ALLOY Data

Hiperco® 50A Alloy

Type Analysis

Carbon	0.00 %	**Manganese**	0.05 %
Silicon	0.05 %	**Cobalt**	48.75 %
Vanadium	2.00 %	**Iron**	49.15 %

General Information

Description

Hiperco® 50A alloy is an iron-cobalt-vanadium soft magnetic alloy possessing high magnetic saturation (24 kilogauss), high D.C. maximum permeability, low D.C. coercive force, and low A.C. core loss. This alloy exhibits magnetic properties superior to those of other commercial iron-cobalt soft magnetic alloys.

In addition, Carpenter produces Hiperco 50 alloy which has nearly the same nominal analysis as Hiperco 50A alloy, but contains small additions of niobium and carbon for grain refinement to achieve higher mechanical strengths with only a slight sacrifice in magnetic properties. Hiperco 50 alloy's higher strength is necessary for rotating component laminations subject to stress from high rotational speeds. Hiperco 50 alloy has been used in strip form primarily for aircraft generators and motors. Contact Carpenter for technical data.

Applications

Hiperco 50A alloy has been used primarily for magnetic cores in electrical equipment requiring high permeability at high magnetic flux densities. It has also been used in tape cores where lowest A.C. losses and high permeability at high inductions are desired.

Properties

Physical Properties

Specific Gravity

--	8.12	

Density

--	0.2930	lb/in³

Mean Coefficient of Thermal Expansion

77 °F, 392 °F	5.30	x 10 $^{-6}$ in/in/°F
77 °F, 752 °F	5.60	x 10 $^{-6}$ in/in/°F
77 °F, 1112 °F	5.80	x 10 $^{-6}$ in/in/°F
77 °F, 1472 °F	6.30	x 10 $^{-6}$ in/in/°F

Mean coefficient of thermal expansion

Temperature		Coefficient	
77°F to	25°C to	10^{-6}/°F	10^{-6}/°C
392	200	5.3	9.5
752	400	5.6	10.1
1112	600	5.8	10.5
1472	800	6.3	11.3

Thermal Conductivity

--	206.8	BTU-in/hr/ft²/°F

Modulus of Elasticity (E)

