Technical Datasheet

CarTech® M2 High Speed Steel

Identification

UNS Number

- T11302

AISI Number

- Type M2

Type Analysis

Single figures are nominal except where noted.

Carbon	0.82 %	**Manganese**	0.30 %
Silicon	0.25 %	**Chromium**	4.25 %
Molybdenum	5.00 %	**Vanadium**	1.80 %
Tungsten	6.25 %	**Iron**	Balance

General Information

Description

CarTech M2® high speed steel is a fine grained molybdenum-tungsten high speed steel which possesses advantages over 18-4-1 high speed steels including less weight per cubic inch, lower hardening temperature and somewhat easier machining.

Applications

CarTech M2 high speed steel has been used in tools such as:

Lathe tools
Planer tools
Drills
Taps
Reamers
Broaches
Milling cutters
Form cutters
Thread chasers
End mills
Gear cutters
Wood knives

Properties

Physical Properties

Specific Gravity	8.15	
Density	0.2940	lb/in³
Mean CTE		
68 to 212°F	5.58	x 10^{-6} in/in/°F
68 to 392°F	6.16	x 10^{-6} in/in/°F
68 to 572°F	6.46	x 10^{-6} in/in/°F
68 to 752°F	6.63	x 10^{-6} in/in/°F
68 to 932°F	6.78	x 10^{-6} in/in/°F
68 to 1112°F	6.83	x 10^{-6} in/in/°F
68 to 1292°F	6.89	x 10^{-6} in/in/°F
68 to 1562°F	6.98	x 10^{-6} in/in/°F

Mean coefficient of thermal expansion

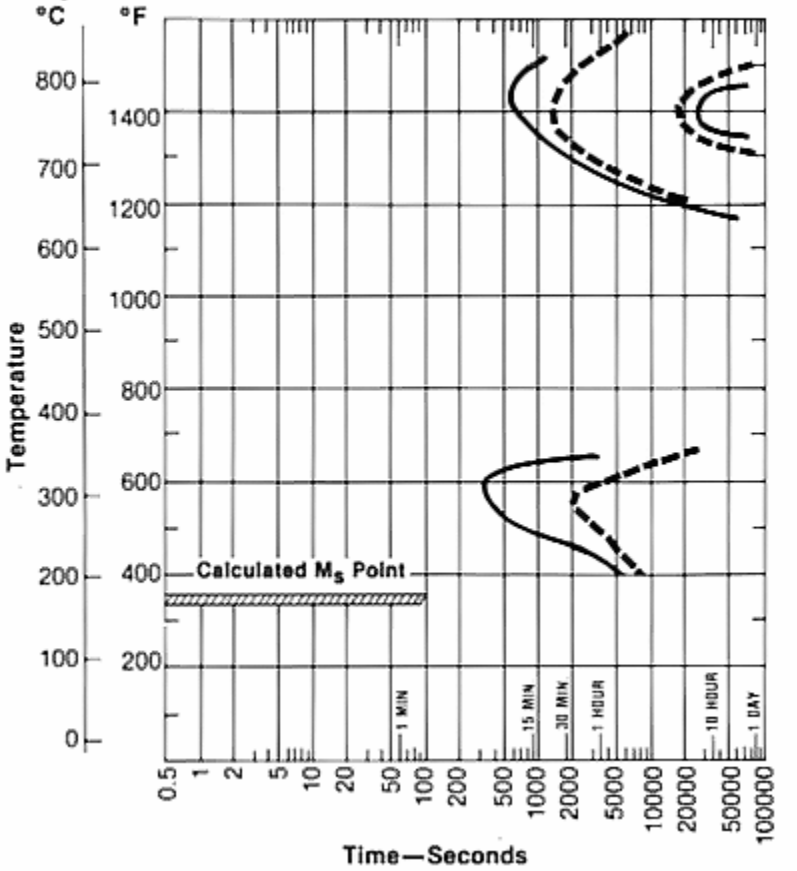
The following figures are the average coefficients between room temperature and the specified elevated temperature. They represent material in the annealed condition and the dimensions are in in/in/° temperature.

