Technical Datasheet CARPENTER TECHNOLOGY

CarTech® No. 610 Tool Steel

Identification

UNS Number
- T30402

AISI Number
- Type D2

Type Analysis

Single figures are nominal except where noted.

Carbon	1.50 %	**Manganese**	0.50 %
Silicon	0.30 %	**Chromium**	12.00 %
Molybdenum	0.80 %	**Vanadium**	0.90 %
Iron	Balance		

General Information

Description

CarTech No. 610 tool steel is an air hardening, high-carbon, high-chromium tool steel possessing extremely high wear resistant properties. It is very deep hardening and is practically free from size change after proper treatment. This tool steel's high chromium content gives it mild corrosion resisting properties in the hardened condition.

CarTech No. 610 tool steel is available in the form of DeCarb-Free (DCF) bars. DCF bars have been cold finished in the mill prior to shipment, eliminating the need for bark removal by the tool and die fabricator.

Applications

CarTech No. 610 tool steel has found applications in:

Blanking dies
Forming dies
Coining dies
Extrusion dies
Drawing dies
Forming rolls
Edging rolls
Beading rolls
Master tools
Heading tools
Long punches
Intricate punches
Slitting cutters

Properties

Physical Properties

Specific Gravity	7.83	
Density	0.2830	lb/in³

Mean CTE	
68 to 212°F	5.81 x 10^{-6} in/in/°F
68 to 392°F	6.29 x 10^{-6} in/in/°F
68 to 572°F	6.56 x 10^{-6} in/in/°F
68 to 752°F	6.76 x 10^{-6} in/in/°F
68 to 932°F	6.93 x 10^{-6} in/in/°F
68 to 1112°F	7.00 x 10^{-6} in/in/°F
68 to 1292°F	7.09 x 10^{-6} in/in/°F
68 to 1472°F	7.24 x 10^{-6} in/in/°F

Mean coefficient of thermal expansion

The following figures are the average coefficients between room temperature and the specified elevated temperature. They represent material in the annealed condition and the dimensions are in in/in/° temperature.

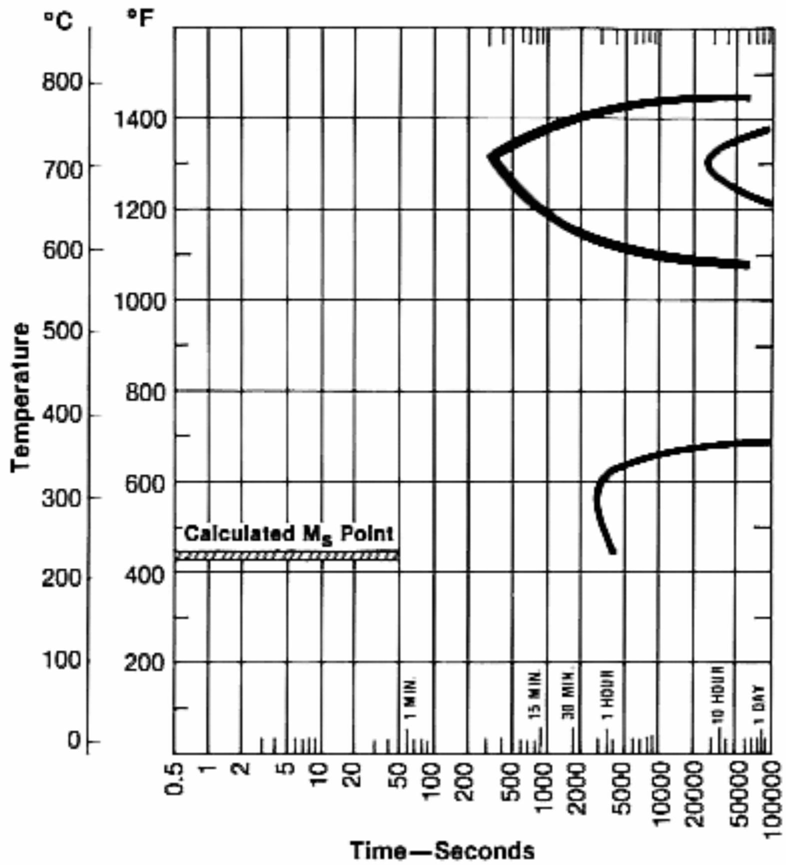
Room Temperature		Average Coefficient	
68°F to	20°C to	10^{-6}/°F	10^{-6}/°C
212	100	5.81	10.5
392	200	6.29	11.3
572	300	6.56	11.8
752	400	6.76	12.2
932	500	6.93	12.5
1112	600	7.00	12.6
1292	700	7.09	12.8
1472	800	7.24	13.0