--	30.0	x 10 ^{3} ksi

Electrical Resistivity

70.0 °F	240.7	ohm-cir-mil/ft

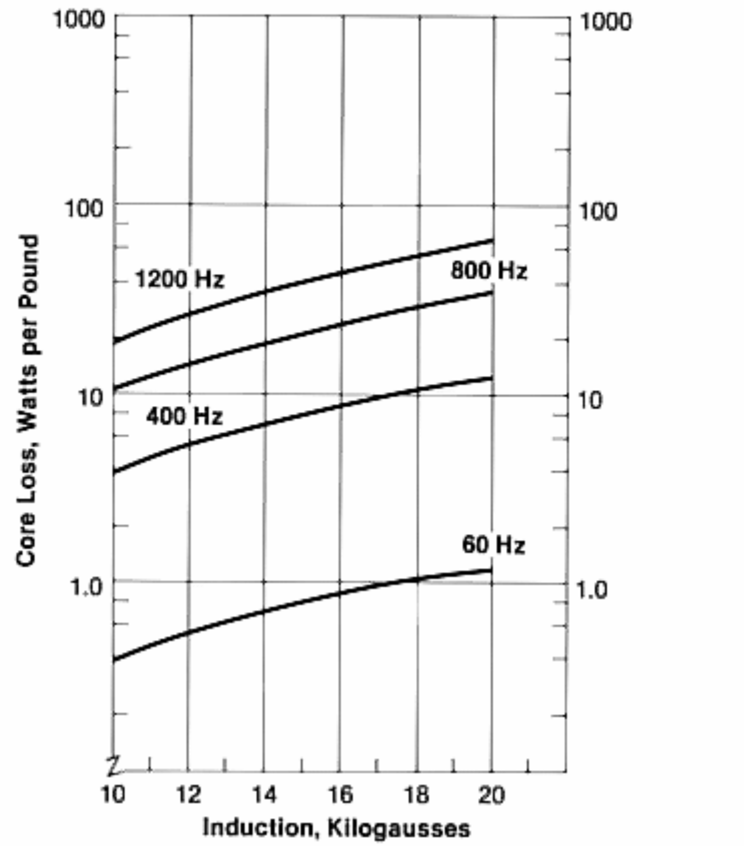
Edition Date: 6/14/05

Curie Temperature	
--	1720 °F

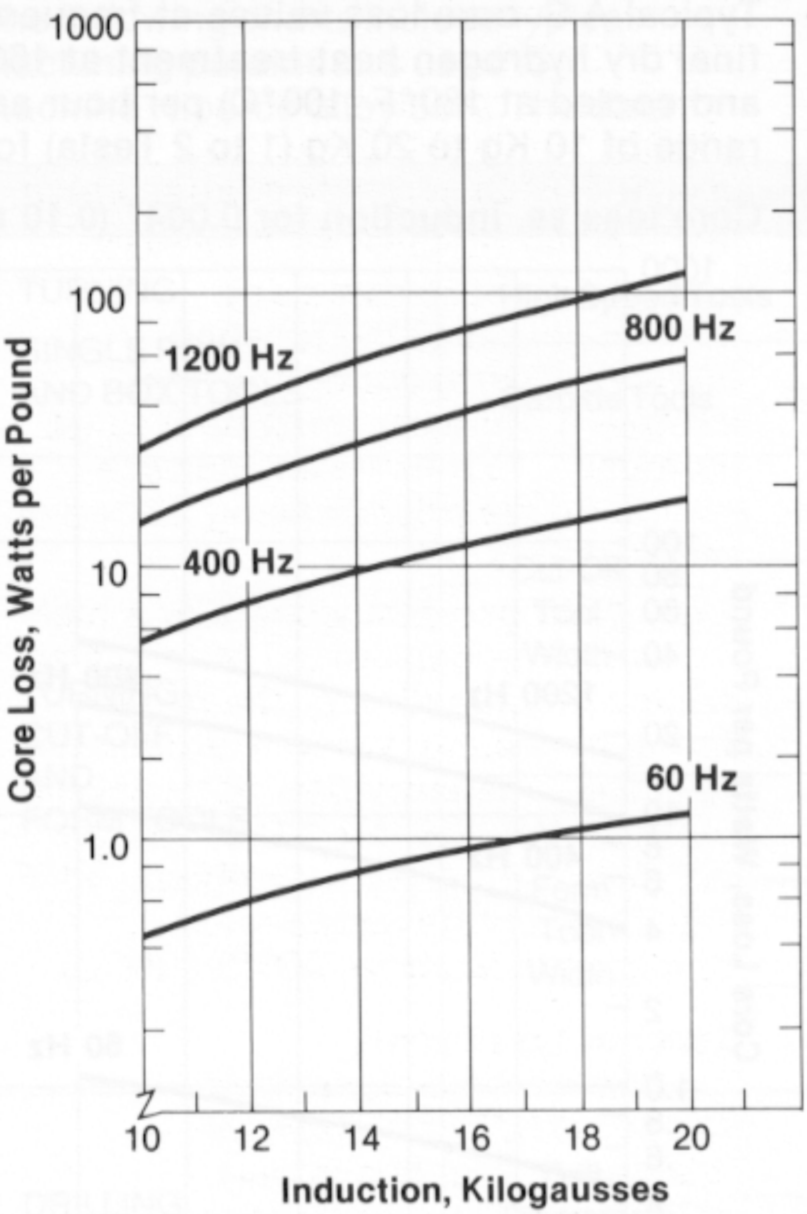
Magnetic Properties

Typical A.C. core loss values at frequencies of 60, 400, 800, and 1200 Hz after a final dry hydrogen heat treatment at 1600°F (871°C) for two hours at temperature and cooled at 180°F (100°C) per hour are shown over the magnetic induction range of 10 Kg to 20 Kg (1 to 2 Tesla) for strip thicknesses as indicated in the hyperlinks entitled "Core loss vs. induction for 0.006" (0.15 mm) thick strip, Core loss vs. induction for 0.010" (0.25 mm) thick strip and Core loss vs. induction for 0.014" (0.35 mm) thick strip."

