Technical Datasheet CARPENTER TECHNOLOGY

CarTech® AerMet®-for-Tooling Alloy

Identification

UNS Number

• K92580

Type Analysis

Single figures are nominal except where noted.

Carbon	0.23 %	**Chromium**	3.00 %
Nickel	11.10 %	**Molybdenum**	1.20 %
Cobalt	13.40 %	**Iron**	Balance

General Information

Description

CarTech AerMet-for-Tooling alloy is a double-vacuum melted alloy possessing high hardness and strength combined with exceptional ductility and toughness. The alloy is designed for components which require a combination of HRC 53/55 hardness with the highest toughness available.

Applications

CarTech AerMet-for-Tooling alloy should be considered as a candidate for use in applications such as:

Punches
Blanking dies
Crimping dies
Embossing dies
Shrink rings
Test equipment
Collets
Chuck jaws
Shear blades
Jigs
Fixtures
Structural members
Coining dies
Shafts
Mandrels
Retaining rings
Swaging tools

Properties

Physical Properties

Density	0.2850 lb/in^3

Mean CTE		
75 to 200°F, Annealed	5.49	$\times 10^{-6}$ in/in/°F
75 to 300°F, Annealed	5.73	$\times 10^{-6}$ in/in/°F
75 to 400°F, Annealed	5.83	$\times 10^{-6}$ in/in/°F
75 to 500°F, Annealed	5.92	$\times 10^{-6}$ in/in/°F
75 to 600°F, Annealed	6.01	$\times 10^{-6}$ in/in/°F
75 to 700°F, Annealed	6.10	$\times 10^{-6}$ in/in/°F
75 to 800°F, Annealed	6.20	$\times 10^{-6}$ in/in/°F
75 to 900°F, Annealed	6.29	$\times 10^{-6}$ in/in/°F
75 to 1000°F, Annealed	6.28	$\times 10^{-6}$ in/in/°F
75 to 200°F, Heat Treated	5.55	$\times 10^{-6}$ in/in/°F
75 to 300°F, Heat Treated	5.77	$\times 10^{-6}$ in/in/°F
75 to 400°F, Heat Treated	5.88	$\times 10^{-6}$ in/in/°F
75 to 500°F, Heat Treated	6.00	$\times 10^{-6}$ in/in/°F
75 to 600°F, Heat Treated	6.08	$\times 10^{-6}$ in/in/°F
75 to 700°F, Heat Treated	6.16	$\times 10^{-6}$ in/in/°F
75 to 800°F, Heat Treated	6.25	$\times 10^{-6}$ in/in/°F
75 to 900°F, Heat Treated	6.34	$\times 10^{-6}$ in/in/°F
75 to 1000°F, Heat Treated	6.43	$\times 10^{-6}$ in/in/°F

