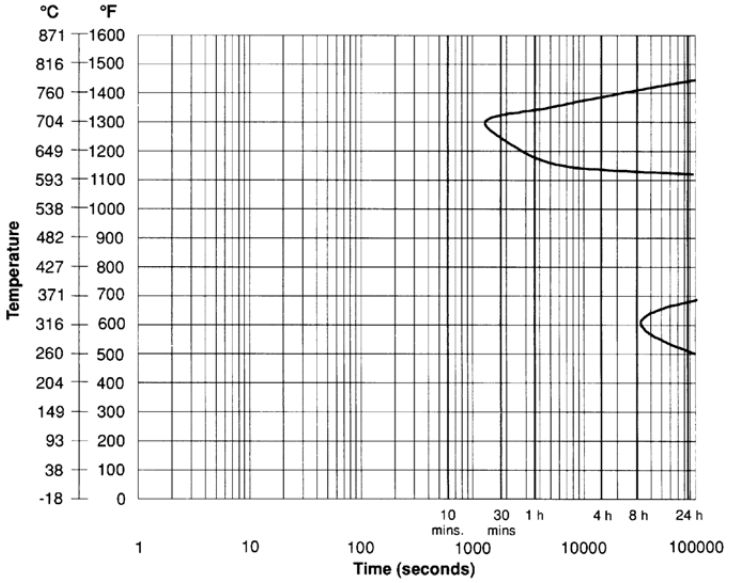
Physical Properties

Specific Gravity	7.62	
Density	0.275 lb/in^3	7625 kg/m^3

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.



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.

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

Heat Treatment

Decarburization

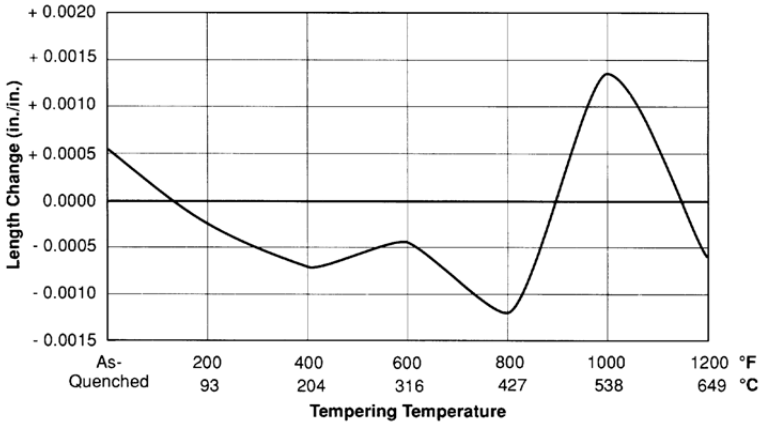
CTS-XHP alloy, like all high carbon tool steels, is subject to decarburization during thermal processing and precautions must be taken to control this condition.

Annealing

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.