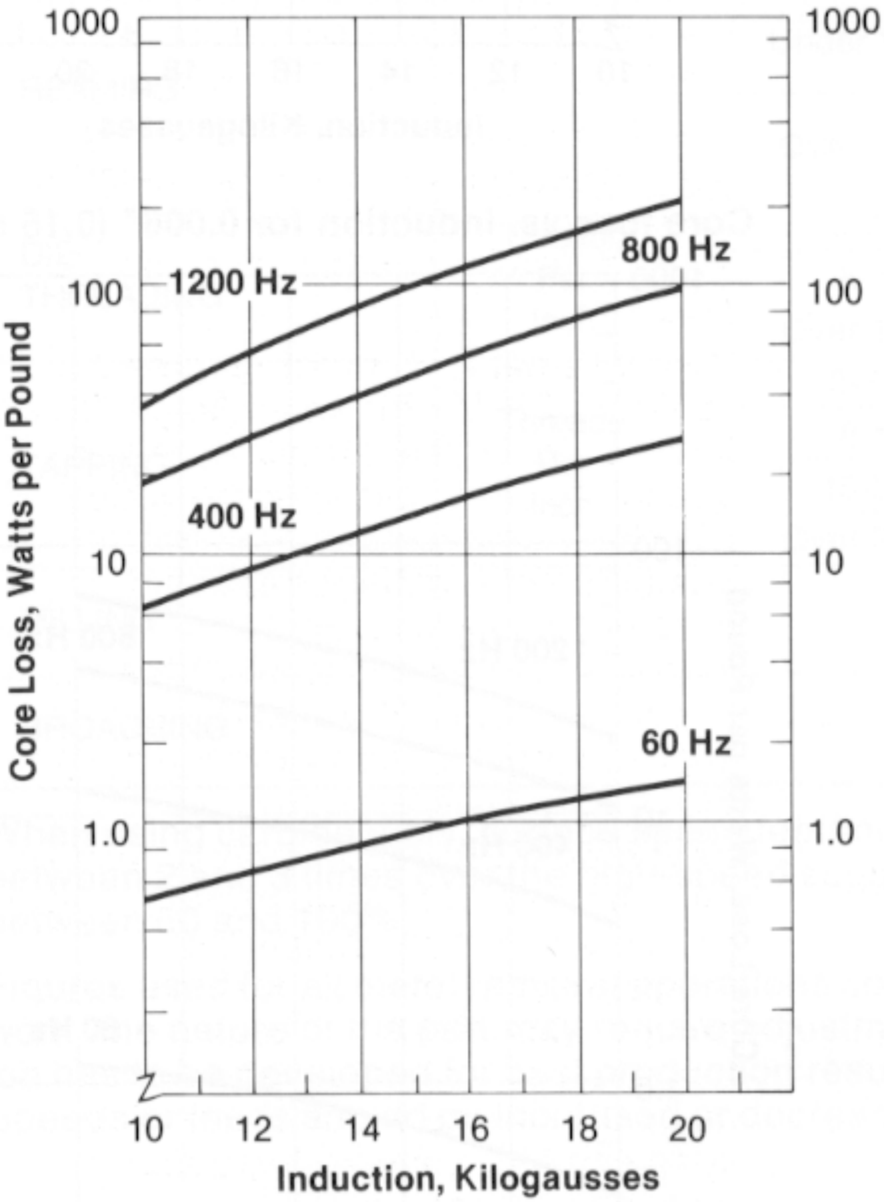
Core loss vs. induction for 0.006" (0.15 mm) thick strip



