CARPENTER ELECTRIFICATION®

DATASHEET

CHROME CORE® 13-XP

Type analysis

Single figures are nominal except where noted

Iron	Balance	**Chromium**	12.50 to 13.50 %	**Silicon**	1.20 to 1.80 %
Molybdenum	0.50 to 1.00 %	**Vanadium**	0.50 to 1.00 %	**Manganese (Maximum)**	0.50 %
Sulfur	0.20 to 0.40 %	**Carbon (Maximum)**	0.03 %	**Phosphorus (Maximum)**	0.030 %

Forms manufactured

Bar-Rounds	**Strip**

Description

Chrome Core 13-XP is a controlled chemistry, free machining, ferritic 13% chromium alloy that is a candidate for use in magnetic components where corrosion resistance superior to pure iron, low carbon steel, and silicon-iron alloys is desired. The alloy improved magnetic responses along with comparable corrosion resistances when compared to 18% Cr ferritic stainless steels.

Key Properties:

- High corrosion resistance
- Extended shelf life
- High permeability
- High induction
- Low high frequency core loss

Markets:

- Automotive
- Industrial
- Consumer
- Medical

Applications:

- Fuel injectors
- Fuel pump motor laminations
- ABS solenoids
- Haptics
- Audio
- High speed motors

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Corrosion resistance

The corrosion resistance of Chrome Core 13-XP was evaluated in several environments along with other soft magnetic ferritic stainless steels.

Salt spray testing	The results of salt spray testing performed in 5% neutral salt spray at 95°F (35°C) for 200 hours (ASTM B-117) are found in the table entitled "Salt Spray Testing – Various Alloys." The Chrome Core 13-XP exhibited time to first rust comparable to Chrome Core 18-FM that has much higher chromium content. The rust ratings after 200 hours again show that Chrome Core 13-XP exhibits performance comparable to the higher alloyed Chrome Core 18-FM and is superior to Type 430 and 430FR alloys.
Corrosive water testing	The same alloys were also tested in a corrosive water environment consisting of 3000 ml distilled water, 5 ml ethyl acetate, 1 ml glacial acetic acid, 0.1 g NaCl, and 0.1 g Na2SO4 at room temperature and boiling. This environment is the corrosive component found in most ethanol fuels. The corrosion rates were determined after 24 hours and again after an additional 168 hours (192 hours total). The most significant differences in corrosion rates were found after 24 hours at room temperature as shown in the table entitled "Corrosive Water Testing – Various Alloys." This test also shows that the Chrome Core 13-XP is comparable to Chrome Core 18-FM and is superior to the other ferritic stainless steels tested.
E85 fuel testing	Immersion testing was also conducted in E85A (85% ethanol, 15% gasoline) at 140°F (60°C) for 1000 hours. All alloys exhibited a negligible weight loss after testing and actual corrosion rates were not determined.

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

Nitric Acid	Moderate	**Sulfuric Acid**	Restricted
Phosphoric Acid	Restricted	**Acetic Acid**	Restricted
Sodium Hydroxide	Moderate	**Salt Spray (NaCl)**	Moderate
Humidity	Good		

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CORROSIVE WATER TESTING RESULTS — VARIOUS ALLOYS

3000 ML DISTILLED WATER, 5 ML ETHYL ACETATE, 1 ML GLACIAL ACETIC ACID, 0.1G NaCl, AND 0.1G Na_2SO_4				
ALLOY	CORROSION RATE, MPY			
	ROOM TEMPERATURE 24 HOURS	ROOM TEMPERATURE 192 HOURS	BOILING 24 HOURS	BOILING 192 HOURS
Chrome Core 13-XP	0.0/0.0	0.0/0.0	0.2/0.2	0.0/0.0
Chrome Core 18-FM	0.0/0.0	0.1/0.1	0.0/0.20	0.0/0.0
Type 430F Solenoid Quality	0.0/0.0	0.0/0.0	0.3/0.5	0.2/0.2
Chrome Core 12-FM	4.3/3.4	1.0/0.7	2.4/1.8	0.5/0.5
Chrome Core 13-FM	5.7/6.5	1.4/1.0	3.3/2.5	0.2/0.2

Corrosion rate measured after 24 hours and then after an additional 168 hours.

SALT SPRAY RESISTANCE (PASSIVATED) — VARIOUS ALLOYS

200 HOURS ASTM B-117 5% NEUTRAL SALT SPRAY		
ALLOY	TIME FOR FIRST RUST (H)	VISUAL APPEARANCE AFTER 200 HOURS
Chrome Core 13-XP	48 24	5 to 10 % rust 10 to 20 % rust
Chrome Core 18-FM	48 72	10 to 20 % rust 10 to 20 % rust
Type 430F Solenoid Quality	2 1	60 to 80 % rust > 80 % rust
Chrome Core 13-FM	3 1	40-60% rust > 80 % rust
Chrome Core 12-FM	1 1	> 80 % rust > 80 % rust

Samples passivated prior to testing (alkaline-acid-alkaline method).

