CARPENTER
ELECTRIFICATION®

DATASHEET

CHROME CORE® 12-FM

Type analysis

Single figures are nominal except where noted.

Iron	Balance	**Chromium**	11.50 to 12.50 %	**Silicon**	0.30 to 0.70 %
Manganese	0.20 to 0.70 %	**Molybdenum**	0.20 to 0.50 %	**Sulfur**	0.20 to 0.40 %
Carbon (Maximum)	0.03 %	**Phosphorus**	0.03 %		

Forms manufactured

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

Description

Chrome Core 12-FM is in a family of controlled chemistry, chromium-iron alloys that are candidates for use in magnetic components where corrosion resistance superior to that of pure iron, low carbon steel, and silicon-iron alloys is desired without the substantial decrease in saturation induction associated with 18% Cr ferritic stainless steels.

Applications could include electromechanical devices requiring some degree of corrosion resistance, either in service or for extended shelf life without the need for protective coatings.

Chrome Core 12-FM has been considered for use in automotive components such as fuel injectors, fuel pump motor laminations, and ABS solenoids.

Key Properties:

- Superior corrosion resistance

Markets:

- Automotive
- Consumer
- Industrial

Applications:

- Fuel injectors
- Fuel pump motor laminations
- ABS solenoids

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Corrosion resistance

Chrome Core 12-FM exhibited no noticeable rusting in 95°F (35°C), 95% relative humidity tests and have demonstrated corrosion resistance generally similar to 18% chromium ferric stainless steel in certain simulated alcohol-base fuel environments.

Chrome Core alloys were evaluated along with comparison materials in environments designed to simulate or exceed the corrosive effects of some methanol fuels. These included boiling corrosive water (proprietary low-pH solution containing chlorides) and a mixture of 50% ethanol and 50% of this corrosive water at room temperature. As seen in the Corrosion Test Results — Simulated Fuel Environment table, there was very light or no significant attack of the Chrome Core alloys. Silicon Core Iron B-FM, a material widely used in less corrosive environments, experienced considerably greater attack than the other alloys listed in the table.

Chrome Core alloys and comparison materials were also evaluated in CM85A corrosive fuel mixture ("Gasoline/Methanol Mixtures of Materials Testing", SAE Cooperative Research Report, September 1990). This was composed of 15% gasoline and 85% aggressive methanol, which contained 0.1% distilled water, 3 ppm chloride ion (NaCl) and 60 ppm formic acid. All specimens were exposed without deaeration in an autoclave at 176°F (80°C) for 250 hours. The following table illustrates that Chrome Core 12 and Chrome Core 12-FM approached the resistance of Type 430F Solenoid Quality. All Chrome Core alloys were superior to Silicon Core Iron B-FM. Apparently, this test provided an oxidizing chloride environment and was, therefore, more severe than many anticipated service applications.

A second autoclave test using the same solution was performed with the air evacuated and without the Silicon Core Iron B-FM specimens to reduce both oxygen and iron contamination. The Chrome Core alloys and Type 430F Solenoid Quality displayed good resistance (corrosion rates of 0.2 mdd or less) in spite of the increased test duration of 763 hours.

Like most ferritic stainless steels, Chrome Core 12-FM will rust in neutral salt spray (fog) testing, although the degree and severity of rusting is substantially less than for either iron, low carbon steel, or silicon-iron alloys.

For optimum corrosion resistance, surfaces must be free of scale, lubricants, foreign particles, and coatings applied for drawing and heading. After fabrication of parts, cleaning and/or passivation should be considered.

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Corrosion resistance (continued)

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)**	Restricted
Humidity	Good		

CORROSION TEST RESULTS IN CM85A FUEL — CHROME CORE ALLOYS, TYPE 430F SOLENOID QUALITY AND SILICON CORE IRON B-FM

250 HOURS AT 176°F (80°C), AUTOCLAVE TESTS PERFORMED WITHOUT DEAERATION

ALLOY	AVERAGE CORROSION RATE, MDD
Chrome Core 8 alloy	13.0
Chrome Core 8-FM alloy	38.9
Chrome Core 12 alloy	3.0
Chrome Core 12-FM alloy	3.1
Type 430F Solenoid Quality	0.2
Silicon Core Iron B-FM	84.3

Milligrams per square decimeter per day (mdd) used rather than mpy corrosion rate because pitting attack occurred.
Duplicate specimens cleaned in ASTM G1 procedure C.3.1 prior to final weighing.

