Technical Datasheet

CARPENTER

Micro-Melt® M4 Alloy

Type Analysis

Carbon	1.45 %	**Manganese**	0.40 %
Sulfur	0.130 %	**Silicon**	0.40 %
Chromium	4.50 %	**Molybdenum**	4.50 %
Vanadium	4.00 %	**Tungsten**	5.75 %
Iron	78.87 %		

In addition, the alloy can be produced with either increased or decreased sulfur levels, depending upon machinability or cleanness requirements.

General Information

Description

Micro-Melt® M4 alloy is a molybdenum-tungsten powder high speed tool steel containing high carbon and vanadium. This grade possesses very high wear resistance coupled with high strength.

Many of the benefits realized in the use of Micro-Melt powder metals, such as Micro-Melt M4 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.

In addition, Carpenter's unique hot rolling and rotary forging capabilities impart minimal distortion characteristics to these alloys.

Applications

Micro-Melt M4 alloy may be considered for many types of tooling applications where good toughness, improved grindability and wear resistance are important.

Possible applications for this alloy may include:

Lathe tools
Planer tools
Drills
Taps
Reamers
Broaches
Milling cutters
Form cutters
Thread chasers
Hobs
Counterbores
Insert-heading dies

Properties

Physical Properties

Specific Gravity	7.97	
Density	0.2860	lb/in³
Mean CTE		
100 to 500°F	5.31	x 10^{-6} in/in/°F
100 to 800°F	6.25	x 10^{-6} in/in/°F
100 to 1000°F	6.64	x 10^{-6} in/in/°F
100 to 1200°F	6.81	x 10^{-6} in/in/°F
100 to 1500°F	6.99	x 10^{-6} in/in/°F

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Mean Coefficient of Thermal Expansion

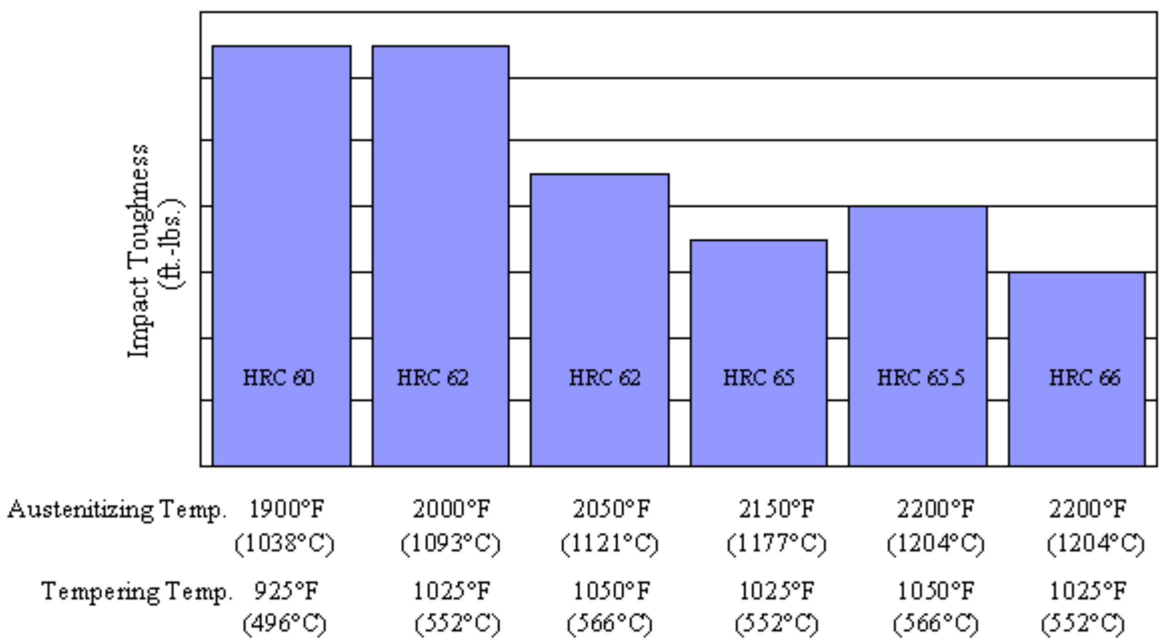
Temperature Range		Expansion Coefficient	
100°F to (°F)	38°C to (°C)	(in/in/°F) x 10^{-6}	(in/in/°C) x 10^{-6}
500	260	5.31	9.56
800	427	6.25	11.25
1000	538	6.64	11.95
1200	649	6.81	12.26
1500	816	6.99	12.58