Isothermal transformation diagram

Austenitizing temperature - 1800°F (982°C)

Isothermal transformation diagram

Austenitizing temperature - 1800°F (982°C)



Typical Mechanical Properties

High-carbon, high-chromium steels such as No. 610 tool steel achieve their excellent wear resistance due to a chemical balance which renders them notch sensitive and low in ductility.

Meaningful tensile data are unavailable. The practical experience indicates that compressive loads in excess of 400,000 psi (2758 Mpa) can be withstood if evenly applied at low rates of loading.

Heat Treatment

Decarburization

Like all high-carbon tool steels, No. 610 tool steel is subject to decarburization during thermal processing. Precautions must be taken to control this condition.

Modern furnaces are available which provide environments designed to minimize decarburization.

Normalizing

Normalizing is not recommended for No. 610 tool steel and is not necessary after furnace cooling as indicated above.

Annealing

No. 610 tool steel should be packed in a suitable container, using a neutral packing compound, or placed in a controlled atmosphere furnace.

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 (11.1°C) per hour until the furnace is black. The furnace may then be turned off and allowed to cool naturally. This practice will produce a maximum hardness of Brinell 241.

Hardening

No. 610 tool steel is extremely sensitive to overheating during hardening. It is therefore imperative that care be taken to insure that the hardening temperature is within the recommended range of 1800/1875°F (982/1024°C).

If overheated, No. 610 tool steel, like other high-carbon, high-chrome tool steels, will not reach its maximum obtainable hardness and will shrink badly.

Don't overheat it. Without preheating, place the tool right in the hot furnace and let it heat naturally until its color uniformly matches the color of the thermocouple in the furnace. Tools should be soaked at temperature 20 minutes plus 5 minutes for each inch of thickness, then quenched in air.

Control of decarburization can be achieved by using any one of the several modern heat-treating furnaces designed for this purpose. If endothermic atmospheres are used a dew point between 20/40°F (-6.7/+4.4°C) is suggested. In older type, manually operated exothermic atmosphere furnaces, an oxidizing atmosphere is required. Excess oxygen of about 4 to 6% is preferred.

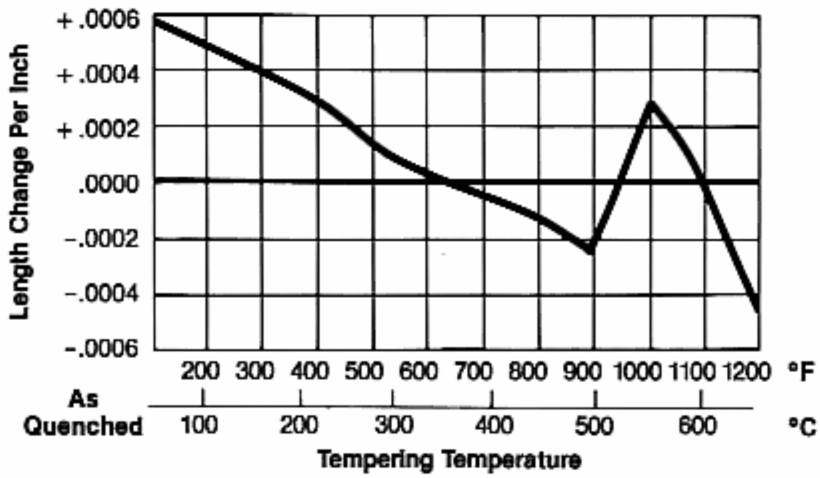
If no atmosphere is available, the tool should be pack hardened or wrapped in stainless steel to protect its surface.