Room Temperature		10^{-6}/°F	10^{-6}/°C
68°F to	20°C to		
212	100	5.58	10.0
392	200	6.16	11.1
572	300	6.46	11.6
752	400	6.63	11.9
932	500	6.78	12.2
1112	600	6.83	12.3
1292	700	6.89	12.4
1382	750	—	—
1472	800	—	—
1562	850	6.98	12.6

Isothermal transformation diagram—Speed Star high speed steel

Austenitizing temperature 2250°F (1232°C)

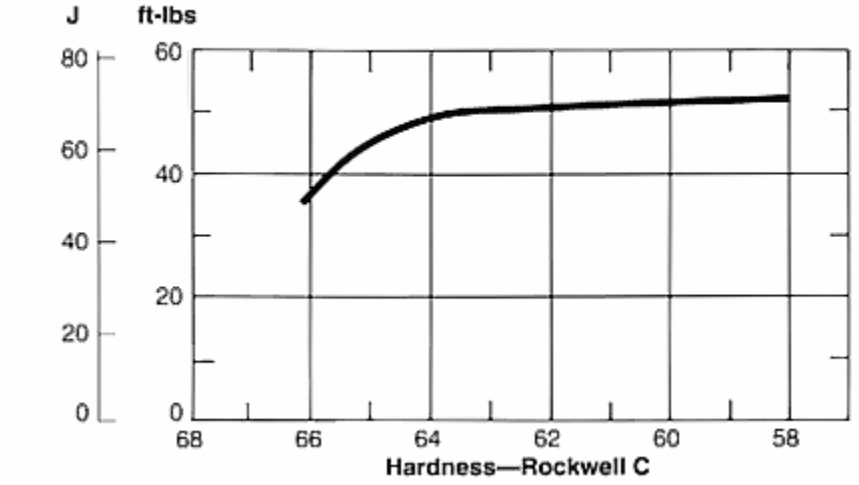
A_{C1} = 1530°F (832°C)



