Technical Datasheet

CarTech® ACUBE® 100 Alloy

Type Analysis

Single figures are nominal except where noted.

Carbon (Maximum)	0.15 %	**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)	1.00 %		

General Information

Description

CarTech ACUBE 100 alloy is a non-magnetic cobalt-based alloy exhibiting high strength, excellent corrosion resistance, and outstanding wear resistance. Exposure to beryllium dust has been tied to a variety of health hazards.CarTech ACUBE 100 is beryllium free, eliminating the health and safety issues associated with beryllium-containing alloys. CarTech ACUBE 100 alloy can be considered as a replacement for copper-beryllium alloys.

CarTech ACUBE 100 alloy is a premium-melted alloy. The finished mill product can be supplied in the annealed, hot worked, or work strengthened (warm worked) condition.

Applications

CarTech ACUBE 100 alloy can be considered for use in applications which require superior resistance to galling and wear such as bushings and bearings.

See Other Information section for wear related data.

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	0.2990	lb/in³
Mean Specific Heat		
212°F	0.1130	Btu/lb/°F
572°F	0.1260	Btu/lb/°F
1112°F	0.1420	Btu/lb/°F
1652°F	0.1580	Btu/lb/°F
1832°F	0.1590	Btu/lb/°F
2012°F	0.1600	Btu/lb/°F

Specific heat

Temperature		Specific Heat	
°F	°C	Btu/(lb•°F)	(W•S)/Kg•°K)
212	100	0.113	470
572	300	0.126	524
1112	600	0.142	590
1652	900	0.158	657
1832	1000	0.159	661
2012	1100	0.160	669

Mean CTE	
68 to 212°F	7.32 x 10^{-6} in/in/°F
68 to 392°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

Mean coefficient of thermal expansion

Temperature		Mean Coefficient (Micro Inches/Inch)	
68°F to (°F)	20°C to (°C)	per °F	per °C
212	100	7.32	13.18
392	200	7.36	13.25
572	300	7.48	13.47
752	400	7.66	13.79
932	500	7.86	14.15
1112	600	8.04	14.47
1292	700	8.38	15.09
1472	800	8.61	15.50
1652	900	8.86	15.95
1832	1000	9.13	16.44
2048	1120	9.19	16.54
2102	1150	9.49	17.08

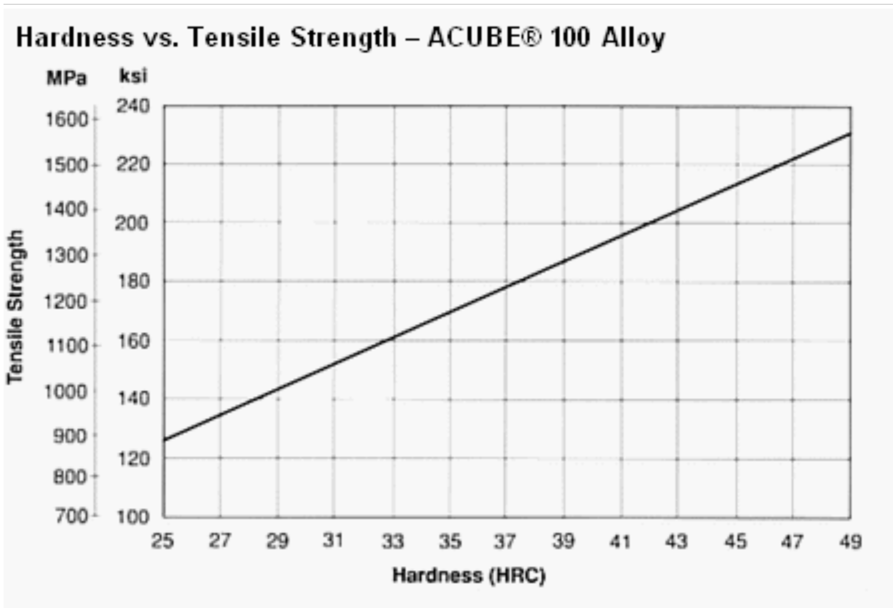
Thermal Conductivity	
73°F	87.82 BTU-in/hr/ft²/°F
212°F	100.8 BTU-in/hr/ft²/°F
572°F	131.4 BTU-in/hr/ft²/°F
1112°F	178.8 BTU-in/hr/ft²/°F
1652°F	211.5 BTU-in/hr/ft²/°F
1832°F	221.6 BTU-in/hr/ft²/°F
2012°F	226.9 BTU-in/hr/ft²/°F
2150°F	246.8 BTU-in/hr/ft²/°F

Thermal conductivity

Temperature		Thermal Conductivity	
°F	°C	(Btu·in)/(hr·ft²·°F)	W/(m·°K)
73	23	87.82	12.66
212	100	100.80	14.53
572	300	131.36	18.93
1112	600	178.77	25.76
1652	900	211.54	30.49
1832	1000	221.57	31.93
2012	1100	226.94	32.71
2150	1177	246.80	35.57

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



Typical Room Temperature Mechanical Properties – ACUBE® 100 Alloy

Condition	0.2% Yield Strength		Tensile Strength		Elongation	Reduction Of Area	Hardness
	Ksi	MPa	ksi	MPa	%	%	HRC
Hot Worked	110	758	160	1103	25	23	33
Warm Worked	145	1000	200	1379	26	21	42
Warm Worked + Aged	162	1117	223	1538	12	10	50

Nominal values are shown representing mid-radius locations of bar stock
ACUBE 100 is typically supplied in the warm worked (work-strengthened) condition.

