CARPENTER ELECTRIFICATION®

DATASHEET

HIPERCO® 50

Type analysis

Single figures are nominal except where noted.

Iron	Balance	**Cobalt**	48.5 %	**Vanadium**	1.9 %
Niobium	0.05 %	**Carbon**	0.01 %		

Forms manufactured

Strip	**Plate**

Additional details available on page 5, Other Information.

Description

Hiperco 50 is an iron-cobalt vanadium soft magnetic alloy that exhibits the highest magnetic saturation (24 kilogauss) of commercially available soft magnetic alloys while maintaining low core loss as compared to electrical steel. This alloy is produced in strip, plate, and slab form and contains a small niobium addition to control grain growth during heat treatment, which allows for varying levels of mechanical strength and magnetic properties.

Hiperco 50 is used in motors and generators for achieving maximum torque density and minimum losses. It helps improve motor power density and efficiency, and can reduce the size of the motor. This alloy also offers the highest forces for actuators in consumer electronic applications, such as speaker, haptic, and sensor devices.

Key Properties:

- High magnetic saturation
- Low core loss compared to electrical steel
- Mechanical strength

Markets:

- Aerospace
- Automotive
- Consumer
- Industrial

Applications:

- Motors
- Generators
- Actuators
- Magnetic bearings

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Typical magnetic anneal physical properties

PROPERTY	At or From	English Units	Metric Units
SPECIFIC GRAVITY	68°F (20°C)	8.12	8.12
DENSITY	—	0.2930 lb/in^3	8.11 g/cm^3
MEAN COEFFICIENT OF THERMAL EXPANSION	77 to 392°F (25 to 200°C)	5.3 x 10^{-6}/°F	9.59 x 10^{-6}/°C
	77 to 752°F (25 to 400°C)	5.6 x 10^{-6} length/length/°F	10.1 x 10^{-6}length/length/°C
	77 to 1112°F (25 to 600°C)	5.8 x10^{-6} length/length/°F	10.5 x 10^{-6} length/length/°C
	77 to 1472°F (25 to 800°C)	6.3 x10^{-6} length/length/°F	11.3 x 10^{-6} length/length/°C
THERMAL CONDUCTIVITY		206.8 Btu in/hr/ft^2/°F	29.83 W/m/°C
ELASTIC MODULUS	—	30 x 10^3 ksi	206.8 GPa
ELECTRICAL RESISTIVITY	70°F (21°C)	241.0 ohm-cir-mil/ft	40.1 x 10^{-8} ohm-m
CURIE TEMPERATURE[1]	—	1720°F	938°C

[1] Curie temperature is phase transition from magnetic to non-magnetic phase

Magnetic properties

AC CORE LOSS

CORE LOSS BY HEAT TREATMENT							
HEAT TREATMENT	0.014 IN (0.355 MM) SPECIFIC CORE LOSS (W/kg)			0.006 IN (0.1524 MM) SPECIFIC CORE LOSS (W/kg)			B (TESLA)
	60 Hz	400 Hz	1000 Hz	60 Hz	400 Hz	1000 Hz	
Typical magnetic anneal	1.5	15.0	60.0	1.15	10.0	34.0	1.0
	2.5	35.0	160.0	2.1	19.25	66.0	1.5
	3.7	63.0	340	3.25	31.0	110	2.0
Typical mechanical anneal	2.48	23.0	80.2	2.17	16.7	46.2	1.0
	4.47	47.5	191	3.96	31.1	93.8	1.5
	7.16	84.5	388	6.54	51.4	157	2.0

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DC PROPERTIES

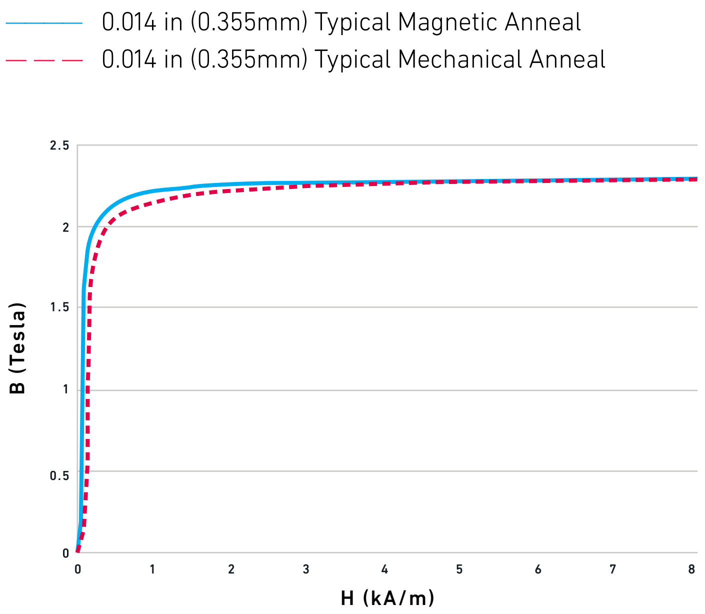
0.014 IN (0.355 MM) STRIP

HEAT TREATMENT	COERCIVITY (A/m) FROM 8 kA/m	DC RELATIVE PERMEABILITY μ_{MAX}	B (TESLA) A/m					
			400	*800*	*1600*	*4000*	*8000*	*16000*
Typical magnetic anneal	45	18000	2.10	2.15	2.23	2.27	2.28	2.30
Typical mechanical anneal	125	7900	2.01	2.12	2.19	2.25	2.28	2.29