Mean coefficient of thermal expansion

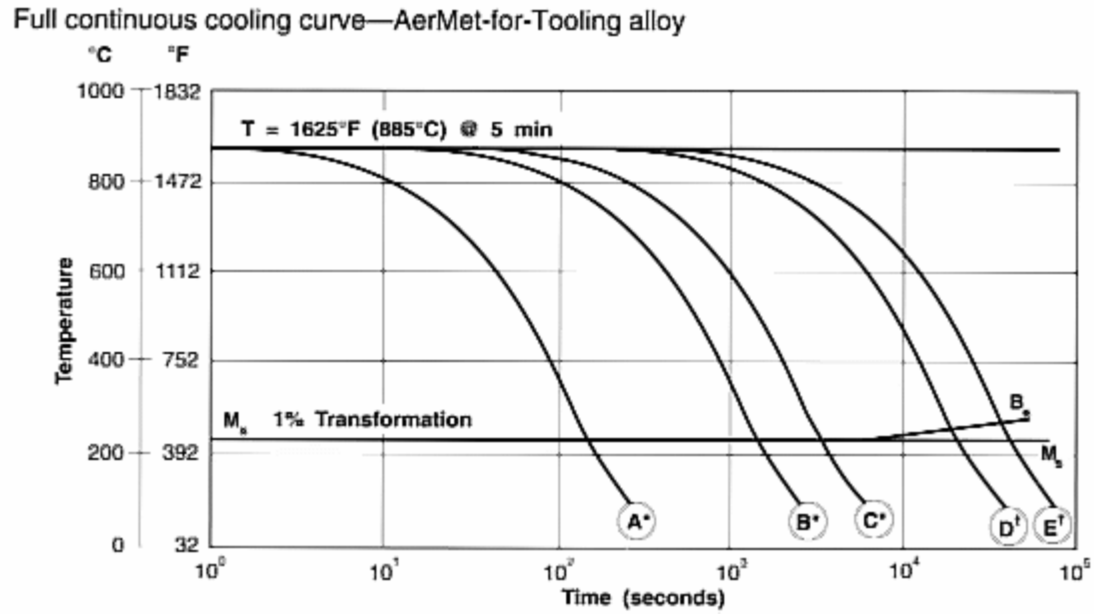
Temperature Range		Condition			
		Annealed		Heat Treated	
75°F to (°F)	25°C to (°C)	$\times 10^{-6}$/°F	$\times 10^{-6}$/°C	$\times 10^{-6}$/°F	$\times 10^{-6}$/°C
200	93	5.49	9.88	5.55	9.99
300	149	5.73	10.31	5.77	10.39
400	204	5.83	10.49	5.88	10.58
500	260	5.92	10.66	6.00	10.80
600	316	6.01	10.82	6.08	10.94
700	371	6.10	10.98	6.16	11.09
800	427	6.20	11.16	6.25	11.25
900	482	6.29	11.32	6.34	11.41
1000	538	6.28	11.30	6.43	11.57

Thermal Conductivity		
77°F	172.0	BTU-in/hr/ft²/°F
212°F	190.0	BTU-in/hr/ft²/°F
392°F	212.0	BTU-in/hr/ft²/°F
572°F	222.0	BTU-in/hr/ft²/°F
752°F	226.0	BTU-in/hr/ft²/°F