Core loss vs. induction for 0.010″ (0.25 mm) thick strip



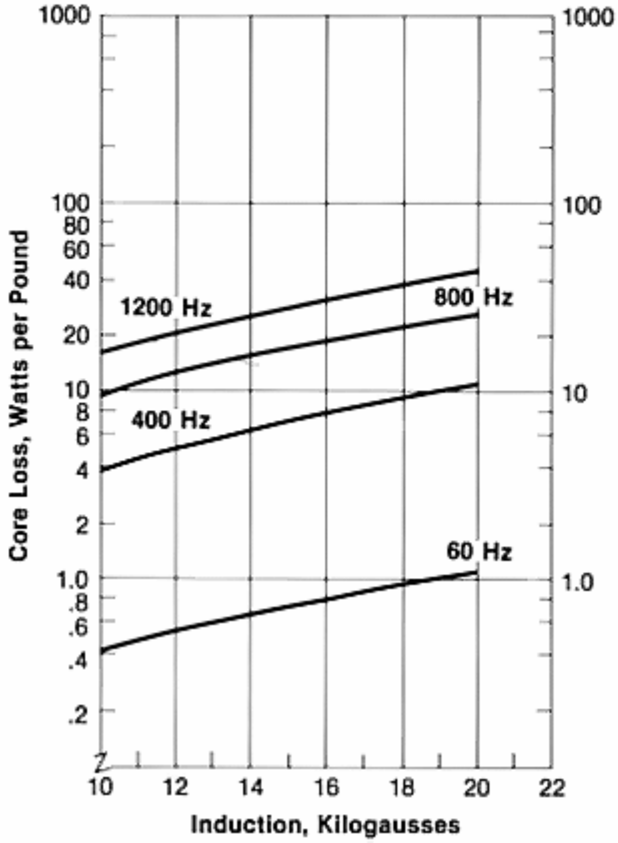
Core loss vs. induction for 0.014″ (0.35 mm) thick strip



Typical A.C. Magnetic Properties—Hiperco 50A Alloy

Typical A.C. core loss values at frequencies of 60, 400, 800, and 1200 Hz after a final dry hydrogen heat treatment at 1600°F (871°C) for two hours at temperature and cooled at 180°F (100°C) per hour are shown over the magnetic induction range of 10 Kg to 20 Kg (1 to 2 Tesla) for strip thicknesses as indicated.