Typical Warm Worked, Room Temperature Tensile Properties of Various Bar Diameters – ACUBE® 100 Alloy

Size		0.2% Yield Strength		Tensile Strength		Elongation	Reduction Of Area
Inch	mm	Ksi	MPa	ksi	MPa	%	%
0.5 – 2.25 Diam.	13-57	131	904	178	1228	7	10
2.6 Diam	67	146	1007	204	1407	26	20
3.1 Diam.	78	142	979	200	1379	27	22
3.5 Diam.	89	146	1007	202	1393	30	24
4.1 Diam.	105	148	1020	202	1393	24	20

Condition: Warm-worked by hot rolling or forging
Test location: Center for <1.5-inch, mid-radius for >1.5-inch (longitudinal)

Heat Treatment

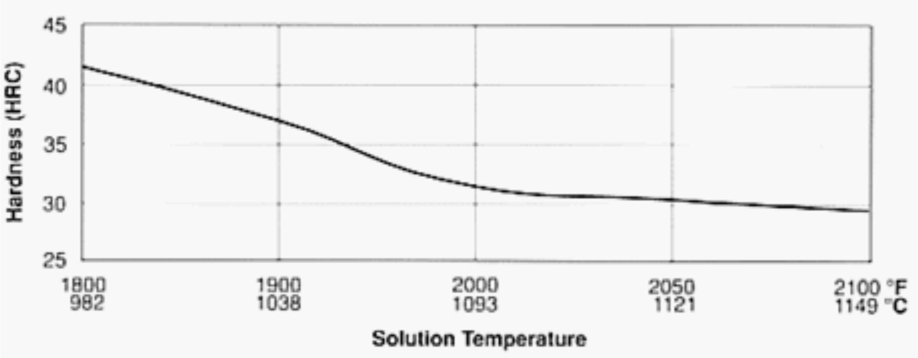
Annealing

ACUBE 100 alloy can be annealed at 2000 to 2050°F (1093 to 1121°C) for 1 to 2 hours followed by water quenching. Finer grain size can be maintained through the use of lower annealing temperatures with corresponding increases in annealed hardness.

Hardening

ACUBE 100 alloy in the warm-worked condition can be further strengthened by thermal treatment in the 1325-1400°F (718-760°C) range for 2-4 hours. Yield strength increases on the order of 10-15% are possible but with larger reductions in tensile ductility.

Effect of Solution Annealing Temperature on Hardness – ACUBE® 100 Alloy
(1 hour, air cooled)



Workability

The alloy should be hot worked from a furnace temperature of 2100-2250°F (1149-1232°C)
Proper precautions must be taken to ensure accurate furnace temperatures at these higher temperatures to preclude hot shortness.
The alloy stiffens rapidly below 2000°F (1093°C) and deformation below 1800°F (982°C) may result in surface tearing.
Thermomechanical processing techniques are normally required to obtain desired finished mechanical properties and uniformity.

Cold Working

High strength levels can be achieved in ACUBE 100 alloy through cold working processes. It should be noted that a significant loss of ductility results from even small amounts of cold work.

Machinability

ACUBE 100 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 and intermetallics in the microstructure. Tool geometry, rigidity, and adequate machine power are all extremely important considerations.

The following table shows typical feeds and speeds for ACUBE 100 alloy.

Typical Machining Speeds and Feeds – ACUBE® 100 Alloy

The speeds and feeds in the following charts are conservative recommendations for initial setup. Higher speeds and feeds may be attainable depending on machining environment.

Turning—Single-Point and Box Tools

Condition	Depth of Cut (Inches)	High Speed Tools			Carbide Tools			
		Speed (fpm)	Feed (ipr)	Tool Mtl.	Speed (fpm)		Feed (ipr)	Tool Mtl.
					Brazed	Throw Away		
BHN less than 260	.100 .025	20 25	.010 .007	M-42	70 90	80 100	.010 .007	C-2 C-3
BHN 260 to 340	.100 .025	15 25	.010 .007	M-47	65 80	75 95	.010 .007	C-2 C-3
BHN greater than 340	.100 .025	12 15	.010 .005	M-42 M-47	60 70	70 80	.010 .007	C-2 C-3