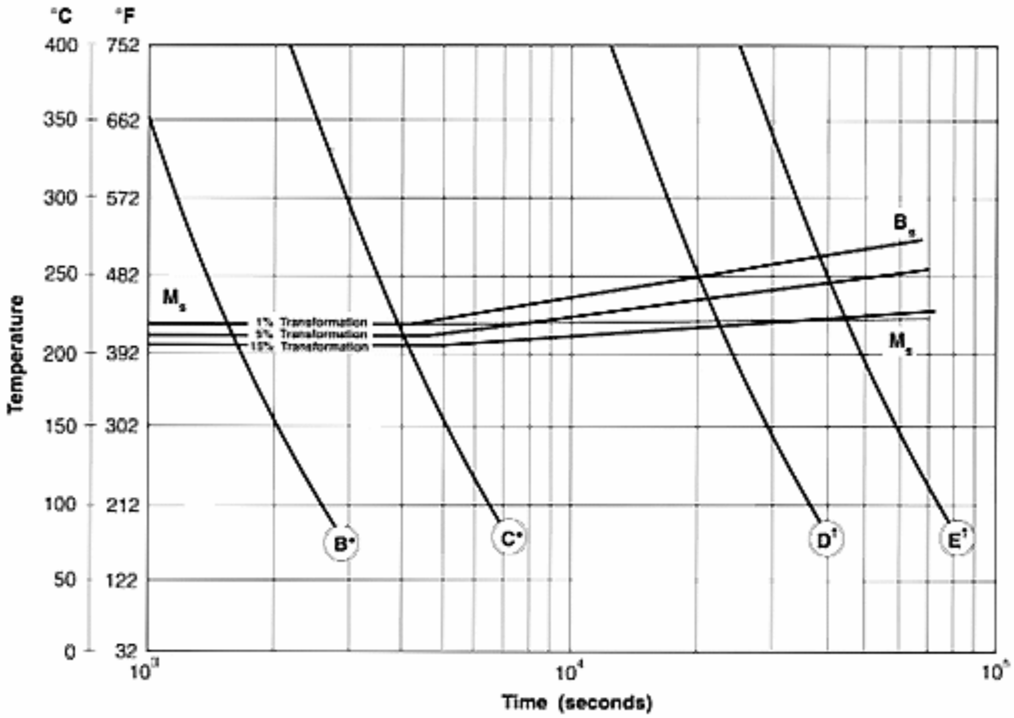
Thermal conductivity

Test Temperature		Btu-in/ft²•h•°F	W/m•K
°F	°C		
77	25	172	24.8
212	100	190	27.4
392	200	212	30.6
572	300	222	32.0
752	400	226	32.6

Modulus of Elasticity (E)	28.2	$\times 10^{3}$ ksi
Critical Temperature (AC1)	1065	°F
Critical Temperature (AC3)	1524	°F


Full continuous cooling curve—AerMet-for-Tooling alloy
°C
°F
1000
1832
800
1472
600
1112
400
752
200
392
0
32
Temperature
T = 1625°F (885°C) @ 5 min
Ms 1% Transformation
Bs
Ms
A*
B*
C*
D†
E†
10^0
10^1
10^2
10^3
10^4
10^5
Time (seconds)

Partial continuous cooling curve—AerMet-for-Tooling alloy
This partial curve represents a critical region of the continuous cooling curve as well as the inclusion of 5 and 15% transformation lines.



* .12" (3 mm) diameter x .39" (10 mm) rod heated to 1625°F (885°C) at 360°F (200°C) per minute, held at 1625°F (885°C) for 5 min, quenched with helium gas.

† .12" (3 mm) diameter x .31" (8 mm) rod heated to 1625°F (885°C) at 360°F (200°C) per minute, held at 1625°F (885°C) for 5 min, quenched with helium gas.

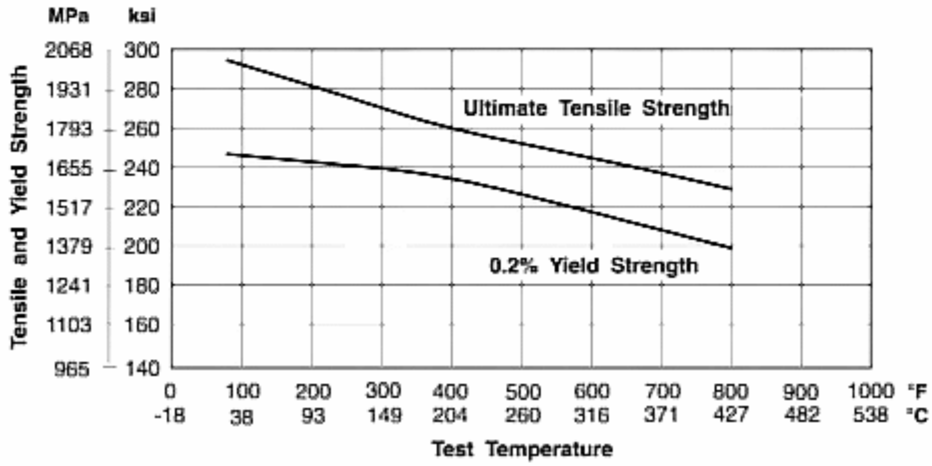
The following chart contains a summary of the data from the partial continuous cooling curve.

Sample ID	Cooling Time Seconds	M_s		B_s		Hardness HRC
		°F	°C	°F	°C	
A	200	437	225	–	–	55.5
B	2000	437	225	–	–	53.0
C	5000	437	225	–	–	52.5
D	28800	428	220	482	250	51.5
E	57600	423	217	500	260	51.5

