Technical Datasheet CARPENTER TECHNOLOGY

CarTech® Micro-Melt® A11 Tool Steel

Identification

UNS Number
- T30311

AISI Number
- A11

Type Analysis

Single figures are nominal except where noted.

Carbon	2.45 %	**Manganese**	0.50 %
Sulfur	0.080 %	**Silicon**	0.90 %
Chromium	5.30 %	**Molybdenum**	1.30 %
Vanadium	9.50 %	**Iron**	Balance

General Information

Description

CarTech Micro-Melt A11 tool steel is a high vanadium tool steel produced using the Carpenter CarTech Micro-Melt powder metal process. This grade possesses wear resistance superior to most other tool steels, including the high speed steels, along with good strength and toughness characteristics.

Many of the benefits realized in the use of CarTech Micro-Melt powder metals, such as CarTech Micro-Melt A11 alloy, are a direct result of the refined microstructure (smaller, more uniformly distributed carbide particles and a finer grain size) and the lack of segregation in the powder metallurgy product. These advantages include ease of grinding, improved response to heat treatment, greater wear resistance, and increased toughness of the finished tool.

CarTech Micro-Melt A11 Tool Steel is equivalent in hardness, wear resistance and heat treating response to CPM 10V* alloy.

* CPM and 10V are registered trademarks of Crucible Materials Corporation.

Applications

CarTech Micro-Melt A11 tool steel may be considered for many applications requiring excellent wear resistance at moderate working temperatures.

Possible applications for this alloy may include:

Punches
Dies for blanking
Piercing dies
Forming rolls and dies
Cold heading
Woodworking tools
Cold extrusion
Slitter knives
Shears
Pellitizer blades
Nozzles
Cold extrusion barrels
Cold extrusion liners
Plastic injection molds
Compacting tools
Steel mill rolls

Properties

Physical Properties

Specific Gravity	7.45	
Density	0.2670	lb/in^3
Mean CTE		
70 to 212°F	5.96	x 10 $^{-6}$ in/in/°F
70 to 300°F	6.10	x 10 $^{-6}$ in/in/°F
70 to 400°F	6.20	x 10 $^{-6}$ in/in/°F
70 to 500°F	6.19	x 10 $^{-6}$ in/in/°F
70 to 800°F	6.55	x 10 $^{-6}$ in/in/°F
70 to 1000°F	6.85	x 10 $^{-6}$ in/in/°F

Mean coefficient of thermal expansion

Temperature Range		Expansion Coefficient	
70°F to (°F)	21°C to (°C)	(in/in/°F) x 10^{-6}	(in/in/°C) x 10^{-6}
212	100	5.96	10.72
300	149	6.10	10.97
400	204	6.20	11.15
500	260	6.19	11.13
800	427	6.55	11.78
1000	538	6.85	12.32

Modulus of Elasticity (E)	29.0	x 10 ^{3} ksi

Typical Mechanical Properties

The determination of accurate mechanical properties on high strength-notch sensitive materials is extremely difficult; however, the following charts give some idea of the relative strength and toughness of Micro-Melt A11 tool steel.

3-Point Bend Test—Micro-Melt A11 Tool Steel

Heat Treatment	Hardness HRC	Break Strength	
		ksi	MPa
Aust. 1950°F (1066°C) 45 min., oil quench, temper 1000°F (538°C) 2hr. + 2 hr.	60.5	675	4654
Aust. 2050°F (1121°C) 30 min., oil quench, temper 1000°F (538°C) 2hr. + 2 hr.	62.5	715	4930

Unnotched Izod Impact Values—Micro-Melt A11 Tool Steel

Heat Treatment	Hardness HRC	Average Impact Values	
		ft/lb	Joules
Aust. 1950°F (1066°C) 30 min., air cool, temper 1000°F (538°C) 2hr. + 2 hr.	60.0	35	47
Aust. 2050°F (1121°C) 30 min., oil quench, temper 1000°F (538°C) 2hr. + 2 hr.	62.0	30	41
Aust. 2150°F (1177°C) 10 min., oil quench, temper 1000°F (538°C) 2 hr., refrigerate -100°F (-73°C) 1 hr., temper 1000°F (538°C) 2 hr., air cool	64.0	25	34

Heat Treatment

Decarburization

Like all high-carbon tool steels, Micro-Melt A11 tool steel is somewhat susceptible to decarburization in hardening. Means of preventing decarburization are well known. Use of modern furnaces such as protective atmosphere furnaces, salt pots, fluidized bed furnaces and vacuum furnaces should minimize decarburization of this alloy.