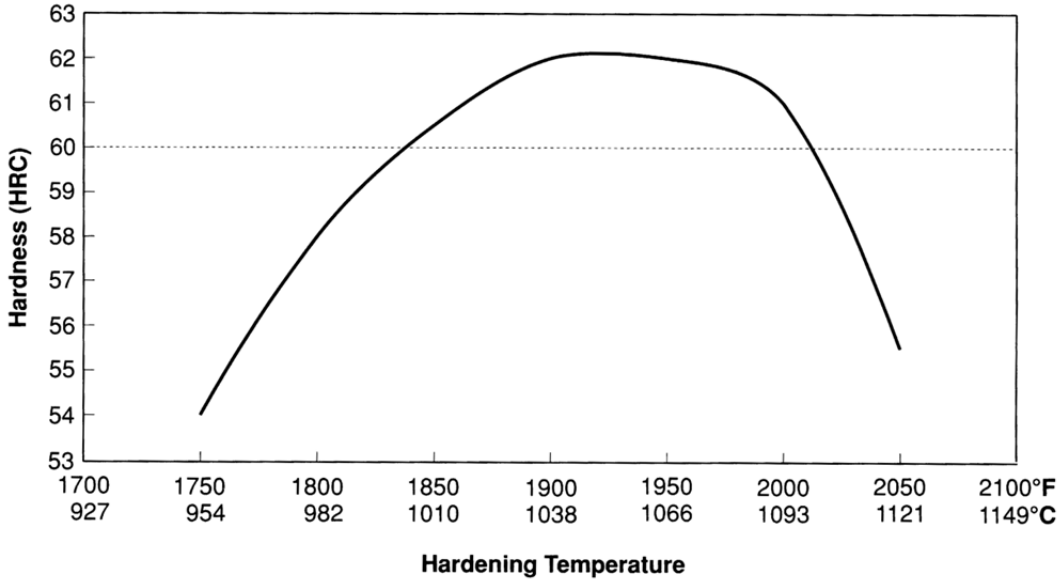
Deformation (Size Change) in Hardening

Size Change in Hardening—CTS-XHP® Alloy
Air quenched from 1925°F (1052°C), tempered 1 hour at temperature.



Heat Treatment continued

As-Air-Cooled Hardness—CTS-XHP® Alloy
25 minutes at hardening temperature, then air cooled.



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

Heat Treatment continued

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	-	-	-
1000	538	59.0	-	-	-
1200	649	42.0	-	-	-
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	-	-	-
1000	538	60.0	-	-	-
1200	649	42.0	-	-	-

Workability

Forging

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. This is not an anneal and, after the forging is cold, it must be annealed.

Workability continued

Machinability

The following chart contains suggested speeds and feeds for machining 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)						
High Speed Tools	Carbide Tools		Cut-Off Tool Width (inches)			Form Tool Width (inches)			
			1/16	1/8	1/4	1/2	1	1 ½	2
T15	C6	50 175	.001 .003	.001 .003	.0015 .0045	.001 .003	.001 .002	.001 .002	.0015 .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.

Typical Mechanical Properties

Hardened Properties

High-carbon, high-chromium steels such as CTS-XHP alloy achieve their excellent wear resistance because of a chemical balance which renders them notch sensitive and low in ductility. Therefore, meaningful tensile data are unavailable.

Compression Test Results—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.

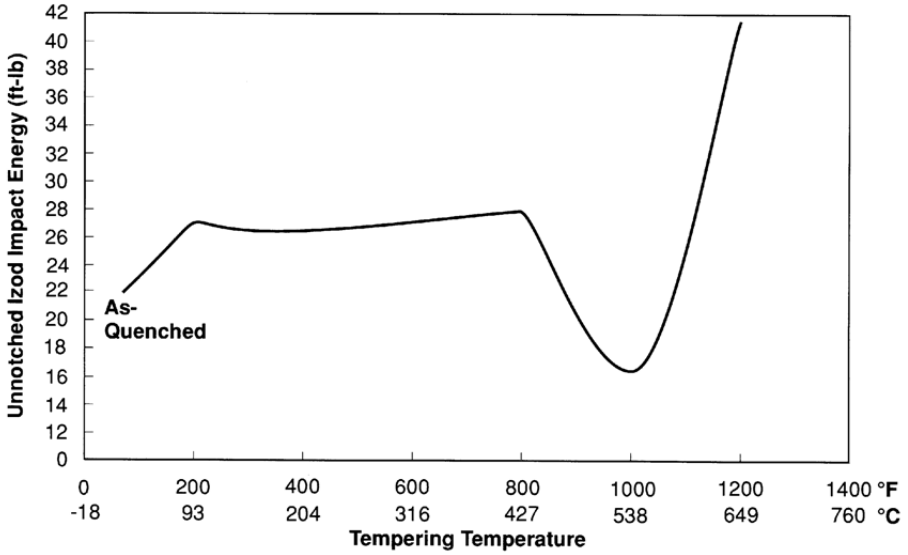
Annealed Properties

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

Unnotched Izod Impact Energy—CTS-XHP® Alloy

Austenitized 1925°F (1052°C), 25 mins., AC and tempered for 1 hour.



Forms Manufactured

- Bar
- Billet
- Strip

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