Typical Mechanical Properties

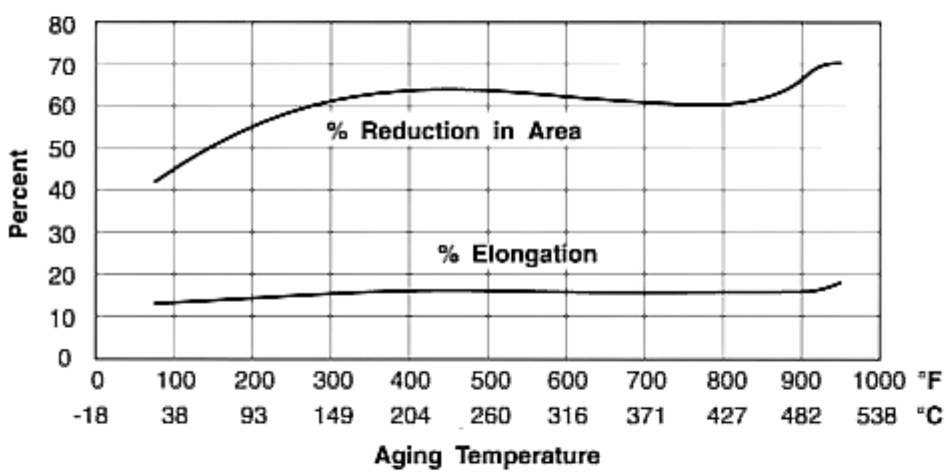
0.2% Offset Yield Strength and Ultimate Tensile Strength vs. Test Temperature—AerMet-for-Tooling Alloy

Heat treated 1625°F (885°C) 1 hour, vermiculite cooled, refrigerated -100°F (-73°C) 1 hour, air warmed, aged 900°F (482°C) 5 hours, air cooled.



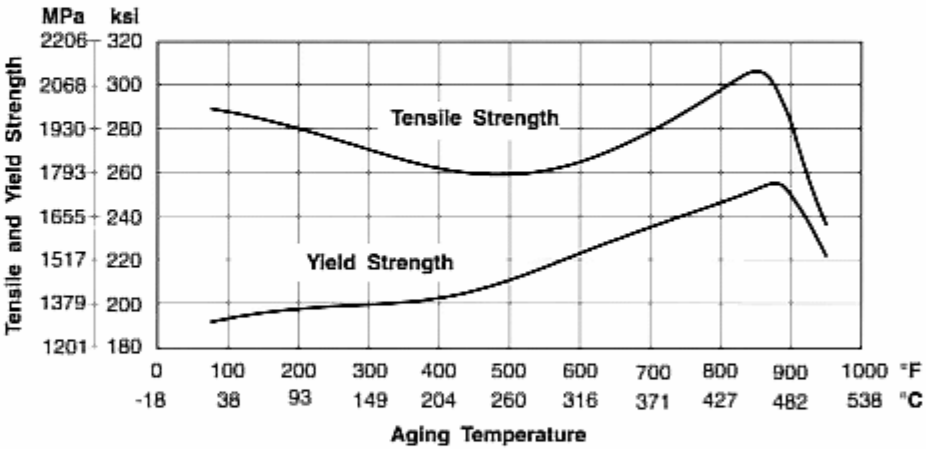
Effect of Aging Temperature on Reduction of Area and Elongation—AerMet-for-Tooling Alloy

Longitudinal orientation. Heat treated 1625°F (885°C) 1 hour, air cooled, refrigerated -100°F (-73°C) 1 hour, air warmed, aged 5 hours, air cooled.