Normalizing

Normalizing is not recommended.

Annealing

Heat slowly to 1600/1650°F (871/899°C), hold for 2 hours, cool slowly at a rate of 20/40°F (11/22°C) per hour to 1000°F (538°C), then air cool. Typical annealed hardness will be 255 to 277 Brinell.

Hardening

Micro-Melt A11 tool steel should be heat treated using proper precautions to prevent decarburization. First, preheat to 1500/1550°F (816/843°C), equalize, and transfer to a furnace maintained at the desired hardening temperature. Alternatively, the tool may be preheated in the vacuum furnace that will be used for the austenitizing cycle.

Austenitize at 1850/2150°F (1010/1177°C) for 5 - 60 minutes, depending on the austenitizing temperature used. General suggestions for the austenitizing time to be used depending upon the austenitizing temperature chosen are given in the heat treatment table found at the end of this section.

For best toughness combined with good wear resistance, austenitize at 1950°F (1066°C) for 30-60 minutes, then air cool to room temperature. Temper immediately to HRC 58/61.

For balanced toughness and wear resistance, austenitize at 2050°F (1121°C) for 20 to 40 minutes, fan air cool, oil quench, or salt quench to 1000°F (538°C) followed by an air cool to room temperature. Alternatively, a vacuum furnace with a 4 bar minimum quench capability may be used. Temper immediately to HRC 60/62.

For the maximum wear resistance at some sacrifice in toughness, austenitize at 2150°F (1177°C) for 5 to 10 minutes, oil quench. If a vacuum furnace is used, it should have a 4 bar minimum quench capability. Temper immediately to HRC 63/65.

Deformation (Size Change) in Hardening

Micro-Melt A11 tool steel changes size only slightly after hardening. An expansion of about 0.0004 inches/inch is typical. Tools will open slightly in the ID and expand on the OD.

Stress Relieving

To relieve machining stresses for greater accuracy in hardening, first, rough machine, then heat to a temperature of 1150/1250°F (621/677°C), equalize, and cool slowly in still air.

Tempering

Tools should be tempered immediately after completion of the quench, when they have reached room temperature. The tempering temperature may be adjusted according to the hardness desired. Tempering is usually performed in the temperature range of 1000/1100°F (538/593°C).

Triple tempering and/or refrigeration at -100°F (-73°C) is suggested when hardening is performed above 2100°F (1149°C). If refrigeration is used, tools should be refrigerated immediately after the first temper.

The effects of the various hardening and tempering temperatures are shown in the following chart.

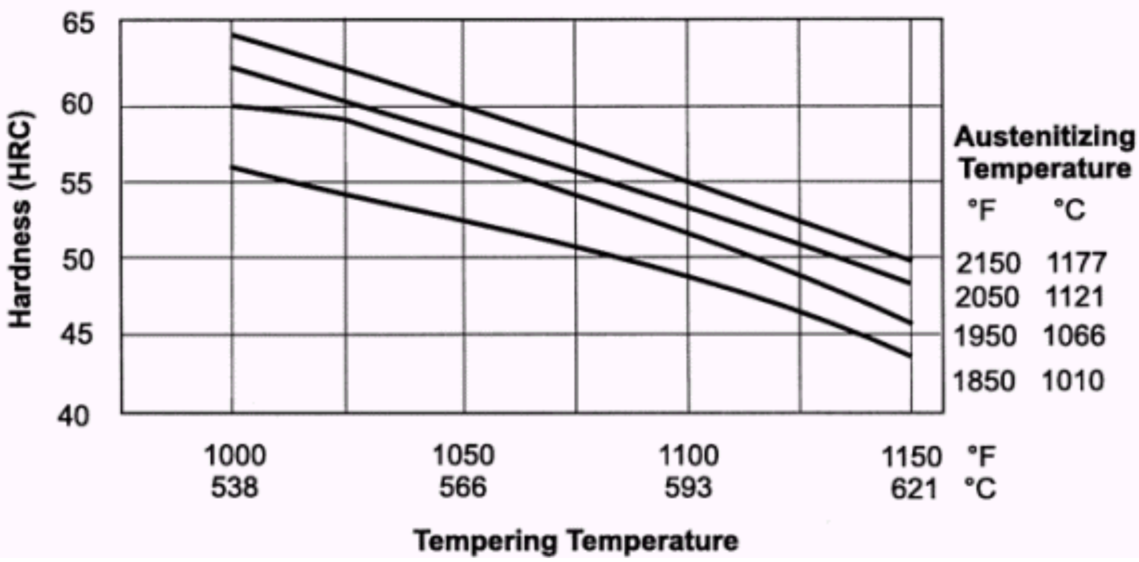
Effect of Hardening and Tempering Temperatures on Hardness—
Micro-Melt A11 Tool Steel