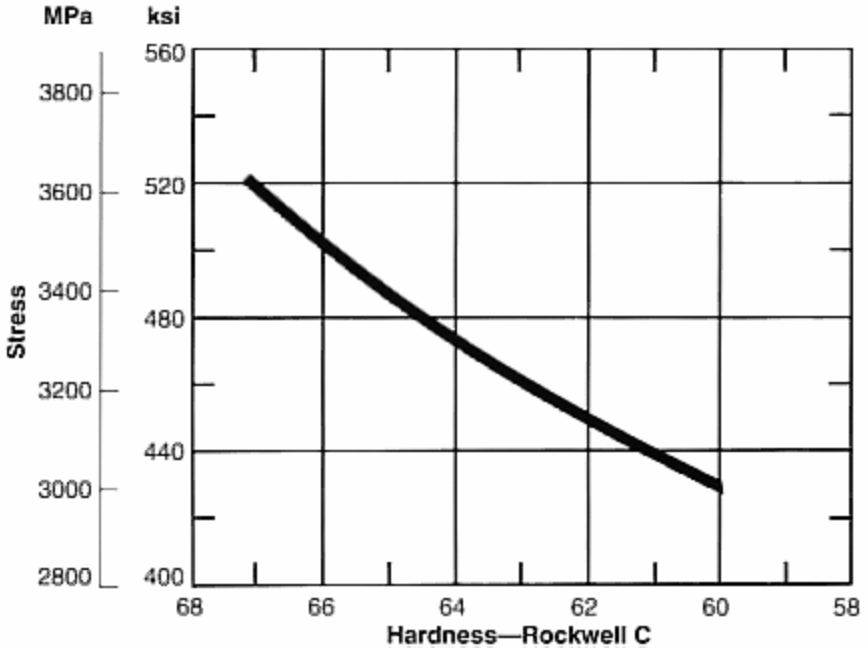
Typical Mechanical Properties

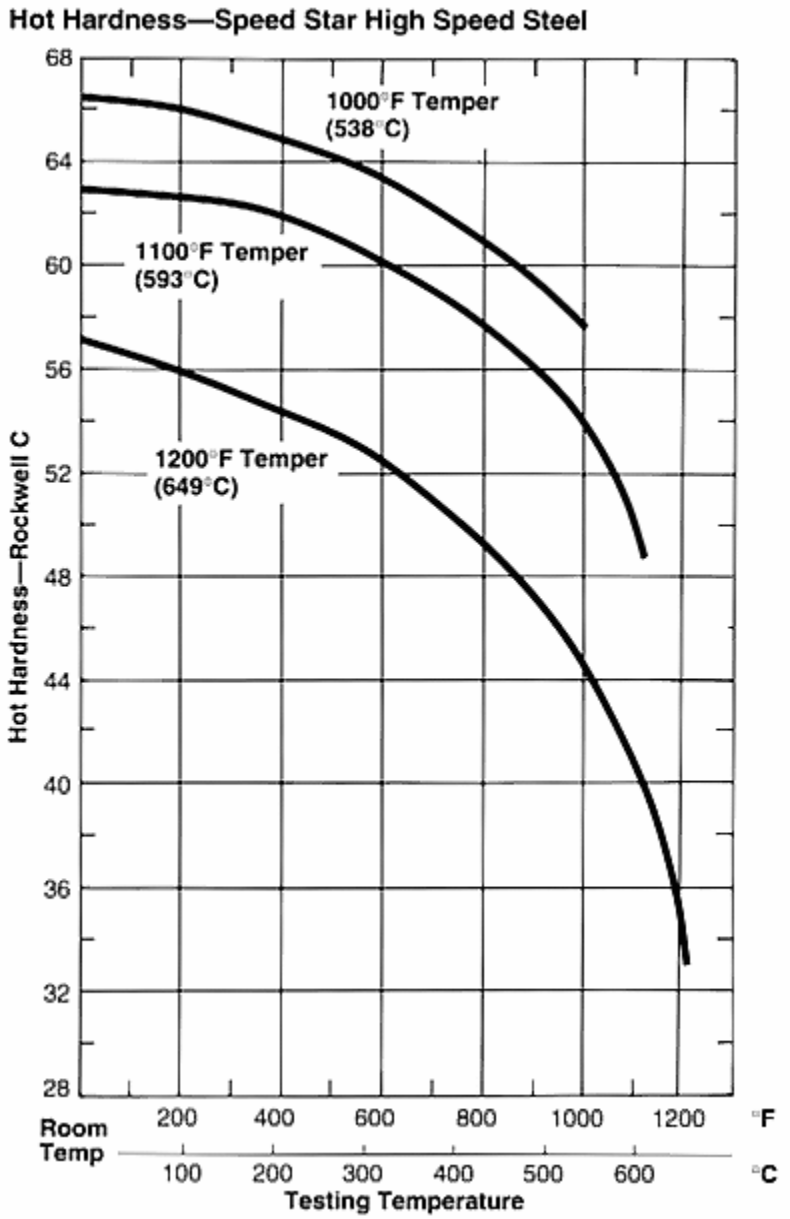
The determination of accurate, meaningful mechanical properties of high strength, notch sensitive materials is extremely difficult. Nevertheless, the following hyperlinks entitled "Hot Hardness, Yield Strength in Compression, Unnotched Izod Impact" give some idea of the strength of Speed Star High speed steel when properly treated and tempered over 900°F (482°C).

Unnotched Izod Impact—Speed Star High Speed Steel



Yield Strength in Compression— Speed Star High Speed Steel





Heat Treatment

Decarburization

Speed Star high speed steel, like all high-carbon tool steels, 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.

Annealing

For annealing, Speed Star high speed steel should either 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) and 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. This will produce a maximum hardness of Brinell 248.

Hardening

First, preheat to 1400/1500°F (760/816°C), then transfer to a superheating furnace with a temperature maintained at 2150/2250°F (1177/1232°C). When neutral salt baths are used for hardening, the temperature should be dropped 25°F (14°C) as compared to furnace temperatures.

Quench in oil - and be sure that tools are cooled below 200°F (93°C) before tempering (cool enough to hold in your hand).

Small sizes under about 1" (25.4mm) in diameter, or delicate sections may be hardened by cooling in still air. It is also quite acceptable to quench in molten salt at temperatures of 1000/1100°F (538/593°C), equalizing for 5 minutes per inch followed by air cooling.

Control of decarburization can be accomplished by using any one for the several modern heat treating furnaces designed for this purpose. If endothermic atmospheres are used, a dew point between +5/15°F (-15/-9.4°C) is suggested for the hardening furnace and +40/50°F (+4.4/10°C) for the preheat temperatures.

In older type manually operated exothermic atmosphere furnaces, preheat with a 5 to 8% CO reducing atmosphere. A 9 to 12% CO reducing atmosphere should be maintained while superheating.

If no atmosphere is available, the tool should be pack hardened or wrapped in stainless steel foil to protect its surface.Carpenter 06 is available in decarb-free flats. These decarb-free flats have a microinch finish of under 150 on all four sides, eliminating the need for bar bark removal.

Deformation (Size Change) in Hardening

Speed Star high speed steel changes size only slightly in hardening. A 1" (25.4mm) cube will expand about 0.0005" (0.013 mm) in hardening at 2225°F (1218°C), and will expand a like amount when tempered at 1050°F (556°C). Cutters and form tools will open up slightly in the I.D. and expand slightly on the O.D.

Stress Relieving

To relieve machining stresses for greater accuracy in hardening - first, rough machine, then heat to a temperature of 1200/1250°F (649/677°C), hold for a minimum of one hour at temperature and cool slowly - then finish machine.

