Technical Datasheet

# CarTech® S2 Tool Steel

## Identification

UNS Number

• T41902

AISI Number

• Type S2

## Type Analysis

*Single figures are nominal except where noted.*

| | | | |
|---|---|---|---|
| **Carbon** | 0.50 % | **Manganese** | 0.40 % |
| **Silicon** | 1.00 % | **Molybdenum** | 0.50 % |
| **Iron** | Balance | | |

## General Information

Description

CarTech S2® tool steel is a water hardening steel possessing extreme toughness. Even at Rockwell C 59/60, it will bend before it breaks. When hardened in medium and large size sections, CarTech S2 tool steel develops a hard case and a tough core. The combination of extreme toughness, hardness and wear resistance makes CarTech S2 tool steel suitable for use in many applications where other tool steels will not perform.

Applications

CarTech S2 tool steel should be considered for tools or parts that require extreme toughness or must not break. Examples Include:

Punches
Knock-out pins
Clutch pins
Indexing pins
Trimming dies
Crimping dies
Swaging dies
Wrenches
Fingers
Shear blades
Heavy-duty forming tools
Heavy-duty coining dies
Special knurls
Stamps
Jaws

CarTech S2 tool steel has also found application in "battering tools," such as:

Pneumatic chisels
Vanstoning dies
Concrete breakers
Caulking tools
Rivet busters
Beading tools
Track chisels
Pipe cutter wheels
Screw drivers
Rivet sets

## Properties

### Physical Properties

| Mean CTE | |
|---|---|
| 68 to 212°F | 6.04 x 10 -6 in/in/°F |
| 68 to 392°F | 6.63 x 10 -6 in/in/°F |
| 68 to 572°F | 7.24 x 10 -6 in/in/°F |
| 68 to 752°F | 7.54 x 10 -6 in/in/°F |
| 68 to 932°F | 7.83 x 10 -6 in/in/°F |
| 68 to 1112°F | 8.01 x 10 -6 in/in/°F |
| 68 to 1292°F | 8.12 x 10 -6 in/in/°F |
| 68 to 1382°F | 8.22 x 10 -6 in/in/°F |

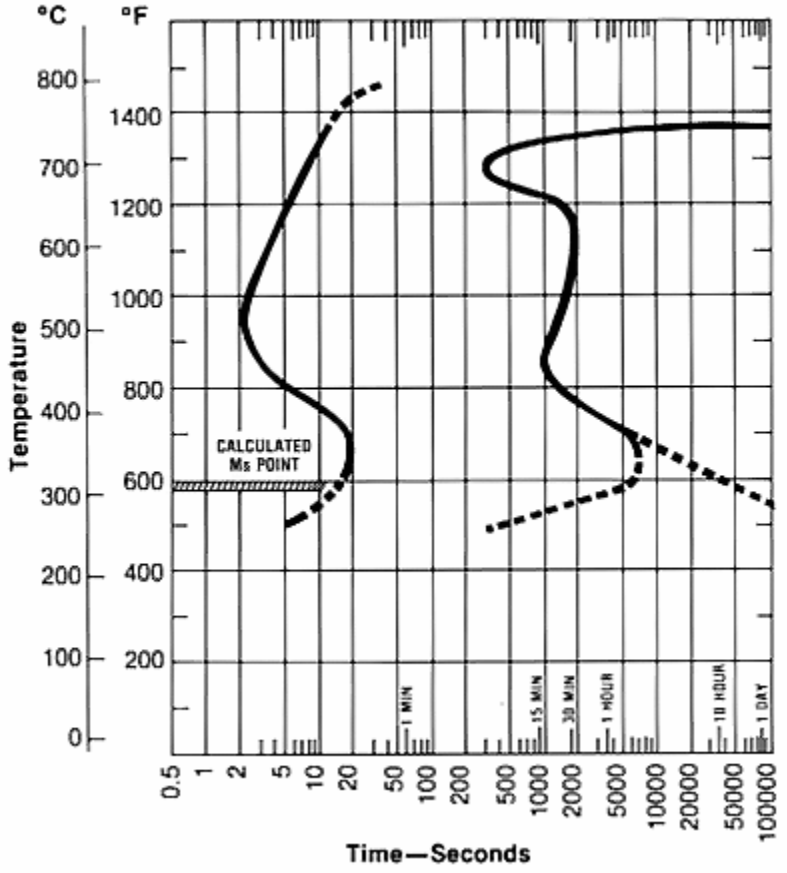
Mean coefficient of thermal expansion

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.