All samples was austenitized in salt for the indicated time at the indicated temperature, oil quenched, and tempered at the indicated temperature for 2 hours + 2 hours.

Tempering Temperature		Austenitized Temperature						
°F	°C	1850°F (1010°C)	1900°F (1038°C)	1950°F (1066°C)	2000°F (1093°C)	2050°F (1121°C)	2100°F (1149°C)	2150°F (1177°C)
As Quenched		—	—	64.5	—	64.0	—	62.5
1000	538	56.0	57.0	60.0	61.0	62.0	62.5	64.0
1025	551	54.0	56.0	59.0	59.5	60.0	61.0	62.0
1050	566	52.5	54.0	56.5	57.0	58.0	59.0	60.0
1100	593	49.0	50.0	52.0	53.0	53.5	54.5	55.0
1150	621	44.0	45.0	46.0	48.0	48.5	50.0	50.0
Austenitizing Time		60 min.	60 min.	45 min.	45 min.	30 min.	20 min.	10 min.

Effect of Hardening and Tempering Temperatures on Hardness—Micro-Melt A11 Tool Steel

All samples were austenitized in salt at the temperature/time combinations shown in the above table, oil quenched, and tempered at the indicated temperature for 2 hours + 2 hours.



Workability

Forging

Heat slowly to 2000°F/2100°F (1093/1149°C). Do not work below 1700°F (927°C). Reheat as necessary. Cool forgings slowly and anneal immediately upon cooling.

Machinability

The machinability of Micro-Melt A11 tool steel in the annealed condition may be rated between 35% to 40% of 1% carbon tool steel. Tooling providers' recommendations for cutting fluids should be followed.

Due to the presence of the fine, uniformly distributed carbides, the grindability of Micro-Melt tool steel is relatively good. Grinding wheel suppliers' recommendations should be followed. Grinding wheels containing ceramic particles may provide improved performance.

Micro-Melt A11 tool steel can be easily cut or machined using the EDM process with proper precautions to prevent and/or remove the "white layer."

Other Information

Wear Resistance

Wear resistance is measured using the Dry Sand/Rubber Wheel wear test (ASTM G65, Method A). Volume loss of the test sample is determined after a 30 minute test time. A lower sample volume loss indicates better wear resistance.

Comparative Dry Sand/Rubber Wheel Abrasion Tests—Micro-Melt A11 Tool Steel
ASTM G65 Method A wear test.

Alloy	Hardness (HRC)	Volume Loss (mm³)
Micro-Melt A11 Alloy	64.0	9.0
Micro-Melt A11 Alloy	60.0	11.1
Micro-Melt A11-LVC Alloy	55.0	14.4
Micro-Melt A11-LVC Alloy	49.0	16.3
AISI M2	65.0	23.3
AISI D2	60.0	41.0
AISI A2	60.0	62.6
AISI H13	51.0	127.0

Forms Manufactured

- Bar-Flats
- Bar-Rounds
- Bar-Squares
- Billet
- HIP'd Shapes
- Plate
- Powder
- Wire

Technical Articles

- A New Guide for Selecting Ferrous Alloys, Tungsten Carbides and Ceramics for Tooling
- The ABC's of Alloy Selection, Heat Treating and Maintaining Cold Work Tooling

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