CORROSION TEST RESULTS — SIMULATED FUEL ENVIRONMENT

UNIFORM ATTACK IN 24 HOUR TEST

ALLOY	CORROSION RATE, mpy[1]	
	BOILING[2]	ROOM TEMPERATURE[3]
Chrome Core 8-FM alloy	19.1/19.7	0.9/1.1
Chrome Core 12-FM alloy	0.8/1.0	0.6/0.7
Type 430F Solenoid Quality	0/0	0.2/0.2
Silicon Core Iron B-FM	244/277	6.9/7.3

1 Mils per year of uniform attack.
2 Boiling corrosive water; proprietary low-pH solution containing chloride.
3 50% ethanol - 50% corrosive water mixture.

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Physical properties

PROPERTY	At or From	English Units	Metric Units
SPECIFIC GRAVITY	—	7.66	7.66
DENSITY	—	0.2770 lb/in^3	7667 kg/m^3
MEAN SPECIFIC HEAT	—	0.1050 Btu/lb/°F	439.6 J/kg·K
MEAN COEFFICIENT OF THERMAL EXPANSION	77 to 122°F (25 to 50°C)	5.90 x 10^{-6} length/length/°F	10.70 x 10^{-6} length/length/°C
	77 to 212°F (25 to 100°C)	5.80 x 10^{-6} length/length/°F	10.40 x 10^{-6} length/length/°C
	77 to 392°F (25 to 200°C)	5.90 x 10^{-6} length/length/°F	10.70 x 10^{-6} length/length/°C
	77 to 572°F (25 to 300°C)	6.10 x 10^{-6} length/length/°F	11.0 x 10^{-6} length/length/°C
	77 to 752°F (25 to 400°C)	6.30 x 10^{-6} length/length/°F	11.40 x 10^{-6} length/length/°C
	77 to 932°F (25 to 500°C)	6.50 x 10^{-6} length/length/°F	11.70 x 10^{-6} length/length/°C
	77 to 1112°F (25 to 600°C)	6.70 x 10^{-6} length/length/°F	12.0 x 10^{-6} length/length/°C
ELASTIC MODULUS	—	29.0 x 10^3 ksi	—
ELECTRICAL RESISTIVITY	70°F (21°C)	343.0 ohm-cir-mil/ft	57 microohm·cm
CURIE TEMPERATURE	—	1350°F	732°C

Magnetic properties

SATURATION FLUX DENSITY (Bs)	17.7 KG
COERCIVITY	2.50 Oe
MAGNETIC PERMEABILITY	3100
RESIDUAL INDUCTION	12.6 kG

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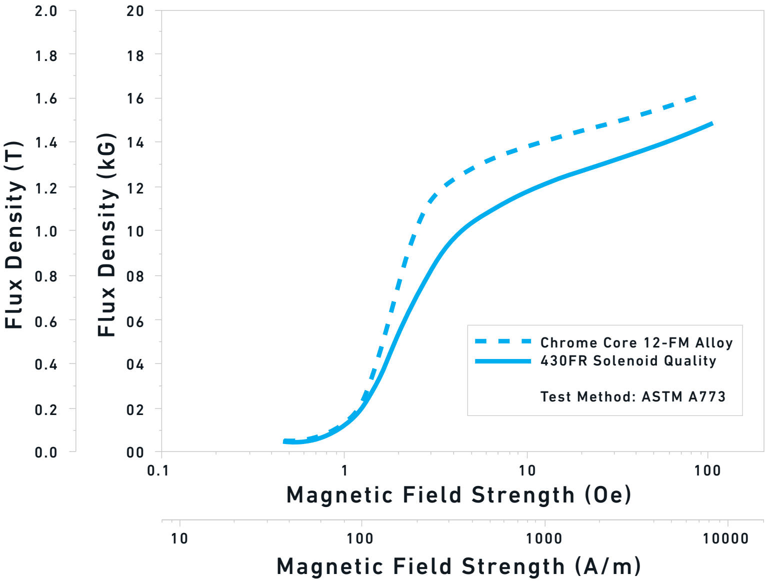
TYPICAL DC NORMAL INDUCTION CURVES FOR BAR PRODUCT — VS. 430FR STAINLESS

Data for fully annealed 0.250 to 0.625 in (6.35 to 15.9 mm) diameter bars tested on a Fahy permeameter per ASTM Method A 341.