Tempering

Be sure to allow sufficient time for the tool to reach the proper temperature and then start timing the tempering operation. Tools should be tempered immediately after the completion of the quench. For best results with most tools, a range of 1025/1050°F (552/566°C) should be used.

Many toolmakers have found it good practice to give high speed tools multiple tempers. The tools are tempered for two hours at 1050°F (566°C), cooled back to room temperature, then retempered for two hours more at a slightly lower temperature of 1000/1025°F (538/552°C). In some cases, a third temper is employed. This procedure produces good toughness at the maximum hardness value.

To secure maximum toughness on Speed Star high speed steel, harden from 2000/2100°F (1093/1150°C) and temper in the range of 700/900°F (371/482°C). This will yield Rockwell hardness of about C 62 with a greater measured toughness (at room temperature) than a two hour temper at 1050/1100°F (566/593°C).

Effect of Hardening and Tempering Temperature on Hardness — Speed Star High Speed Steel

Average values—Rockwell C scale.

Tempering Temperature Two Hours at Heat		Hardening Temperature Quenched in Oil		
		2150° F 1177° C	2200° F 1204° C	2275° F 1246° C
°F	°C			
As hardened		65	65	64
300	149	64	65	64
400	204	63	63	62
500	260	61	61	61
600	316	61	61	61
700	371	61	61	61
800	427	61	62	62
900	482	62	63	62
950	510	63	64	64
1000	538	64	65	65
1050	566	64	65	65
1100	593	63	64	64
1150	621	61	62	62

Workability

Forging

Preheat very slowly to 1500/1600°F (816/871°C), then increase the furnace temperature to full heat of 1950/2050°F (1066/1121°C).

Do not forge under 1700°F (927°C). Reheat as often as necessary.

Small, simple forgings may be cooled slowly in lime or ashes. The best practice for large forgings is to place them in a furnace heated to about 1400/1450°F (760/788°C), soak uniformly at this heat, then shut off the heat and let the forgings cool in the furnace. This is not an anneal. When the forgings are cool they should be properly annealed.

Machinability

The machinability of Speed Star high speed steel may be rated between 45 and 50% of Type W-1 tool steel or about 30 to 35% of B1112.

Following are typical feeds and speeds for Speed Star high speed steel.

The machinability of Speed Star high speed steel may be rated between 45 and 50% of Type W-1 tool steel or about 30 to 35% of B1112.

The following charts include typical machining parameters used to machine Speed Star high speed steel. The data listed should be used as a guide for initial machine setup only.

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
				Brazed	Throw Away		
.150	60	.015	M-42	225	280	.015	C-6
.025	75	.007	M-42	280	370	.007	C-7

Turning—Cut-Off and Form Tools

Speed, fpm	Feed, Inches per Rev.							Tool Material
	Cut-Off Tool Width, Inches			Form Tool Width, Inches				
	1/16	1/8	1/4	1/2	1	1-1/2	2	
60	.001	.001	.0015	.0015	.001	.0007	.0007	M-2
220	.002	.003	.0045	.003	.002	.0015	.0015	C-6

Drilling

Speed, fpm	Feed, Inches per Rev.								Tool Material
	Nominal Hole Diameter, Inches								
	1/16	1/8	1/4	1/2	3/4	1	1-1/2	2	
45	.001	.002	.003	.005	.007	.009	.011	.013	M-1; M-10

Tapping

Speed, fpm	Tool Material
25	M-1; M-7; M-10

Reaming

High Speed Tool								Carbide Tools	
Speed, fpm	Feed, Inches per Rev. Reamer Diameter, Inches						Tool Material	Speed, fpm	Tool Material
	1/8	1/4	1/2	1	1-1/2	2			
45	.003	.005	.008	.012	.015	.018	M-1;M-2;M-7	150	C-2

Die Threading

Speed, fpm				Tool Material
7 or Less	8 to 15	16 to 24	25 and up, T.P.I.	
8-12	12-18	18-25	20-30	M-1; M-2; M-7; M-10

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	70	.001	.002	.003	.004	M-2; M-7	275	.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	10	6	4	70	.006

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

Applicable Specifications

- ASTM A600
- QQ-T-590

Forms Manufactured

- Bar-Flats
- Bar-Rounds
- Bar-Squares

Technical Articles

- A Three-Point Program for Improving the Performance of Cold Work Tooling
- New Ideas for Machining Austenitic Stainless Steels
- New Powder Metal Alloy Bridges Gap Between High Speed Steel and Tungsten Carbide
- The ABC's of Alloy Selection, Heat Treating and Maintaining Cold Work Tooling

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