Deformation (Size Change) in Hardening

The accompanying chart within the hyperlink entitled "Size Change of No. 610 Tool Steel" shows typical length changes of No. 610 tool steel when it has been properly hardened and tempered. Note that the length change information is presented in inches per inch of original length. The chart indicates that this material can be expected to expand when tempered to temperatures below 625°F (329°C). When tempered between 625°F (329°C) and 950°F (10°C) it will shrink.

Tool steels hold size best when quenched from the proper hardening temperature. If overheated, they tend to show severe shrinkage after tempering.

Size Change of No. 610 Tool Steel
1" (25.4 mm) round, air quenched from 1850°F (1010°C), tempered 1 hour at indicated temperature.



Stress Relieving

To relieve machining stresses for greater accuracy in hardening, first rough machine, then heat to temperature of 1200/1250°F (649/677°C) and slowly cool. After cooling, the part or parts may be finish machined.

Tempering

No. 610 tool steel has two toughness peaks, one at 450°F (232°C) and the other at 700°F (371°C). For the best combination of toughness and hardness, temper at 450°F (232°C). While this is the best tempering temperature for practically all applications, greater ductility can be obtained by tempering at 700°F (371°C), although there will be some sacrifice of hardness. Double tempering is desired with the second temper 25°F (13.8°C) below the first temper.

The hardness curve for No. 610 tool steel shows the same "kickback" or secondary hardening found in high-speed steels. In this material, it occurs at 1000°F (538°C) and, if by accident tools have been overheated in hardening, causing shrinkage and loss of hardness, they might be salvaged by tempering them at 1000°F (538°C). They will regain some of their lost hardness and will expand close to their former size. The hardness values given in the chart at 1000°F (538°C) are based on 1 hour soaking time. Longer soaking time will result in somewhat lower Rockwell C hardness.

Since No. 610 tool steel maintains a high hardness after a 1000°F (538°C) temper, it lends itself well to gas nitriding or liquid cyaniding. This provides added wear resistance for forming tools.

Effect of Tempering Temperature on Hardness of No. 610 Tool Steel
Air quenched from 1850°F (1010°C), tempered 1 hour at indicated temperature

Tempering Temperature		Rockwell C Hardness	Equivalent Scleroscope
°F	°C		
As Hardened		62/63	88
200	93	61/62	86
400	204	59/60	83
450	232	59/60	83
550	288	56/57	77
700	371	56/57	77
800	427	56/57	77
900	482	58/59	82
1000	538	59/60	83
1100	593	50/55	70
1200	649	44/45	58

Workability

Forging

No. 610 tool steel forges very much like high-speed steel. Heat uniformly and forge from a temperature of 1925/2000°F (1052/1093°C). Do not continue to forge below 1700°F (927°C). Reheat as often as necessary to maintain proper forging temperature.

Small, simple forgings can be cooled slowly in lime. The best practice for large forgings is to place them in a furnace heated to approximately 1550°F (843°C), soak uniformly at this temperature, then shut off the heat and allow the material to cool slowly in the furnace. This is not an anneal. After the forging is cold, it must be annealed as indicated below.

Machinability

The machinability of No. 610 tool steel may be rated between 35 and 40% of Type W-1 tool steel, or about 25 to 30% of B1112.

The linked charts contain information on typical speeds and feeds used in machining No. 610 tool steel. All results are for operations performed on material in the annealed condition.

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The following charts contain information on typical speeds and feeds used in machining No. 610 tool steel. All results are for operations performed on material in the annealed condition.

