ELECTRICAL IRON

Type analysis

Single figures are nominal except where noted

Iron	Balance	**Chromium**	0.20 %	**Manganese**	0.12 %
Silicon	0.12 %	**Nickel**	0.08 %	**Vanadium**	0.05 %
Carbon (Maximum)	0.02 %	**Phosphorus**	0.010 %	**Sulfur**	0.010 %

Forms manufactured

Bar-Rounds	**Billet**	**Strip**

Description

Electrical Iron is a low carbon iron produced using the electric arc melting process. Other elements commonly found in low carbon irons are held as low as possible in order to provide a material capable of producing good direct current soft magnetic properties.

After a standard magnetic aging treatment, the coercivity (Hc) from 15 kG increases less than 6% when employing a 1562°F (850°C) forming gas initial heat treatment.

Key Properties:

- Low carbon iron
- Good direct current soft magnetic properties

Markets:

- Aerospace
- Automotive
- Consumer
- Industrial

Applications:

- Solenoids
- Relays
- Magnetic pole pieces
- Flux carrying members

> ELECTRICAL IRON

Physical properties

PROPERTY	At or From	English Units	Metric Units
SPECIFIC GRAVITY	—	7.86	7.86
DENSITY	—	0.2840 lb/in^3	7861 kg/m^3
MEAN COEFFICIENT OF THERMAL EXPANSION ANNEALED MATERIAL	68 to 212°F (20 to 100°C)	6.80 x 10^{-6} length/length/°F	12.24 x 10^{-6} length/length/°C
	68 to 392°F (20 to 200°C)	7.00 x 10^{-6} length/length/°F	12.6 x 10^{-6} length/length/°C
	68 to 572°F (20 to 300°C)	7.60 x 10^{-6} length/length/°F	13.68 x 10^{-6} length/length/°C
	68 to 752°F (20 to 400°C)	8.10 x 10^{-6} length/length/°F	14.58 x 10^{-6} length/length/°C
	68 to 932°F (20 to 500°C)	8.30 x 10^{-6} length/length/°F	14.94 x 10^{-6} length/length/°C
	68 to 1112°F (20 to 600°C)	8.60 x 10^{-6} length/length/°F	15.48 x 10^{-6} length/length/°C
	68 to 1292°F (20 to 700°C)	8.80 x 10^{-6} length/length/°F	15.84 x 10^{-6} length/length/°C
ELECTRICAL RESISTIVITY	70°F (21°C)	78.22 ohm-cir-mil/ft	13.00 microohm·cm
CURIE TEMPERATURE	—	1400°F	760°C

Magnetic properties

Items as supplied from the mill do not exhibit the most soft magnetic properties of which they are capable. Further heat treatment is required to improve magnetic properties (see "Heat treatment" section).

Magnetic properties of material supplied from the mill are a function of the condition requested. Mill process annealed items will exhibit softer magnetic properties than a hot rolled, cold drawn, or cold rolled product. To some degree, magnetic properties follow mechanical properties; the lower the mechanical properties, the better the magnetic properties.

Only certain items can be supplied in the mill process annealed condition. Mutual agreement between Carpenter and fabricator regarding anticipated magnetic properties is necessary.

> ELECTRICAL IRON

Determination of direct current (DC) magnetic properties

The form of the product supplied will determine the type of specimen used in evaluating magnetic properties or magnetic property capability.

Round and square items less than 1 in. (25.4 mm) in dimension, rectangular items having largest dimension less than 1.50 in. (38.1 mm), and strip products cold rolled at a width less than 1.50 in. (38.1 mm) are evaluated via ASTM A-341.

Larger items are evaluated per ASTM A-596. ASTM A-596 is the more accurate method of test and will show higher permeability values than ASTM A-341.

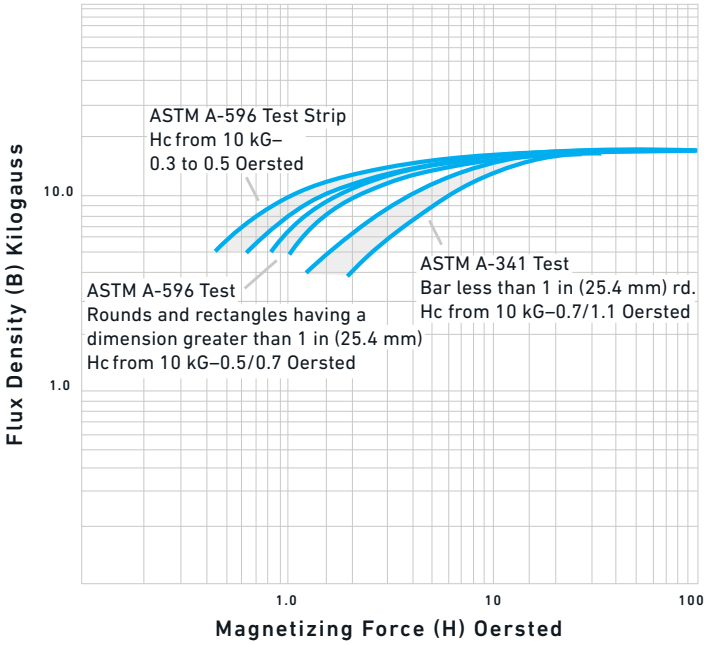
When determining the magnetic property capability of a finished mill product, a wet hydrogen atmosphere is employed. The specimen is heated to 1562°F (850°C) for 4 hours and furnace cooled at 180°F (100°C) per hour to 1000°F (540°C).