0.006 IN (0.1524 MM) STRIP

HEAT TREATMENT	COERCIVITY (A/m) FROM 8 kA/m	DC RELATIVE PERMEABILITY μ_{MAX}	B (TESLA) A/m					
			400	*800*	*1600*	*4000*	*8000*	*16000*
Typical magnetic anneal	50	15000	2.05	2.15	2.20	2.27	2.28	2.30
Typical mechanical anneal	125	7400	1.99	2.11	2.18	2.25	2.28	2.29

DC B v H



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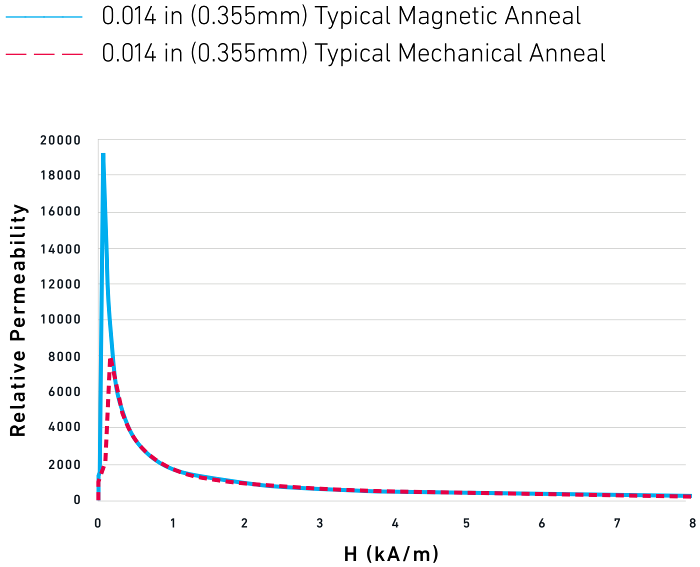
DC RELATIVE PERMEABILITY



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Typical mechanical properties

0.014 IN (0.355 MM) STRIP

HEAT TREATMENT	0.2% YIELD STRENGTH		ULTIMATE TENSILE STRENGTH		ELONGATION IN 2 IN (50.8 MM)	HARDNESS
	ksi	MPa	ksi	MPa	%	ROCKWELL C
Cold rolled unannealed	175	1270	190	1310	2	36
Typical magnetic anneal	32	220	85	586	5-15	—
Typical mechanical anneal	60	414	135	930	5 -15	—

0.006 IN (0.1524 MM) STRIP

HEAT TREATMENT	0.2% YIELD STRENGTH		ULTIMATE TENSILE STRENGTH		ELONGATION IN 2 IN (50.8 MM)	HARDNESS
	ksi	MPa	ksi	MPa	%	ROCKWELL C
Cold rolled unannealed	190	1310	205	1413	1	40
Typical magnetic anneal	28	193	75	517	5-15	—
Typical mechanical anneal	56	386	135	930	5 -15	—

Heat treatment

Annealing

It is important to avoid any contamination of the finished parts during heat treatment. All parts must be cleaned thoroughly to remove any surface contaminants prior to annealing.

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

Anneal parts at 1300/1600°F (704/871°C) for 2 to 4 hours in dry hydrogen or vacuum and cool at 250/400°F (139/222°C) per hour until 600°F (316°C) is reached, after which any cooling rate can be employed. The exact heat treat temperature used will depend on the particular application and the desired compromise between magnetic and mechanical properties as shown in the table below. Increasing temperature within the range of 1300 to 1600°F (704 to 871°C) will result in improved magnetic properties and decreased yield and tensile strengths. However, the temperature should never exceed 1600°F (871°C), as soft magnetic characteristics will start to decline due to formation of an austenitic phase.

MECHANICAL STRENGTH	DC PERMEABILITY	AC CORE LOSS
Higher	Lower	Higher
Medium	Medium	Medium
Lower	Higher	Lower

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Coatings

Inlac	Inlac coating is applied in a continuous process on coils of strip to create a mix of magnesium-based compounds on both sides of the strip surface. This surface layer acts as an inert barrier between laminations during heat treating and prevents adhesion. Additionally, during AC excitation, it provides improved electrical insulation between laminations reducing eddy current effects on core loss.
Oxide	Annealed laminations can be heat treated in an oxygen bearing atmosphere in the range of 600 to 900°F (316 to 480°C) to grow a thin oxide layer on the surface. This coating provides an enhanced level of electrical insulation between laminations, greatly reducing eddy current effects during AC excitation. Oxide heat treatment soak times are generally less than 5 hours and can be adjusted to refine coating thickness.

Other information

Applicable specifications	ASTM A801 Alloy Type 1, MIL A 47182

Appendix

PHYSICAL PROPERTIES	ASTM STANDARD #
Density	B311-17
Coefficient of thermal expansion	E228
Thermal conductivity	ASTM E1225 - 13
Modulus of elasticity	ASTM A370 Section 14, E8-E8M
Electrical resistivity	B193
Curie temperature	A 894/A 894M-00
AC magnetic properties	A927/A927M
DC magnetic properties	A596/A596M
Mechanical properties	E8, A677 Section 9

For additional information, please contact your nearest sales office:
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