Technical Datasheet

CarTech® Micro-Melt® BioDur® CCM® Alloy

Type Analysis

Single figures are nominal except where noted.

Carbon (Maximum)	0.14 %	**Manganese (Maximum)**	1.00 %
Silicon (Maximum)	1.00 %	**Chromium**	26.00 to 30.00 %
Nickel (Maximum)	1.00 %	**Molybdenum**	5.00 to 7.00 %
Cobalt	Balance	**Nitrogen (Maximum)**	0.25 %
Iron (Maximum)	0.75 %		

General Information

Description

CarTech Micro-Melt BioDur CCM alloy is a non-magnetic, cobalt-chromium-molybdenum wrought alloy exhibiting high strength, corrosion resistance, and wear resistance. This alloy is a powder metallurgy version of CarTech BioDur CCM alloy (ASTM F 1537 Alloy 1), which is a high nitrogen, low carbon wrought version of ASTM F 75 cast alloy.

CarTech Micro-Melt BioDur Carpenter CCM alloy is produced by vacuum induction melting (VIM) followed by gas atomization and hot isostatic pressing to produce 100% dense billets. These billets are then processed by conventional steelmaking practices to produce millform products such as billet, bar and wire that are subsequently processed into finished articles. Hot isostatically pressed (HIP'd) near net shapes and loose powder are also available for processing into finished articles.

CarTech Micro-Melt BioDur CCM alloy possesses the following product attributes:

- homogeneous chemistry and microstructure;
- small, uniformly distributed carbides, typically less than 5 microns in length as measured on longitudinal sections;
- higher yield strength and ultimate tensile strength than cast-wrought BioDur Carpenter CCM alloy in the warm-worked or annealed conditions;
- higher hardness than cast-wrought BioDur Carpenter CCM alloy in the warm -worked or annealed conditions
- finer grain size than cast-wrought BioDur Carpenter CCM alloy in the warm- worked or annealed conditions;
- higher rotating beam fatigue strength than cast-wrought BioDur Carpenter CCM alloy in the warm-worked condition.

Carpenter generally supplies CarTech Micro-Melt BioDur CCM alloy in the warm-worked condition since this condition provides the highest mechanical properties, highest hardness, finest grain size, and highest fatigue strength.

Applications

CarTech Micro-Melt BioDur CCM alloy has been used in the orthopedic implant industry for joint replacement and fracture fixation devices such as total hip, knee, and shoulder replacements. This alloy is particularly suited for small diameter bar and wire applications, where high strength or high fatigue resistance is required.

Corrosion Resistance

Important Note: *The following 4-level rating scale is intended for comparative purposes only. Corrosion testing is recommended; factors which affect corrosion resistance include temperature, concentration, pH, impurities, aeration, velocity, crevices, deposits, metallurgical condition, stress, surface finish and dissimilar metal contact.*

Nitric Acid	Excellent	Sulfuric Acid	Good
Phosphoric Acid	Good	Acetic Acid	Excellent
Sodium Hydroxide	Moderate	Salt Spray (NaCl)	Excellent
Sea Water	Good	Humidity	Excellent