Turning—Cutoff and Form Tools

Condition	Speed (fpm)	Feed (ipr)							Tool Mtl.
		Cutoff Tool Width (Inches)			Form Tool Width (Inches)				
		1/16	1/8	1/4	1/2	1	1-1/2	2	
BHN less than 300	15 45	.002 .003	.004 .0045	.005 .006	.004 .004	.002 .003	.002 .0025	.001 .0015	M-42 C-2
BHN greater than 300	15 45	.002 .003	.003 .003	.004 .0045	.003 .003	.002 .0025	.002 .002	.001 .001	M-42 C-2

Reaming

Condition	High Speed Tool								Carbide Tools	
	Speed (fpm)	Feed Inches Per Rev Reamer Diameter, In.						Tool Mtl.	Speed (fpm)	Tool Matl.
		1/8	1/4	1/2	1	1-1/2	2			
BHN less than 300	20	.002	.006	.008	.010	.012	.014	M-42	60	C-2
BHN greater than 300	15	.002	.006	.008	.010	.012	.014	M-42	50	C-2

Drilling

Condition	Speed (fpm)	Feed (ipr)							Tool Mtl.
		Cutoff Tool Width, Inches			Form Tool Width, Inches				
		1/16	1/8	1/4	1/2	1	1-1/2	2	
BHN less than 300	20	--	.002	.003	.003	.004	--	--	M-42
BHN greater than 300	15	--	.002	.003	.003	.004	--	--	

Threading, Die

Condition	Speed (fpm)				Tool Material
	7 or less	8 to 15	16 to 24	25 and up T.P.I.	
BHN less than 300	4-6	5-8	6-10	8-12	M-2, M-7, M-10
BHN greater than 300	3-4	3-5	4-8	5-10	M-42

Milling, End–Peripheral

Condition	Depth of Cut in.	High Speed Tool						Carbide Tool					
		Speed (fpm)	Feed (ipt) Cutter Diameter (in.)				Tool Mtl.	Speed fpm	Feed (ipt) Cutter Diameter (in.)				Tool Mtl.
			1/4	1/2	3/4	1-2			1/4	1/2	3/4	1-2	
BHN less than 300	.050	15	.002	.002	.003	.004	M42	60	.001	.002	.003	.004	C-2
BHN greater than 300		12	.0015	.0015	.002	.003		50	.0015	.0015	.002	.003	

Tapping

Condition	Speed (fpm)	Tool Material
BHN less than 300	10	M1, M7, M10
BHN greater than 300	7	M1, M7, M10, Nitrided

Broaching

Condition	Speed (fpm)	Chip Load (ipt)	Tool Material
BHN less than 300	8	.002	M-42
BHN greater than 300	6	.002	

Other Information

Wear Resistance

Bushing Wear Test Properties

The bushing wear test involves slow oscillation of a 0.9" OD by 0.7" ID bushing over a hardened pin. The bushing is loaded with progressively higher loads up to 10,000 pounds for a total of 1,850 cycles. Each cycle consists of a rotation from 0 to +25 degrees, to 0 degrees, then to -25 degrees and back to 0 degrees. Performance is determined by the threshold load for the onset of wear and the change in bushing dimensions after the 1,850 cycles. Refer to the table entitled Bushing Wear Test Properties.

Galling Test Properties

The Button-on-Block Galling Test (ASTM G98) involves rotating a compressively loaded 1/2" (12.7 mm) diameter button against a block counterclockwise 360°, clockwise 360°, then counterclockwise 360° and determining the highest stress that can be sustained without visible galling damage. Refer to the table entitled Galling Test Properties.

Bushing Wear Test Properties – ACUBE® 100 Alloy

Alloy	Bushing Wear Test			
	Threshold Load		Average Dimensional Change (2-3 tests)	
	lb	kg	Wall thickness	Width
ACUBE 100 (warm worked condition)	>10,000	>4356	-0.000"	+0.009"
Cu-Be Alloy (AMS 4533)	10,000	4356	-0.016"	+0.054"
Nitrogen-strengthened stainless steel (AMS 5848)	<10,000	<4356	-0.017"	+0.135"

Galling Test Properties (ASTM G98) – ACUBE® 100 Alloy

Alloy	Galling Test Threshold Galling Stress	
	ksi	MPa
ACUBE 100	>20	>138
Type 316	<1	<7
440C	18	124
MP35N*	5	35

*MP35N is a registered trademark of SPS Technologies, Inc.

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.

- AMS 5918

Forms Manufactured

- Bar-Rounds
- Billet
- Wire
- Wire-Rod

Technical Articles

- Beryllium-Free Alloy for High-Load Bushing and Bearing Applications

Disclaimer:
The information and data presented herein are typical or average values and are not a guarantee of maximum or minimum values. Applications specifically suggested for material described herein are made solely for the purpose of illustration to enable the reader to make his/her own evaluation and are not intended as warranties, either express or implied, of fitness for these or other purposes. There is no representation that the recipient of this literature will receive updated editions as they become available.

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