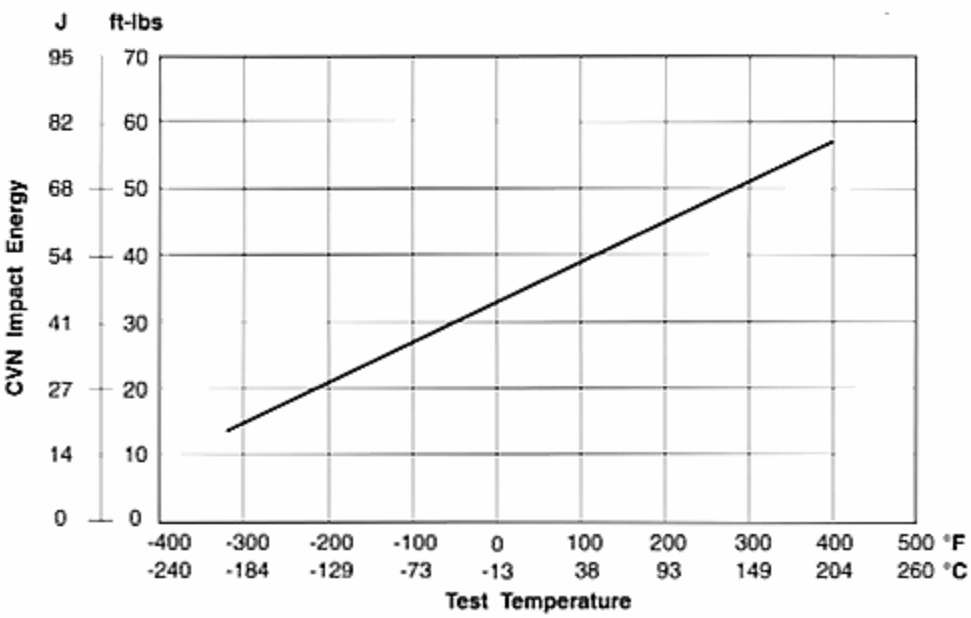
Effect of Aging Temperature on Tensile and Yield Strengths—AerMet-for-Tooling Alloy

Longitudinal orientation. Heat treated 1625°F (885°C) 1 hour, air cooled, refrigerated -100°F (-73°C) 1 hour, air warmed, aged 5 hours, air cooled.



Typical Charpy V-Notch Impact Energy—AerMet-for-Tooling Alloy

L-R orientation. Heat treated 1625°F (885°C) 1 hour, vermiculite cooled, refrigerated -100°F (-73°C) 1 hour, air warmed, aged 900°F (482°C) 5 hours.



Typical Mechanical Properties—AerMet-for-Tooling Alloy

Longitudinal orientation. Heat treated 1675°F (913°C) 30 minutes, air cooled, double aged 875°F (468°C) or 900°F (482°C).

0.2% Yield Strength		Ultimate Tensile Strength		% Elongation	% Reduction of Area	Hardenability Rockwell C	Charpy V-Notch
ksi	MPa	ksi	MPa				
875°F (468°C) (2.5hr+2.5hr)							
260	1793	300	2069	12	60	55	20
900°F (482°C) (2.5hr+2.5hr)							
250	1724	285	1965	14	65	53.5	25

The no deep freeze cycle provides an excellent combination of hardness and toughness. However, somewhat better toughness can be achieved using a deep freeze.

Shear Strength—AerMet-for-Tooling Alloy

ksi 175
MPa 1207

Heat Treatment

AerMet-for-Tooling alloy must be solution treated, quenched and aged for proper heat treatment.

Decarburization

Like other carbon bearing high strength alloy, AerMet-for-Tooling alloy is subject to decarburization during hardening. Heat treatment should take place in a neutral atmosphere furnace, salt bath or vacuum. Decarburization should be determined by comparing the surface and internal hardness of a small test cube for proper response. Metallographic determination of decarburization is not recommended for this alloy.

Normalizing

AerMet-for-Tooling alloy can be normalized after forging by heating to 1650°F (899°C), holding for one hour and air cooling to room temperature. Optimum softening for machining is obtained by following the 1650°F (899°C) normalize with a 16 hour 1250°F (677°C) overage anneal.

Annealing

AerMet-for-Tooling alloy is softened by using a 1250°F (677°C) overage anneal for 16 hours. The optimum annealed hardness of 40 HRC maximum is obtained following this anneal.

Solution Treatment

The solution treatment temperature range for heat treaters with deep freeze capability is 1625°F ±25°F (885°C ±14°C) for 1 hour. For heat treaters lacking deep freeze capability, the solution treatment temperature is 1675°F ±25°F (885°C ±14°C) for 30 minutes plus 5 minutes per inch of thickness. The solution treatment temperature must be monitored by a thermocouple attached to the load.