Properties

Physical Properties

Specific Gravity	8.29	
Density	0.2995	lb/in³
Mean Specific Heat		
73°F	0.1061	Btu/lb/°F
210°F	0.1123	Btu/lb/°F
570°F	0.1252	Btu/lb/°F
1100°F	0.1410	Btu/lb/°F
1700°F	0.1570	Btu/lb/°F
1800°F	0.1580	Btu/lb/°F
2012°F	0.1599	Btu/lb/°F
Mean CTE		
68 to 212°F	7.32	x 10 -6 in/in/°F
68 to 382°F	7.36	x 10 -6 in/in/°F
68 to 572°F	7.48	x 10 -6 in/in/°F
68 to 752°F	7.66	x 10 -6 in/in/°F
68 to 932°F	7.86	x 10 -6 in/in/°F
68 to 1112°F	8.04	x 10 -6 in/in/°F
68 to 1292°F	8.38	x 10 -6 in/in/°F
68 to 1472°F	8.61	x 10 -6 in/in/°F
68 to 1652°F	8.86	x 10 -6 in/in/°F
68 to 1832°F	9.13	x 10 -6 in/in/°F
68 to 2048°F	9.19	x 10 -6 in/in/°F
68 to 2102°F	9.49	x 10 -6 in/in/°F
Thermal Conductivity		
73°F	87.82	BTU-in/hr/ft²/°F
212°F	100.8	BTU-in/hr/ft²/°F
572°F	131.4	BTU-in/hr/ft²/°F
1110°F	178.8	BTU-in/hr/ft²/°F
1650°F	211.5	BTU-in/hr/ft²/°F
1830°F	221.6	BTU-in/hr/ft²/°F
2012°F	226.9	BTU-in/hr/ft²/°F
2150°F	246.8	BTU-in/hr/ft²/°F
Poisson's Ratio	0.300	
Modulus of Elasticity (E)	35.0	x 10 3 ksi
Modulus of Rigidity (G)	13.4	x 10 3 ksi

Typical Mechanical Properties

RR Moore Rotating Beam Fatigue Endurance Limit – Micro-Melt® BioDur® Carpenter CCM® Alloy and BioDur Carpenter CCM Alloy

Alloy	Endurance Limit	
	ksi	MPa
Micro-Melt® BioDur® Carpenter CCM® Alloy	130	896
BioDur Carpenter CCM Alloy	120	827

Specimens tested at a frequency of 6,000 RPM.

Typical Room Temperature Warm-Worked Mechanical Properties –
Micro-Melt® BioDur® Carpenter CCM® Alloy and BioDur Carpenter CCM Alloy

Alloy	0.2% Yield Strength		Ultimate Tensile strength		% Elongation in 4D	% Reduction of Area	HRC Hardness
	ksi	MPa	ksi	MPa			
Micro-Melt® BioDur® Carpenter CCM® Alloy	162	1117	206	1420	28	24	46
BioDur Carpenter CCM Alloy	150	1034	199	1372	25	21	44
ASTM F799 Requirements	120	827	170	1172	12	12	35

Tension test data: Tensile specimens were low stress ground prior to testing.

Heat Treatment

Annealing

Micro-Melt BioDur Carpenter CCM alloy is typically annealed at 2000°F/2100°F (1093°C/1149°C) for 30 minutes followed by air cooling. The resultant annealed microstructure has a 7 to 8 ASTM E 112 grain size number and a hardness of 36 to 40 HRC. Finer grain sizes and higher annealed hardnesses can be attained by using lower annealing temperatures. Micro-Melt BioDur Carpenter CCM alloy maintains a finer grain size and a higher hardness than BioDur Carpenter CCM alloy for the same annealing parameters as shown in the following tables.

Effect of Annealing Temperature on Grain Size –
Micro-Melt® BioDur® Carpenter CCM® Alloy and BioDur Carpenter CCM Alloy

Annealing Temperature °F	Avg. Grain Diameter (microns)		Avg. ASTM Grain Size No.	
	Micro-Melt® BioDur® Carpenter CCM® Alloy	BioDur Carpenter CCM Alloy	Micro-Melt BioDur Carpenter CCM Alloy	BioDur Carpenter CCM Alloy
Unannealed	4.6	5.7	13.5	12.5
1500	4.3	6.2	13.5	12.5
1600	4.3	6.3	13.5	12.5
1700	5.4	6.5	13.5	12.5
1800	6	7.3	13.5	12.5
1900	26	31.7	9	7
1950	37.2	73.9	7	5
2000	27	66.5	8	5
2100	43.3	104	7	4

Annealing Cycle: Heat at Temperature 30 minutes + AC to RT.