If DC magnetic property capability data are to be provided, the order must be endorsed accordingly. Carpenter standard heat treatment consists of heating in a forming gas atmosphere at 1562°F (850°C) for 1 to 2 hours and slow cool. HC from 15 kG is not to exceed 1.50 oersted. Order must indicate heat treatment and magnetic requirements if they differ from our standard evaluations.

> ELECTRICAL IRON

Direct current (DC) magnetic properties

Test specimen heat treated in wet hydrogen atmosphere at 1562°F (850°C) for 4 hours and cooled at a rate of 180°F (100°C) per hour. Ring specimen used for ASTM A-596. 10 in. (25.4 cm) straight bar used for ASTM A-341.



Typical mechanical properties

CARPENTER ELECTRICAL IRON						
FORM	0.2% YIELD STRENGTH		ULTIMATE TENSILE STRENGTH		ELONGATION 2 IN (50.8 MM)	HARDNESS
	ksi	MPa	ksi	MPa	%	ROCKWELL B
3/8 in (9.53 mm) bar diameter	55/60	379/414	65/72	448/496	20	75/90
1 in (2.54 mm) bar diameter	40/53	276/365	50/65	345/448	22	55/65
Annealed strip	38/53	262/365	45/60	310/414	35	50/70
Unannealed strip	60/65	414/448	65/72	448/496	20	80/90

> ELECTRICAL IRON

Heat treatment

Thermal treatment	Magnetic properties of the fabricated magnetic core parts produced from the mill product can be improved by a thermal treatment. Heat treating temperatures of 1350°F (730°C) or higher should be employed to obtain part uniformity of magnetic properties. With increasing temperature, DC magnetic properties become softer provided no surface contamination of carbon, sulfur, oxygen, or nitrogen is encountered. The heat treating atmosphere used is a very important factor. Further improvement in DC magnetic properties can be achieved by employing an atmosphere capable of decarburizing and desulfurizing the material. Degree of material purification is also a function of time at temperature.
Heat treating for best DC magnetic properties	Heat charge in a wet hydrogen atmosphere with a dew point of approximately 75°F (24°C) to 1562°F (850°C) and hold at temperature for 2 to 4 hours, then cool at a rate of 180/306°F (100/170°C) per hour to 1000°F (540°C) and at any rate thereafter. Other atmospheres, including pack anneal, vacuum, dry hydrogen, argon, and forming gas (hydrogen and nitrogen) may be used with a treating temperature in the 1350/2150°F (730/1180°C) range. Do not use wet hydrogen above 1740°F (950°C).

Machinability

The following tables include the machining parameters used to machine Electrical Iron.
The data listed should be used as a guide for initial machine setup only.

> ELECTRICAL IRON

Typical feeds and speeds

TURNING — SINGLE-POINT AND BOX TOOLS

DEPTH OF CUT, IN	HIGH-SPEED TOOLS			CARBIDE TOOLS			
	SPEED, FPM	FEED, IPR	TOOL MATERIAL	SPEED, FPM		FEED, IPR	TOOL MATERIAL
				BRAZED	THROW AWAY		
.150	80	.015	M-2	350	400	.020	C-6
.025	110	.007	M-3	400	490	.007	C-7

TURNING — CUT-OFF AND FORM TOOLS

SPEED, FPM	FEED, IPR							TOOL MATERIAL
	CUT-OFF TOOL WIDTH, IN			FORM TOOL WIDTH, IN				
	1/16	1/8	1/4	1/2	1	1-1/2	2	
70	.001	.0015	.002	.0015	.001	.001	.0007	M-2
250	.003	.0045	.006	.003	.0025	.0025	.0015	C-6

DRILLING

SPEED, FPM	FEED, IPR								TOOL MATERIAL
	NOMINAL HOLE DIAMETER, IN								
	1/16	1/8	1/4	1/2	3/4	1	1-1/2	2	
70	.001	.002	.004	.007	.010	.012	.015	.018	M-42

TAPPING

SPEED, FPM	TOOL MATERIAL
15-20	M-1, M-7, M-10

DIE THREADING

SPEED, FPM				TOOL MATERIAL
7 OR LESS	8 TO 15	16 TO 24	25 AND UP, TPI	
8–20	10–25	15–30	20–35	M-1, M-2, M-7, M-10

MILLING — END PERIPHERAL

DEPTH OF CUT, IN	HIGH-SPEED TOOLS						CARBIDE TOOLS					
	SPEED, FPM	FEED, IN PER TOOTH				TOOL MATERIAL	SPEED, FPM	FEED, IN PER TOOTH				TOOL MATERIAL
		CUTTER DIAMETER, IN						CUTTER DIAMETER, IN				
		1/4	1/2	3/4	1-2			1/4	1/2	3/4	1-2	
.050	60	.002	.003	.005	.006	M-42	300	.0025	.004	.006	.008	C-6

> ELECTRICAL IRON

Additional machinability notes

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 A848 Alloy 1

For additional information, please contact your nearest sales office:
electrification@cartech.com | 610 208 2000

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 their 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.

Unless otherwise specified, registered trademarks are property of CRS Holdings Inc., a subsidiary of Carpenter Technology Corporation.

© 2020 CRS Holdings Inc. All rights reserved. v 05-20