| 68°F to | 20°C to | 10⁻⁶/°F | 10⁻⁶/°C |
|---|---|---|---|
| 212 | 100 | 6.04 | 10.9 |
| 392 | 200 | 6.63 | 11.9 |
| 572 | 300 | 7.24 | 13.0 |
| 752 | 400 | 7.54 | 13.6 |
| 932 | 500 | 7.83 | 14.1 |
| 1112 | 600 | 8.01 | 14.4 |
| 1292 | 700 | 8.12 | 14.6 |
| 1382 | 750 | 8.22 | 14.8 |

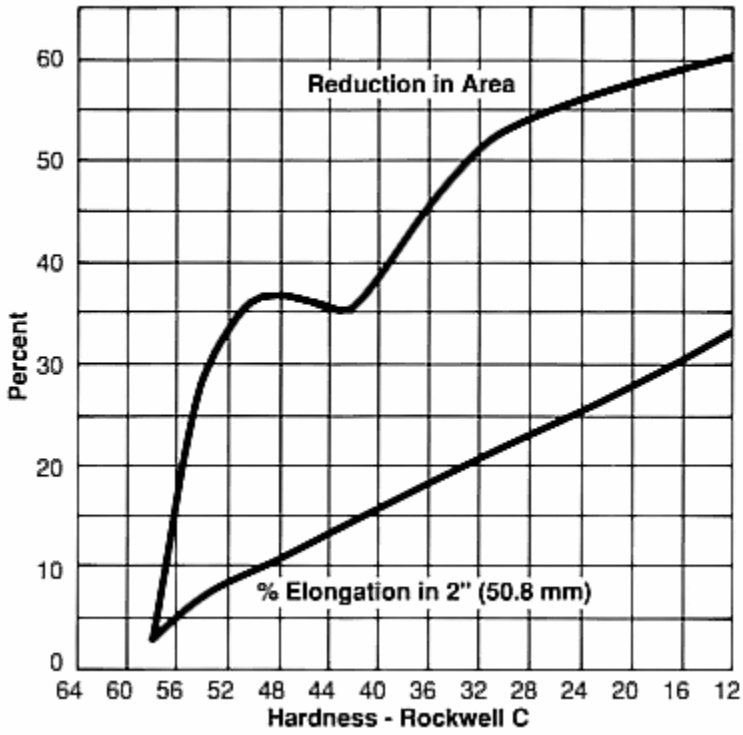
Isothermal transformation diagram - Solar Tool Steel

Austenitizing temperature - 1525°F (829°C)