Core loss vs. induction for 0.004″ (0.10 mm) thick strip

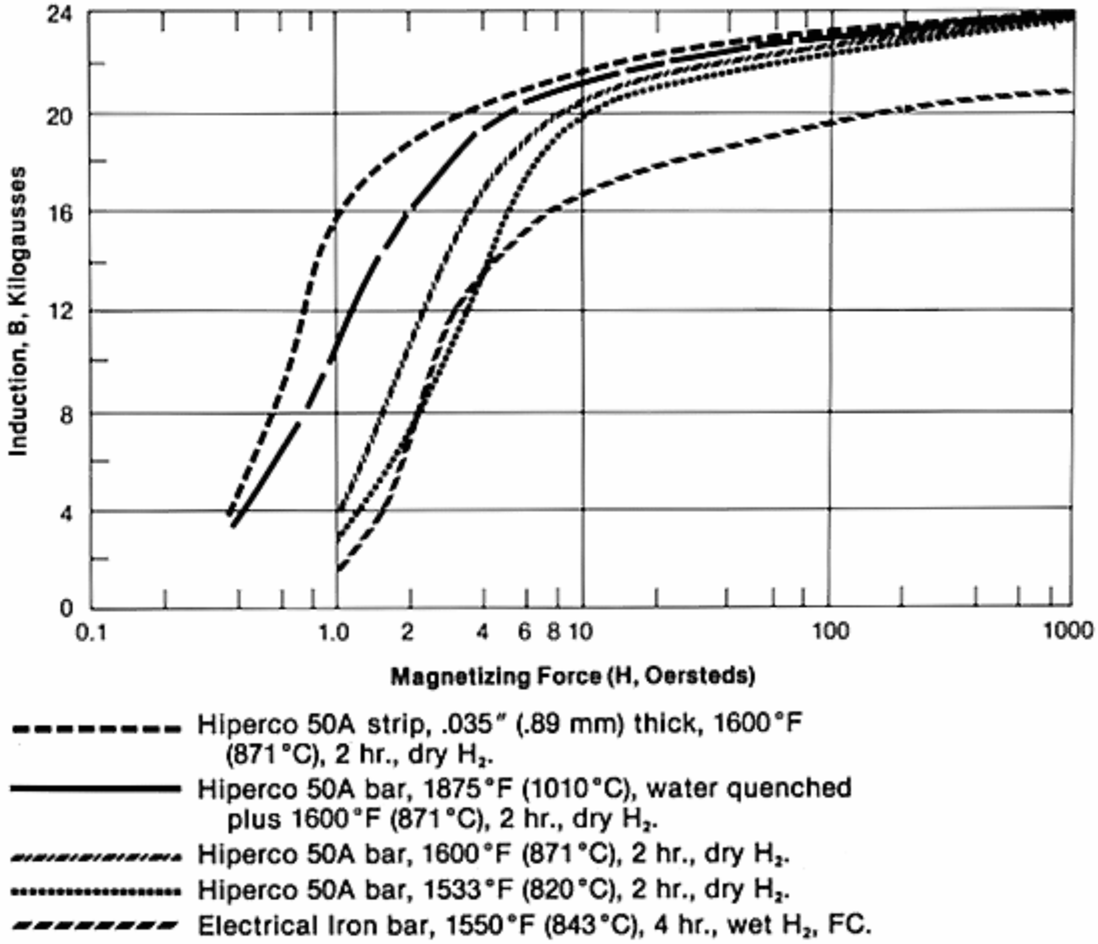


Typical D.C. Magnetic Properties — Hiperco 50A Alloy

After heat treatment indicated.

Magnetic Properties Induction, (B) at Applied Field, (H) Oersteds	Laminations or Tape Cores Made from Strip	Standard Treatment of Bar	Option 1 Duplex Treatment or Parts Made from 1.25" Rd. C.G. Bar	Option 2 Slow Cool Treatment for Any Size Part or Bar
	1600°F (871°C)	1600°F (871°C)	1850°F (1010°C) W.Q. Plus 1600°F (871°C)	1700°F (927°C) Plus Controlled Slow Cool
B @ H = 2 Oe	15.5 Kg	10.0 Kg	16.0 Kg	11.0 Kg
B @ H = 4 Oe	18.6 Kg	15.5 Kg	19.0 Kg	17.5 Kg
B @ H = 6 Oe	20.0 Kg	18.0 Kg	20.2 Kg	19.0 Kg
B @ H = 10 Oe	21.0 Kg	20.0 Kg	21.0 Kg	20.0 Kg
B @ H = 50 Oe	22.7 Kg	22.5 Kg	22.7 Kg	22.5 Kg
B @ H = 100 Oe	22.9 Kg	22.8 Kg	22.8 Kg	22.8 Kg
B @ H = 200 Oe	23.5 Kg	23.0 Kg	23.0 Kg	23.0 Kg
H_c from H = 200 Oe	0.4 Oe	1.9 Oe	0.6 Oe	1.0 Oe

Typical D.C. Magnetization Curves—Hiperco 50A Alloy vs. Electrical Iron



Saturation Magnetostriction

--	60 x 10^{-6} in/in

Typical Mechanical Properties

Typical Mechanical Properties – Hiperco® 50A Alloy

Strip

Tensile Strength		Yield Strength		% Elongation in 2" (50.8 mm)
ksi	MPa	ksi	MPa	
As Cold Rolled				
195	1344	185	1276	1
1550° (843°) 2 hrs. in H, and cooled at 200°F (93°C) per hour				
104	717	53	365	7

Heat Treatment

Standard Treatment

Anneal parts at 1575/1600°F (857/871°C) for 2 to 4 hours in dry hydrogen or vacuum and cool at 150/350°F (83/194°C) per hour until 600°F (316 °C) is reached, after which any cooling rate can be employed.

It is important to avoid any contamination of the finished fabricated parts during the heat treatment. All parts must be cleaned thoroughly to remove any surface contaminants prior to being placed in an air-tight retort.

A dry hydrogen atmosphere or a high vacuum is recommended to minimize oxide contamination of the parts during annealing. When hydrogen is employed, the entry dew point should be dryer than -60°F (-51 °C) and the exit dew point dryer than about -40°F (-40 °C) when the inside retort temperature is above 900°F (482°C).

Optional Treatments

For Centerless Ground Bars less than 1.250" (31.75 mm) Diameter-

This duplex practice is only recommended for centerless ground bars in the size range given. Larger centerless ground bars, shapes, or hot rolled bars may be subject to cracking if quenched in this manner. This is a two-step treatment where the first step conditions the material for best machinability while the second develops optimum magnetic properties.

Preheat treat 2 to 3 foot lengths at 1850°F (1010°C) for about 30 minutes in air or protective atmosphere and quench bars in cold agitated water with their long axes in the vertical position. This preheat treatment develops a coarse acicular martensitic type structure which imparts ductility to the material and improves machining of the finish part.