Modulus of Elasticity (E) 31.0 x 10^{3} ksi

Typical Mechanical Properties

The determination of accurate mechanical properties on high-strength, notch-sensitive materials is extremely difficult. Nevertheless, the following graph entitled “Relative Unnotched Izod Impact Toughness of Micro-Melt M4 Given Various Heat Treatments” gives some idea of the relative toughness resulting from different heat treating practices on Micro-Melt M4 alloy

Relative Unnotched Izod Impact Toughness of Micro-Melt® M4 Alloy Given Various Heat Treatments



Heat Treatment

Decarburization

Micro-Melt M4 alloy is somewhat susceptible to decarburization in hardening. However, use of a controlled atmosphere furnace will insure that there is no decarburization during heat treatment. Use of modern furnaces such as protective atmosphere furnaces, salt pots, fluidized bed furnaces and vacuum furnaces should minimize decarburization of this alloy.

Annealing

Suitable precautions should be taken to prevent carburization and decarburization.

Heat slowly to 1560/1620°F (849/882°C) and cool slowly in the furnace to 1100°F (593°C) at a rate of 20/40°F (11/22°C) per hour. Brinell hardness should be in the range 207/248.

Hardening

Micro-Melt M4 alloy should be heat treated using proper precautions to prevent decarburization.

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First, preheat to 1400/1500°F (760/816°C), equalize, and transfer to a furnace maintained at the desired hardening temperature. Alternatively, the tool may be preheated in the vacuum furnace which will be used for the austenitizing cycle.

Austenitize at 1900/2200°F (1038/1204°C) for 3 - 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 at the end of this section.

Quench in oil - and be sure that tools are cooled below 200°F (93°C) before tempering (cool enough to hold in your hand). If a vacuum furnace is used, it should have a 4 bar minimum quench capability.

Small sizes under 1" (25.4 mm) in diameter or delicate sections may be hardened by cooling in still air. It is also 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.

Deformation (Size Change) in Hardening

Micro-Melt M4 alloy changes size only slightly in hardening. A 1" (25.4 mm) cube will expand about 0.0005" (0.013 mm) in hardening at 2200°F (1204°C) and will expand a like amount when tempered at 1025°F (552°C). Cutters and form tools will open up slightly in the hole, and expand slightly on the OD.

Stress Relieving

To relieve machining stresses for greater accuracy in hardening, first rough machine, then heat slowly to 1250/1300°F (677/704°C) allow to equalize, then cool in still air. Finish machining tools after cooling.

Tempering

Be sure to allow sufficient time for the tool to reach the proper temperature and then start timing the tempering operation.

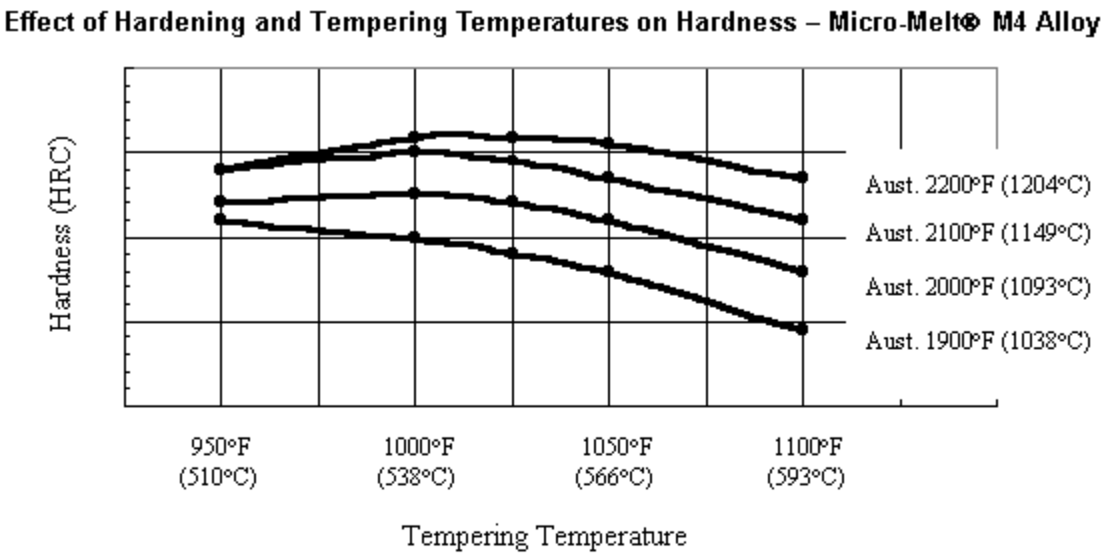
Tools should be tempered immediately after the completion of the quench. For best results with most tools, a range of 1000/1150°F (538/621°C) is suitable. For cutting tools, double or triple temper at 1010/1050°F (543/566°C) where maximum wear resistance is desired.