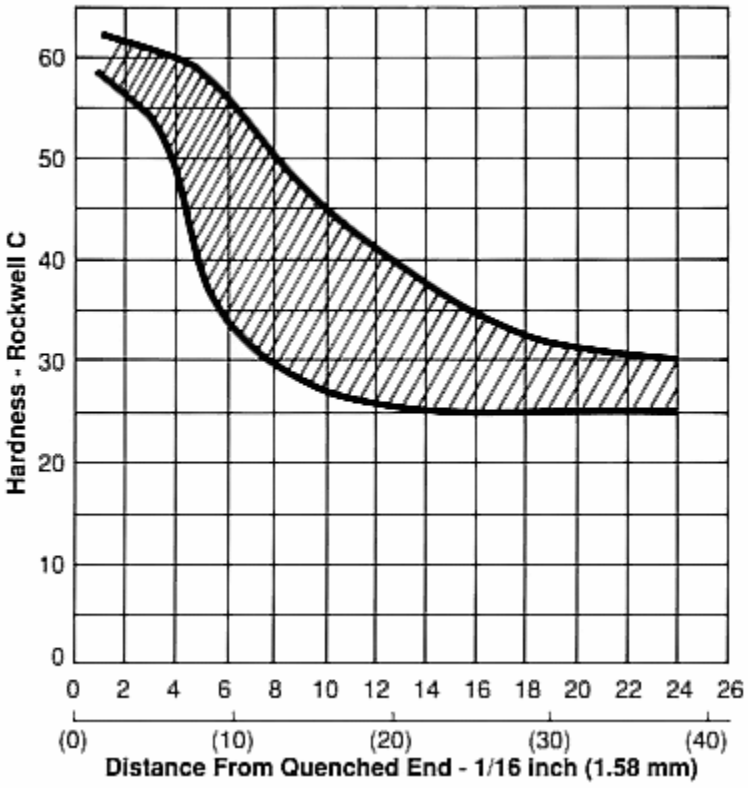


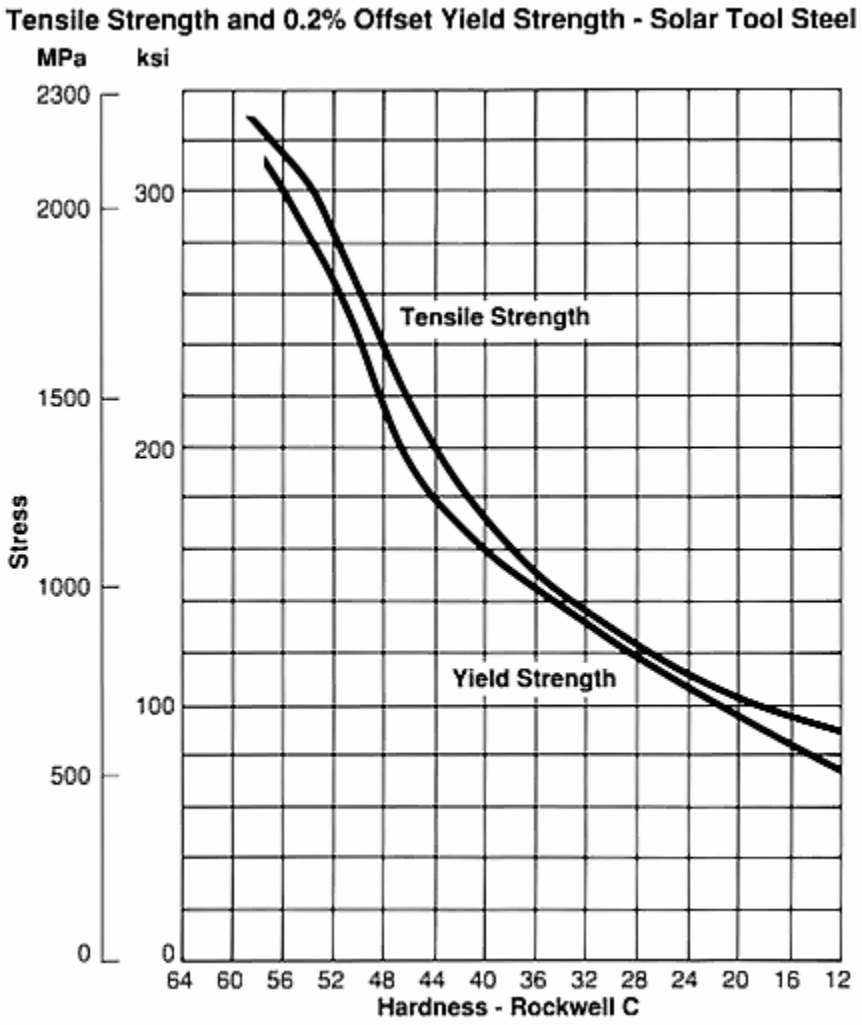
## Typical Mechanical Properties

% Elongation in 2 inches (50.8 mm) and Reduction in Area - Solar Tool Steel




Jominy Hardenability - Solar Tool Steel






## Heat Treatment

### Decarburization

Solar tool steel, like all high-carbon tool steels, is subject to decarburization during thermal processing and precautions must be taken to control this condition. Modern furnaces are available which provide environments designed to minimize decarburization.

### Normalizing

Forgings are normalized by heating to 1650°F (899°C) and cooling in air.

### Annealing

For annealing, Solar tool steel should either be placed in a controlled atmosphere furnace or packed in a suitable container, using a neutral packing compound. Heat uniformly to 1375/1425°F (746/774°C) and cool very slowly in the furnace at a rate of no 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 202.

### Hardening

During hardening, suitable protection should be provided to prevent excessive scaling and decarburization.

First, heat the salt bath or furnace to 1550°F (843°C). Without preheating, place the tool right in the hot furnace near the thermocouple and let it heat naturally until it uniformly matches the color of the thermocouple. Soak five minutes per inch of thickness, then quench in brine.

All water hardening steels should be quenched in 5% to 10% brine and may be quenched right down to bath temperatures.

Use flushing fixtures for quenching tools having hollow impressions.

Small tools under about 1/2" (12.7mm) in diameter can be heated to 1600°F (871°C) in controlled atmosphere furnaces or neutral salt baths and quenched in oil. This procedure results in less distortion and size change and less danger of cracking.

Control of decarburization can be accomplished by using any one of the several modern heat treating furnaces designed for this purpose. If endothermic atmospheres are used, a dew point between +45/50°F (+7/10°C) is suggested.

In older type manually operated exothermic atmosphere furnaces, an oxidizing atmosphere is required. Excess oxygen of about 2 to 4% is preferred.

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

### Deformation (Size Change) in Hardening

Solar tool steel tends to expand in large sizes where a straight carbon tool steel would shrink. Rectangular blocks of Solar tool steel will tend to harden with concave faces (the flat surfaces will become slightly hollow) where a straight carbon tool steel would bulge under similar conditions. Holes bored in Solar tool steel will tend to expand or open up in heat treatment. Allowance should be made for this size change. Solar tool steel is not suitable for use in tools and dies which require extreme accuracy during hardening.