Quenching

AerMet-for-Tooling alloy is an air hardening grade and should be cooled slowly. Cooling to 400°F (204°C) in less than 10 minutes is not recommended; therefore, water quenching is not recommended.

Proper quenching practice is essential for AerMet-for-Tooling alloy. The alloy should be cooled from the solution treatment temperature to 150°F (66°C) in 1 to 2 hours to develop optimum properties.

Individual sections larger than 2" in diameter or 1" thick (plate) must be quenched with oil in order to obtain 150°F (66°C) in 1 to 2 hours. Individual sections up to 2" diameter or 1" thick (plate) will air cool to 150°F (66°C) in 1 to 2 hours.

The cooling rate of the furnace load must be monitored by a thermocouple attached to the hottest spot in the load to insure that a 1 to 2 hour cool to 150°F (66°C) is obtained. If the 2 hour quench time is exceeded, then a special heat treatment cycle may be required. Contact Carpenter for details.

Cold Treatment

If the 1625°F ±25°F (885°C ±14°C) cycle has been used followed by cooling to room temperature, to obtain the full toughness capability of AerMet-for-Tooling alloy, cool to -100°F (-73°C) and hold for 1 hour. The parts can then be air warmed.

Straightening

AerMet-for-Tooling alloy exhibits minimal size change during heat treatment; however, for some parts, mechanical straightening to compensate for distortion during heat treatment is appropriate.

Prior to straightening, a low temperature stress relief at 350/400°F (177/204°C) for 5 hours following the refrigeration operation will provide an optimal combination of ductility and yield strength for the mechanical straightening operation.

Age

For tools that have been given a deep freeze, the standard aging treatment for AerMet-for-Tooling alloy is 900°F ±10°F (482°C ±6°C) for 5 hours. For those parts that have not been deep frozen, a double age at 900°F ±10°F (482°C ±6°C) (2.5hr + 2.5hr) is necessary. Parts made from AerMet-for-Tooling alloy should never be aged at a temperature below 875°F (468°C).

Effect of Aging Temperature on Hardness—AerMet-for-Tooling Alloy
Specimens solution treated using 1625°F (885°C) 1 hour, air cooled, refrigerated -100°F (-73°C) 1 hour.

Aging Temperature*	HRC
As hardened	51.0/53.0
875°F (468°C) 5 hrs.	54.5/55.5
900°F (482°C) 5 hrs.	53.0/54.0
925°F (496°C) 5 hrs.	51.0/52.5

* 5 hours total time

Workability

Forging

Primary breakdown forging of AerMet-for-Tooling alloy should be done at a maximum starting temperature of 2250°F (1232°C). Finish forging should be done from 1800°F (982°C) with a finishing temperature below 1650°F (899°C) in order to optimize the final heat treated properties. Following forging, the parts should be air cooled to room temperature and then annealed. Following the anneal the forgings should be normalized in order to restore properties to the dead zone.

Machinability

AerMet-for-Tooling alloy is somewhat more difficult to machine than 4340 at Rockwell C 38. Carbide tools are recommended at 280 to 350 SFM.

Following rough machining, if a stress relief is desired, stress relieve at 800°F (427°C) for 1 to 3 hours.

Other Information

Wear Resistance

In metal-to-metal sliding situations, AerMet-for-Tooling alloy exhibits excellent wear resistance.

When AerMet-for-Tooling alloy is subject to sliding metal-to-metal wear, three observations have been made. First, the surface finish improves with time. Second, the coefficient of friction declines with time. Third, the wear rate is low. In environments where pure abrasion is involved, such as ASTM G65 Procedure "A", the wear resistance of AerMet-for-Tooling alloy measures 180-200 mm^3.

Wear resistance can be improved by a variety of coatings such as vanadium carbide, chrome nitride and titanium nitride.

Forms Manufactured

- Bar-Rounds
- Billet
- Strip
- Wire

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
- An Evaluation of Alloys for Golf Club Face Plates
- Coated Tools of High Strength, High Tough Steel Produce up to 100 Times More Powder Metal Parts
- The ABC's of Alloy Selection, Heat Treating and Maintaining Cold Work Tooling

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