Effect of Annealing Temperature on Hardness (HRC) –
Micro-Melt® BioDur® Carpenter CCM® Alloy and BioDur Carpenter CCM Alloy

Annealing Temperature °F	Average Mid-Radius Hardness		Average Surface Hardness	
	Micro-Melt® BioDur® Carpenter CCM® Alloy	BioDur Carpenter CCM Alloy	Micro-Melt BioDur Carpenter CCM Alloy	BioDur Carpenter CCM Alloy
Unannealed	46	44	51.5	48.5
1500	49	45	49.5	48.5
1600	47	45	46.5	46.5
1700	45	44	46.5	45.5
1800	45	45	45.5	45
1900	36	36	37	36
1950	36	34	37	34
2000	36	32	36	32
2100	39	35	40	35

Annealing Cycle: Heat at Temperature 30 minutes + AC to RT.

Workability

Hot Working

Micro-Melt BioDur Carpenter CCM alloy can be hot worked from a furnace temperature of 2050/2200°F (1121/1204°C). Proprietary thermomechanical processing techniques are normally required to obtain desired finished mechanical properties and uniformity.

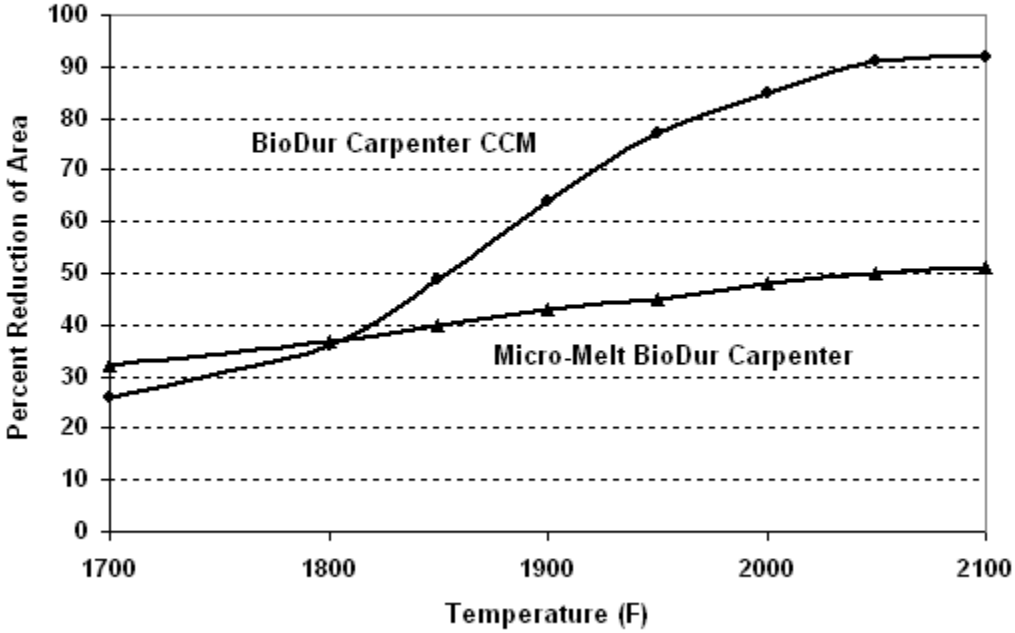
Gleeble Testing for Hot Workability

Gleeble* testing is used by Carpenter as a measure of a material's hot workability. On-heating Gleeble data show the general temperature range over which an alloy can be hot worked at a given strain rate, as well as the temperature where the ductility falls to zero (hot shortness).

The temperature corresponding to the peak ductility of the on-heating curve is generally recommended to be used as the heating temperature for the material. Refer to the diagram "Comparative On-Heating Gleeble Curves." Using this temperature, the Gleeble on-cooling curve is shown in the diagram "Comparative On-Cooling Gleeble Curves." This curve shows relative ductility, measured as percent reduction of area, as a function of temperature. Forty to 50 percent reduction of area is considered acceptable. Fifty to 60 percent is good, 60 to 70 percent is excellent, and higher than 70 percent is superior.