### Stress Relieving

To relieve machining stresses for greater accuracy in hardening - first, rough machine, then anneal below the critical from 1200/1250°F (649/677°C) and cool slowly - then finish machine.

### Tempering

Solar tool steel should be tempered to achieve the hardness shown by the hyperlink titled "Effect of Tempering Temperature on Hardness." Most tools should be tempered at 300°F (149°C) to produce a hardness of Rockwell C 59/60. Shanks of pneumatic chisels should be tempered at 900°F (482°C). When Solar tool steel is oil quenched from 1600°F (871°C), temper at 275/300°F (135/149°C) to relieve hardening strains.

Do not temper solar tool steel to color because a straw color begins to appear at 400°F (204°C) - which is too high a temperature for most tools. Solar tool steel may be tempered back and used at lower hardnesses if evaluation of the application indicates that the sacrifice in wear resistance and gain in ductility warrant the higher tempering temperature.

**Effect of Tempering Temperature on Hardness - Solar Tool Steel**
Specimens brine or oil quenched from 1550/1600°F (843/871°C) and tempered 1 hour at indicated temperature.

| Tempering Temperature | | Rockwell C Hardness |
|---|---|---|
| °F | °C | |
| As quenched | | 61/63 |
| 300 | 149 | 59/60 |
| 400 | 204 | 57/58 |
| 500 | 260 | 55/56 |
| 600 | 316 | 54/55 |
| 700 | 371 | 52/53 |
| 800 | 427 | 49 |
| 900 | 482 | 45 |
| 1000 | 538 | 42/43 |
| 1100 | 593 | 38 |
| 1200 | 649 | 31 |
| 1300 | 704 | 23/24 |

## Workability

### Forging

Forge from a temperature not over 2100°F (1149°C). Heat rapidly and avoid unnecessary soaking in order to minimize surface decarburization. Cool the forgings in dry air.

### Machinability

The machinability of Solar tool steel may be rated between 65/75% of a 1% carbon water hardening tool steel, or about 45/55% of B1112. Approximate turning speeds of 85/110 surface feet per minute (0.43/0.56 m/s) are suggested when using high-speed cutting tools.

Following are typical feeds and speeds for Solar tool steel.

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 | 90 | .015 | M-2 | 310 | 410 | .020 | C-6 |
| .025 | 100 | .007 | M-3 | 410 | 500 | .007 | 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 | |
| 75 | .0015 | .002 | .0025 | .0025 | .0015 | .0015 | .001 | M-2 |
| 250 | .004 | .005 | .006 | .005 | .0035 | .0035 | .0025 | 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 | |
| 55 | .001 | .002 | .003 | .007 | .009 | .011 | .014 | .016 | M-1; M-10 |

Reaming

| High-Speed Tools | | | | | | | Carbide Tools | | |
|---|---|---|---|---|---|---|---|---|---|
| Speed, fpm | Feet, Inches per Rev | | | | | | Tool Material | Speed, fpm | Tool Material |
| | Reamer Diameter, Inches | | | | | | | | |
| | 1/8 | 1/4 | 1/2 | 1 | 1-1/2 | 2 | | | |
| 85 | .003 | .005 | .008 | .011 | .015 | .018 | M-7 | 250 | C-2 |

Milling—End Peripheral

| Depth of Cut In. | High-Speed Tools | | | | | | Carbide Tools | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Speed, fpm | Feed—Inches per Tooth | | | | Tool Material | Speed, fpm | Feed—Inches per Tooth | | | | Tool Material |
| | | Cutter Diameter, Inches | | | | | | Cutter Diameter, Inches | | | | |
| | | 1/4 | 1/2 | 3/4 | 1-2 | | | 1/4 | 1/2 | 3/4 | 1-2 | |
| .050 | 85 | .002 | .003 | .004 | .005 | M-2; M-7 | 365 | .002 | .003 | .005 | .007 | C-6 |

Broaching

| Speed, fpm | Chip Load, Inches per Tooth | Tool Material |
|---|---|---|
| 15 | .003 | M-42 |

Sawing—Power Hack Saw

| Pitch—Teeth per Inch | | | | Speed | Feed |
|---|---|---|---|---|---|
| Material Thickness, Inches | | | | | |
| 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 |

Additional Machinability Notes

Figures used for all metal removal operations 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.

Weldability

Solar tool steel can be satisfactorily welded under normal conditions. It is important that welding rod of the same type analysis is used. Brazing of insert dies of carbide tools on shanks of Solar tool steel has also been successfully done.

## Other Information

### Applicable Specifications

- ASTM A681
- QQ-T-570

### Forms Manufactured

- Bar-Rounds
- Billet



Edition Date: 08/01/1990