The second part of the duplex treatment involves the employment of the standard treatment as described earlier. At no time should the temperature of the second treatment exceed 1600°F (871°C) because of the formation of a nonmagnetic austenitic phase which transforms upon cooling, thereby degrading magnetic properties due to transformation stresses.

For Products Produced from Any Size Bar-

This practice can be applied to all parts produced from bar products, regardless of their size since no rapid quench practices are required. It provides improved capability magnetic properties on especially large cross sections compared to those of the standard heat treatment. Note, however, it is a lengthy process and, therefore, more expensive.

Heat the finish machined part in dry hydrogen or high vacuum to 1700°F (927°C) (heating rate is not critical) and hold at 1700°F (927°C) for three to four hours. Cool at 20°F (11°C) maximum per hour to 1350°F (732°C), then cool to 950°F (510°C) at 200°F (111°C) per hour. Cool at any rate thereafter.

Workability

Machinability

Following are typical feeds and speeds for Hiperco 50A alloy.

Typical Machining Speeds and Feeds – Hiperco® 50A 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

Depth of Cut (Inches)	Micro-Melt® Powder High Speed Tools			Carbide Tools (Inserts)			
	Tool Material	Speed (fpm)	Feed (ipr)	Tool Material	Speed (fpm)		Feed (ipr)
					Uncoated	Coated	
.150	M48, T15	36	.010	C2	100	120	.010
.025		48	.005	C3	110	130	.005

Turning—Cut-Off and Form Tools

Tool Material		Speed (fpm)	Feed (ipr)						
Micro-Melt® Powder HS	Carbide Tools		Cut-Off Tool Width (inches)				Form Tool Width (inches)		
			1/16	1/8	1/4	1/2	1	1 ½	2
M48, T15		30	.001	.001	.0015	.0015	.001	.0007	.0007
	C2	80	.003	.003	.0045	.003	.002	.002	.002

Rough Reaming

Micro-Melt® Powder HS		Carbide Tools		Feed (ipr) Reamer Diameter (inches)					
Tool Material	Speed (fpm)	Tool Material	Speed (fpm)	1/8	1/4	1/2	1	1 ½	2
M48, T15	36-72	C2	70	.002	.006	.008	.010	.012	.014

Drilling

High Speed Tools									
Tool Material	Speed (fpm)	Feed (inches per revolution) Nominal Hole Diameter (inches)							
		1/16	1/8	1/4	1/2	3/4	1	1 ½	2
M42	40	.001	.002	.004	.007	.008	.010	.012	.015

Die Threading

FPM for High Speed Tools				
Tool Material	7 or less, tpi	8 to 15, tpi	16 to 24, tpi	25 and up, tpi
M1, M2, M7, M10	8-20	10-25	15-30	20-40

Milling, End-Peripheral

Depth of Cut (in)	Micro-Melt® Powder HS Tools						Carbide Tools					
	Tool Material	Speed (fpm)	Feed (ipt) Cutter Diameter (in)				Tool Material	Speed (fpm)	Feed (ipt) Cutter Diameter (in)			
			1/4	1/2	3/4	1-2			1/4	1/2	3/4	1-2
.050	M48, T15	42	.0005	.001	.002	.006	C6	200	.001	.002	.003	.004

Tapping

High Speed Tools	
Tool Material	Speed (fpm)
M1, M7, M10	6-15

Broaching

Micro-Melt® Powder HS Tools		
Tool Material	Speed (fpm)	Chip Load (ipt)
M48, T15	9.6-14.4	.002

Additional Machinability Notes

When using carbide tools, surface speed feet/minute (SFPM) can be increased between 2 and 3 times over the high-speed suggestions. Feeds can be increased between 50 and 100%.

Figures used for all metal removal operations covered are average. On certain work, the nature of the part may require adjustment of speeds and feeds. Each job has to be developed for best production results with optimum tool life.
Speeds or feeds should be increased or decreased in small steps.

Other Information

Applicable Specifications

- ASTM A801 Alloy Type 1
- MIL A 47182

Forms Manufactured

- Bar-Rounds
- Billet
- Strip
- Wire

Technical Articles

- A Simplified Method of Selecting Soft Magnetic Alloys
- Soft Magnetic Alloys with Improved Corrosion Resistance