Technical Datasheet CARPENTER TECHNOLOGY

CarTech® Micro-Melt® A11-LVC Tool Steel

Type Analysis

Single figures are nominal except where noted.

Carbon	1.70 to 1.85 %	**Manganese**	0.35 to 0.60 %
Sulfur (Maximum)	0.030 %	**Silicon**	0.75 to 1.10 %
Chromium	4.75 to 5.75 %	**Molybdenum**	1.10 to 1.50 %
Vanadium	8.25 to 9.50 %	**Iron**	Balance

General Information

Description

CarTech Micro-Melt A11-LVC tool steel is a high vanadium tool steel produced using the Carpenter CarTech Micro-Melt powder process. This grade possesses wear resistance superior to most other tool steels along with good strength and toughness characteristics. In addition, it provides higher toughness characteristics than CarTech Micro-Melt A11 alloy with slightly lower wear resistance.

Many of the benefits realized in the use of CarTech Micro-Melt powder metals, such as CarTech Micro-Melt A11-LVC 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-LVC Tool Steel is equivalent in hardness, wear resistance and heat treating response to CPM 9V* alloy.

* CPM and 9V are registered trademarks of Crucible Materials Corporation.

Applications

CarTech Micro-Melt A11-LVC tool steel may be considered for applications where less wear resistance than CarTech Micro-Melt A11 tool steel is needed but more toughness is required. The applications for which this tool steel should be considered may include:

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

Properties

Physical Properties

Specific Gravity	7.45	
Density	0.2670	lb/in³

Mean CTE	
70 to 212°F, Annealed	6.05 x 10^{-6} in/in/°F
70 to 400°F, Annealed	6.13 x 10^{-6} in/in/°F
70 to 800°F, Annealed	6.48 x 10^{-6} in/in/°F
70 to 1200°F, Annealed	6.69 x 10^{-6} in/in/°F
70 to 1450°F, Annealed	6.86 x 10^{-6} in/in/°F
500 to 1200°F, Annealed	6.97 x 10^{-6} in/in/°F
500 to 1450°F, Annealed	7.13 x 10^{-6} in/in/°F
70 to 212°F, Hardened and Tempered	6.25 x 10^{-6} in/in/°F
70 to 400°F, Hardened and Tempered	6.34 x 10^{-6} in/in/°F
70 to 800°F, Hardened and Tempered	6.60 x 10^{-6} in/in/°F
70 to 1200°F, Hardened and Tempered	6.78 x 10^{-6} in/in/°F
70 to 1450°F, Hardened and Tempered	6.96 x 10^{-6} in/in/°F
500 to 1200°F, Hardened and Tempered	6.99 x 10^{-6} in/in/°F
500 to 1450°F, Hardened and Tempered	7.20 x 10^{-6} in/in/°F

Mean coefficient of thermal expansion

Temperature Range		Coefficient			
		Annealed		Hardened and Tempered	
		(in/in)/°F x 10^{-6}	(mm/mm)/°C x 10^{-6}	(in/in)/°F x 10^{-6}	(mm/mm)/°C x 10^{-6}
70°F to 212°F	21°C to 100°C	6.05	10.89	6.25	11.25
70°F to 400°F	21°C to 204°C	6.13	11.03	6.34	11.42
70°F to 800°F	21°C to 427°C	6.48	11.67	6.60	11.88
70°F to 1200°F	21°C to 649°C	6.69	12.05	6.78	12.20
70°F to 1450°F	21°C to 788°C	6.86	12.35	6.96	12.53
500°F to 1200°F	260°C to 649°C	6.97	12.55	6.99	12.58
500°F to 1450°F	260°C to 788°C	7.13	12.84	7.20	12.96

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-LVC tool steel.

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

Heat Treatment	Hardness HRC	Break Strength		UTS	
		ksi	MPa	ksi	MPa
Tough Treat 1950°F (1066°C) 45 min, air cool, temper 1100°F (593°C) 2hr + 2 hr	49.0	605	4171	610	4206
Wear Treat 2050°F (1121°C) 30 min, air cool, temper 1075°F (579°C) 2hr + 2 hr	55.0	730	5033	735	5068

Unnotched Izod Impact Values—Micro-Melt A11-LVC Tool Steel

Heat Treatment	Hardness HRC	Impact Values ft/lb
Tough Treat 1950°F (1066°C) 1 hr, air cool, temper 1100°F (593°C) 2hr + 2 hr	50.0	30 Transverse 100 Longitudinal
Wear Treat 2050°F (1121°C) 30 min, air cool, temper 1075°F (579°C) 2hr + 2 hr	54.0	25 Transverse 85 Longitudinal

Heat Treatment

Decarburization

Micro-Melt A11-LVC tool steel, like all high carbon tool steels, is somewhat susceptible to decarburization in hardening. Means of preventing decarburization are well known. Modern furnaces which employ protective environments, such as protective atmospheres, salt pots, fluidized bed furnaces and vacuum furnaces, should present no difficulty with 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-LVC 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. Tools are usually held at heat for 30 to 60 minutes.

Tough Treatment:
Austenitize at 1950°F (1066°C) 30/60 minutes, air cool. Temper immediately to HRC 48/50.

Wear Treatment:
Austenitize at 2050°F (1121°C) 15/30 minutes, air cool. Temper immediately to HRC 53/55.

Note: For larger section sizes, fan air cooling or step quenching in oil or salt may be used in order to obtain the optimum quench rate.

Deformation (Size Change) in Hardening

Micro-Melt A11-LVC tool steel changes size only slightly after hardening. An expansion of about 0.0005 inches/inch is typical. Tools will open up 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 hardening treatment. The tempering temperature may be adjusted according to the final hardness desired. Tempering is usually performed in the temperature range of 1000/1100°F (538/593°C).

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

**Effect of Hardening and Tempering Temperatures on Hardness—
Micro-Melt A11-LVC Tool Steel**
All samples were austenitized for 30 minutes in salt, air cooled and tempered for 2 hr. + 2 hr.

Tempering Temperature		Average Rockwell C Hardness				
°F	°C	1900°F (1038°C)	1950°F (1066°C)	2000°F (1093°C)	2050°F (1121°C)	2100°F (1149°C)
As Quenched		55.0	58.0	59.5	61.0	62.0
1000	538	54.5	56.0	57.0	58.5	60.0
1025	551	54.0	55.0	56.0	57.5	59.5
1050	566	52.0	53.5	54.0	55.5	57.0
1100	593	47.5	49.0	50.5	52.0	53.0
1150	621	41.0	43.0	44.0	46.5	47.0
1200	649	35.5	36.5	39.0	40.0	41.5

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-LVC tool steel in the annealed condition may be rated between 35 and 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 A11-LVC tool steel is relatively good. Grinding wheel suppliers' recommendations should be followed. Grinding wheels containing ceramic particles may provide improved performance.

Micro-Melt A11-LVC tool steel can be easily EDM'd. Use 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
ASTM G65 Method A Wear Test.

Alloy / Treatment	Hardness (HRC)	Volume Loss (mm³)
Micro-Melt A11-LVC / Wear Treatment	55.0	14.4
Micro-Melt A11-LVC / Tough Treatment	49.0	16.3
Micro-Melt A11 / Wear Treatment	63.0	9.0
Micro-Melt A11 / Tough Treatment	59.0	12.0
AISI M2 / Standard Treatment*	65.0	23.3
AISI D2 / Standard Treatment*	60.0	41.0
AISI A2 / Standard Treatment*	60.0	62.6
AISI H13 / Standard Treatment*	51.0	127.0

* Standard treatment refers to standard hardening/tempering treatment for these grades.

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

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