The effects of various hardening and tempering temperatures on the Rockwell hardness of Micro-Melt M4 alloy are illustrated in the hyperlinks titled "Effect of Tempering Temperature on Hardness" and "Effect of Tempering Temperature on Hardness – Figure".

Effect of Hardening and Tempering Temperatures on Hardness – Micro-Melt® M4 Alloy

Tempering Temperature		Austenitizing Temperature					
°F	°C	1900°F (1038°C)	2000°F (1093°C)	2050°F (1121°C)	2100°F (1149°C)	2150°F (1177°C)	2200°F (1204°C)
950	510	60.5/61.5	61.5/62.5	62.5/63.5	63.5/64.5	64.0/65.0	63.5/64.5
1000	538	59.5/60.5	62.0/63.0	63.5/64.5	64.5/65.5	65.5/66.5	65.5/66.5
1025	551	58.5/59.5	61.5/62.5	62.5/63.5	63.5/64.5	65.0/66.0	65.5/66.5
1050	566	57.5/58.5	61.0/62.0	61.5/62.5	63.0/64.0	64.5/65.5	65.0/66.0
1100	593	54.0/55.0	57.5/58.5	58.5/59.5	60.5/61.5	62.5/63.5	63.0/64.0
1150	621	49.5/50.5	52.5/53.5	53.5/54.5	55.5/56.5	56.5/57.5	57.5/58.5
Austenitizing Time		60 min.	45 min.	30 min.	20 min.	12 min.	3-5 min.

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



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

Workability

Machinability

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

Micro-Melt M4 alloy 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

The relative wear resistance of Carpenter Micro-Melt M4 alloy compared to other high speed steels is shown in the figure "Relative Wear Resistance of High Speed Steels." Wear resistance was measured using a Dry Sand/Rubber Wheel abrasion test, ASTM G65. Results were normalized, with a higher value indicating better wear resistance.

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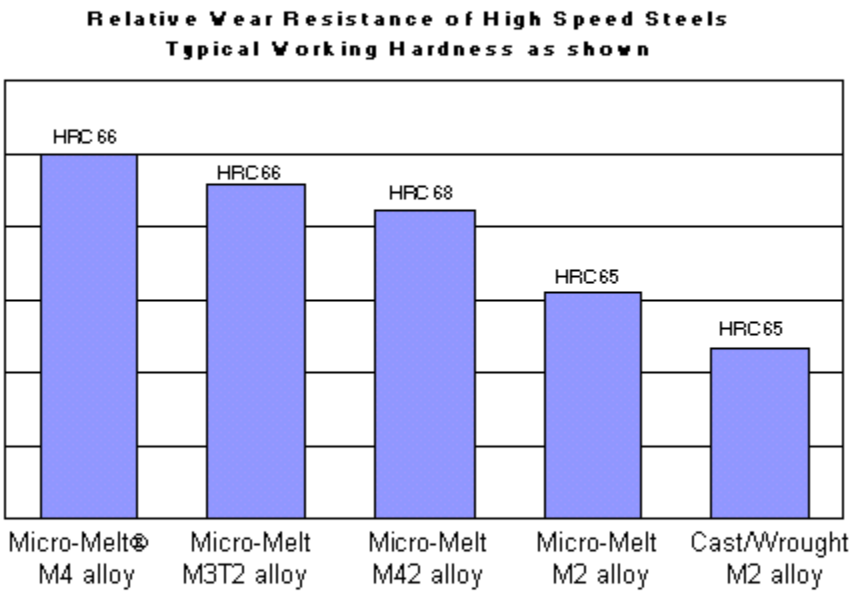

Forms Manufactured

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

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
- New Powder Metal Alloy Bridges Gap Between High Speed Steel and Tungsten Carbide
- New Powder Metal Die Steel for Cold Work Tooling Applications
- The ABC's of Alloy Selection, Heat Treating and Maintaining Cold Work Tooling