Physical properties

PROPERTY	At or From	English Units	Metric Units
DENSITY	—	0.2751 lb/in^3	7615 kg/m^3
MODULUS OF ELASTICITY (E)	—	27.0 x 10^3 ksi	186.16 GPa
ELECTRICAL RESISTIVITY	70°F (21°C)	489.8 ohm-cir-mil/ft	81.4 microohm·cm
CURIE TEMPERATURE	—	1272°F	689°C

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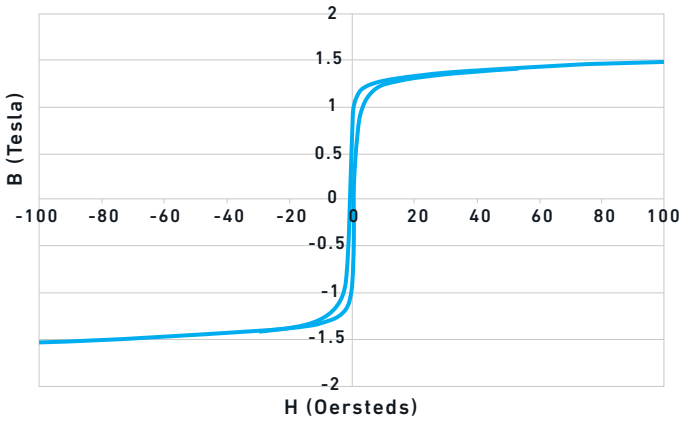
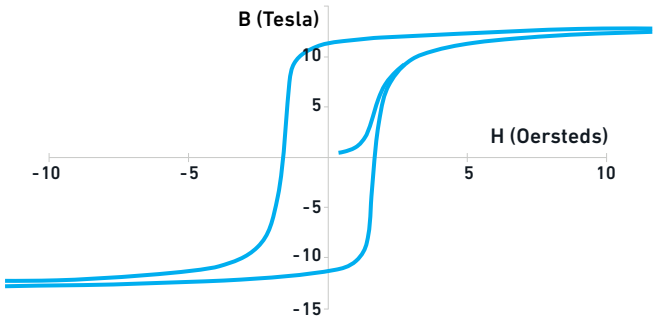
Magnetic properties

BH CURVE — CHROME CORE 13-XP, BAR-ROUNDS





COMPARISON OF PHYSICAL/MAGNETIC PROPERTIES

ALLOY	SATURATION FLUX DENSITY Bs, (Tesla)	MAXIMUM PERMEABILITY	RESISTIVITY μΩ-MM	MICROOHM·CM	COERCIVITY Hc (A/m)
Chrome Core 13-XP	1.7	3300	814	81	127
Chrome Core 13-FM	1.7	2900	779	78	140
Chrome Core 12-FM	1.7	3100	570	57	200
Chrome Core 18-FM	1.5	1500	755	76	199
Type 430F Solenoid Quality	1.56	3300	760	76	200

Values represent typical properties and actual values may vary depending upon bar diameter.

SATURATION FLUX DENSITY	17000 G	17 kG	1.7 T
COERCIVITY	1.60 Oe		
MAXIMUM PERMEABILITY	3200		

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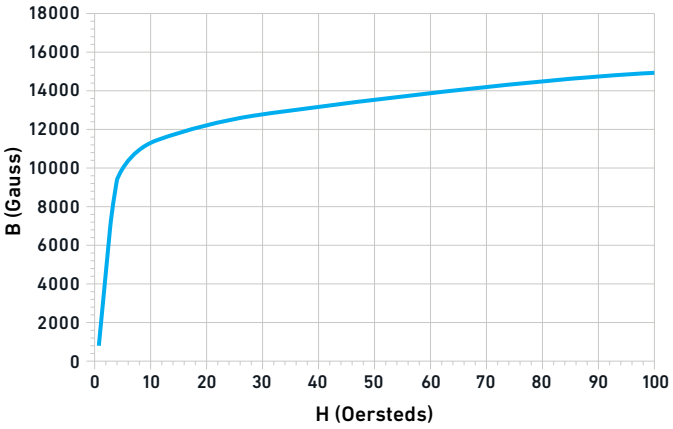
BH CURVE — CHROME CORE 13-XP, STRIP



SATURATION FLUX DENSITY	17000 G	17 kG	1.7 T
COERCIVITY	1.40 Oe		
MAXIMUM PERMEABILITY	2600		

Typical mechanical properties

0.471 IN DIAMETER BAR

	0.2% YIELD STRENGTH		ULTIMATE TENSILE STRENGTH		ELONGATION IN 2 IN (50 MM)	REDUCTION IN AREA
	ksi	MPa	ksi	MPa	%	%
Annealed for optimum magnetic properties	45	310	70	483	35	50

0.004 IN STRIP

	0.2% YIELD STRENGTH		ULTIMATE TENSILE STRENGTH		ELONGATION IN 2 IN (50 MM)	REDUCTION IN AREA
	ksi	MPa	ksi	MPa	%	%
	57	390	77	530	24	—

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Heat treatment

Annealing, bar-rounds	Anneal at a temperature of 850°C ± 14°C (1560°F ± 25°F) for 2 to 4 hours. Annealing temperatures above 880°C (1616°F) should be avoided because of potential degradation of the magnetic properties. The cooling rate after the anneal is not critical, although rapid cooling and quenching may induce stresses that impair the magnetic characteristics. Any inert annealing atmosphere such as vacuum, inert gases, or dry forming gas is satisfactory. Attempts to decarburize the alloy using a wet hydrogen atmosphere are not recommended. Similar heat treating practices can be used to soften the alloy for further forming.
Annealing, strip	No heat treatment required.

Workability and other information

Cold working	Chrome Core 13-XP can be formed and cold drawn. Cold work will increase the hardness and degrade the magnetic properties. Because it is free machining, this alloy will withstand less cold work than non-free machining ferritic alloys and is not recommended for parts produced by large amounts of cold deformation.
Weldability	Chrome Core 13-XP is not recommended for most arc welding or oxyacetylene welding processes due to the free machining nature of the alloy. Solid state welding, such as friction or inertia welding, as well as high-energy processes, such as laser and electron beam welding, may be satisfactory. Post-weld heat treatment is desirable for toughness and magnetic performance. Use of austenitic stainless steel filler metal is not recommended due to the magnetic air gap created.

For additional information, please contact your nearest sales office:
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