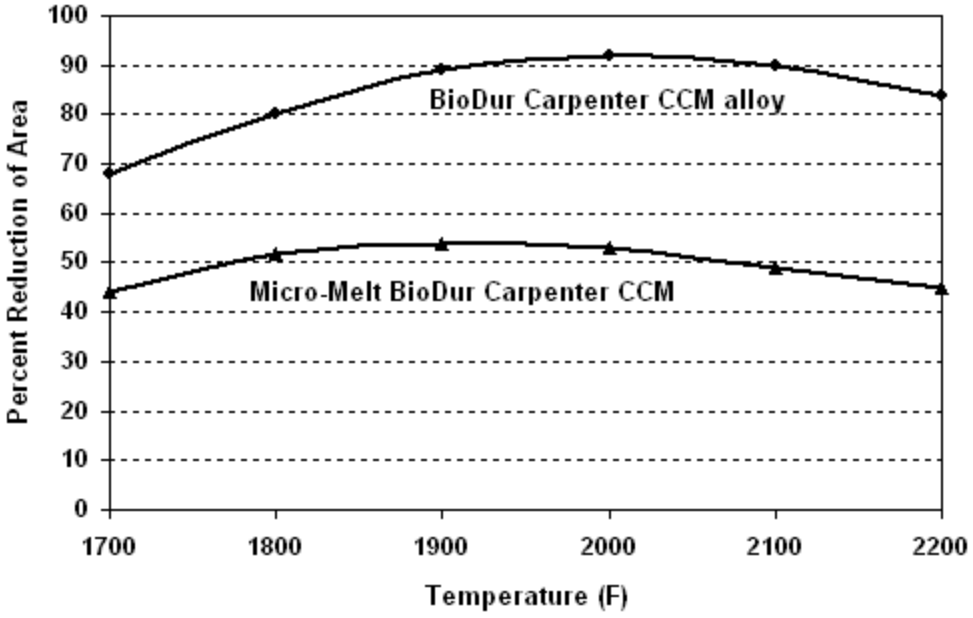
*Gleeble is a registered trademark of Dynamic Systems Inc.

Comparative On-Cooling Gleeble Curves from 2100°F (1149°C)
Micro-Melt® BioDur® Carpenter CCM® Alloy and
BioDur Carpenter CCM Alloy
(Strain Rate = 20/sec)



Gleeble is a registered trademark of Dynamic Systems Inc.

Comparative On-Heating Gleeble Curves
Micro-Melt® BioDur® Carpenter CCM® Alloy and
BioDur Carpenter CCM Alloy
(Strain Rate = 20/sec)



Gleeble is a registered trademark of Dynamic Systems Inc.

Cold Working

High strength levels can be achieved in Micro-Melt BioDur Carpenter CCM alloy through either hot/cold work or cold-work only processes. Ductility decreases as the amount of cold work increases.

Machinability

Micro-Melt BioDur Carpenter CCM alloy is difficult to machine in any heat treated condition due to its extremely high work-hardening rate, low thermal conductivity, and the presence of hard, abrasive carbides in the microstructure. Tool geometry, rigidity, and adequate machine power are all extremely important considerations. As a starting point, machinability parameters for other cobalt-based alloys such as Carpenter L-605 alloy may be used as a guideline.

The following are typical feeds and speeds for Micro-Melt BioDur Carpenter CCM alloy.

Other Information

Applicable Specifications

Note: While this material meets the following specifications, it may be capable of meeting or being manufactured to meet other general and customer-specific specifications.

- ASTM F1537
- ASTM F799
- ISO 5832-12
- ISO 5832-4

Forms Manufactured

- Bar
- Billet
- HIP'd Shapes
- Powder
- Wire

Technical Articles

- Benefits of P/M Processed Cobalt-Based Alloy for Orthopaedic Medical Implants
- Effect of Cold Drawing and Heat Treating on Powder Metallurgy Processed ASTM F 1537 Alloy 1 & Alloy 2 Barstock

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