Turning—Single Point and Box Tools

Depth of Cut In.	High-Speed Tools			Carbide			
	Speed, fpm	Feed, ipr	Tool Material	Speed, fpm		Feed, ipr	Tool Material
				Brazed	Throw Away		
.150	45	.010	M-2	160	210	.010	C-6
.025	60	.005	M-3	210	250	.005	C-7

Turning—Cut-Off and Form Tools

Speed, fpm	Feed, ipr							Tool Material
	Cut-Off Tool Width, Inches			Form Tool Width, Inches				
	1/16	1/8	1/4	1/2	1	1-1/2	2	
45	.001	.001	.0015	.0015	.001	.0007	.0007	M-2
145	.002	.002	.003	.0025	.0015	.0015	.0015	C-6

Drilling

Speed, fpm	Feed, ipr								Tool Material
	Nominal Hole Diameter, Inches								
	1/16	1/8	1/4	1/2	3/4	1	1-1/2	2	
30	.001	.001	.003	.005	.007	.008	.010	.012	M-42

Reaming

High-Speed Tool							Carbide Tool		
Speed, fpm	Feed, ipr Reamer Diameter, Inches						Tool Material	Speed, fpm	Tool Material
	1/8	1/4	1/2	1	1-1/2	2			
25	.002	.003	.005	.007	.010	.012	M-7	80	C-2

Milling—End Peripheral

Depth of Cut In.	High-Speed Tools						Carbide Tools					
	Speed, fpm	Feed—Inches per tooth Cutter Diameter, Inches				Tool Material	Speed, fpm	Feed—Inches per tooth Cutter Diameter, Inches				Tool Material
		1/4	1/2	3/4	1-2			1/4	1/2	3/4	1-2	
.050	55	.001	.002	.003	.004	M-2;M-7	200	.0015	.0025	.004	.005	C-6

Broaching

Speed, fpm	Chip Load, Inches per tooth	Tool Material
10	.002	M-42

Sawing—Power Hack Saw

Pitch—Teeth per Inch Material Thickness, Inches				Speed	Feed
Under 1/4	1/4-3/4	3/4-2	Over 2	Strokes/Minute	Inches/Stroke
10	6	6	4	140	.006
10	6	6	4	70	.003
10	10	6	4	85	.003
10	10	6	4	55	.005
10	8	6	4	75	.003

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 and feeds should be increased or decreased in small steps.

Additional Machinability Notes

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 and feeds should be increased or decreased in small steps.

Other Information

Wear Resistance

All specimens air hardened from 1850°F (1010°C) and tempered 1 hour at indicated temperature. The wear characteristics shown in the linked chart were generated using ASTM G65 Procedure A, which is the ASTM Standard Practice for Conducting Dry Sand/Rubber Wheel Abrasions Tests.

The data are presented as a volume loss as required by the ASTM standard. Note that a lower number indicates better wear resistance.

Dry Sand/Rubber Wheel Abrasion Test
All specimens air hardened from 1850°F (1010°C) and tempered 1 hour at indicated temperature

Tempering Temperature		Rockwell C Hardness	Average Volume Loss ASTM
°F	°C		
As-Hardened		63/64	37.6
450	232	59.5	40.8
1075	579	52	53.0
1125	607	48	61.9
1200	649	43/44	85.9

The wear characteristics shown in the chart were generated using ASTM G65 Procedure A, which is the ASTM Standard Practice for Conducting Dry Sand/Rubber Wheel Abrasion Tests.

The data are presented as a volume loss as required by the ASTM standard. Note that a lower number indicates better wear resistance.

Applicable Specifications

- ASTM A681
- QQ-T-570

Forms Manufactured

- Bar-Rounds
- Billet
- Strip

Technical Articles

- A New Guide for Selecting Ferrous Alloys, Tungsten Carbides and Ceramics for Tooling
- A Three-Point Program for Improving the Performance of Cold Work Tooling
- Coated Tools of High Strength, High Tough Steel Produce up to 100 Times More Powder Metal Parts
- Forging Difficult Alloys: How to Get Better Results, Consistently
- New Powder Metal Alloy Bridges Gap Between High Speed Steel and Tungsten Carbide
- Selecting New Stainless Steels for Unique Applications
- The ABC's of Alloy Selection, Heat Treating and Maintaining Cold Work Tooling

Edition Date: 12/06/11

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