Typical mechanical properties

ANNEALED FOR OPTIMUM MAGNETIC PROPERTIES

HEAT TREATMENT	0.2% YIELD STRENGTH		ULTIMATE TENSILE STRENGTH		ELONGATION IN 2 IN (50 MM)	REDUCTION OF AREA	HARDNESS
	ksi	**MPa**	**ksi**	**MPa**	**%**	**%**	**HRB**
Annealed	33	228	61	421	40	73	73

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Heat treatment

Standard treatment	Due to its relatively low chromium content, Chrome Core 12-FM will form austenite if heated to too high a temperature, and some hardening will occur if the austentized part is rapidly cooled. Consequently, the best heat treatment for improved soft magnetic properties is to subcritically anneal. Anneal at a temperature of 800°C +/-14°C (1472°F +/-25°F) for 2 to 4 hours. 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.

Workability

Cold working	Chrome Core 12-FM will withstand less cold working than the non-free machining versions and is not recommended for parts produced by large amounts of cold deformation.
Weldability	Chrome Core 12-FM is not recommended for welding.

Typical feeds and speeds

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

TURNING — SINGLE-POINT AND BOX TOOLS

DEPTH OF CUT, IN	HIGH-SPEED TOOLS			CARBIDE TOOLS (INSERTS)			
	SPEED, FPM	FEED, IPR	TOOL MATERIAL	SPEED, FPM		FEED, IPR	TOOL MATERIAL
				UNCOATED	COATED		
.150	165	.015	M-2	575	750	.015	C-6
.025	185	.007	M-3	650	850	.007	C-7

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TURNING — CUT-OFF AND FORM TOOLS

SPEED, FPM	**FEED, IPR**							**TOOL MATERIAL**	
	CUT-OFF TOOL WIDTH, IN			**FORM TOOL WIDTH, IN**				**HIGH-SPEED TOOLS**	**CARBIDE TOOLS**
	1/16	*1/8*	*1/4*	*1/2*	*1*	*1-1/2*	*2*		
150	.0015	.002	.0025	.0025	.002	.0015	.001	M-2	—
400	.004	.0055	.007	.005	.004	.0035	.0035	—	C-6

ROUGH REAMING

HIGH-SPEED TOOLS		**CARBIDE TOOLS**		**FEED, IPR, REAMER DIAMETER, IN**					
SPEED, FPM	**TOOL MATERIAL**	**SPEED, FPM**	**TOOL MATERIAL**	*1/8*	*1/4*	*1/2*	*1*	*1-1/2*	*2*
130	M-7	—	—	—	—	—	—	—	—
—	—	150	C-2	.005	.008	.013	.018	.022	.025

DRILLING — HIGH-SPEED TOOLS

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*	
100–150	.001	.003	.006	.010	.014	.017	.021	.025	M-1, M-10

DIE THREADING — HIGH-SPEED TOOLS

SPEED, FPM				**TOOL MATERIAL**
7 OR LESS, TPI	**8 TO 15, TPI**	**16 TO 24, TPI**	**25 AND UP, TPI**	
15–25	30–40	40–50	50–60	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, IPT**				**TOOL MATERIAL**
		CUTTER DIAMETER, IN						**CUTTER DIAMETER, IN PER TOOTH**				
		1/4	*1/2*	*3/4*	*1-2*			*1/4*	*1/2*	*3/4*	*1-2*	
.050	140	.002	.002	.004	.005	M-2, M-7	400	.001	.002	.005	.007	C-6

TAPPING — HIGH-SPEED TOOLS

SPEED, FPM	**TOOL MATERIAL**
20-45	M-1, M-7, M-10

BROACHING — HIGH-SPEED TOOLS

SPEED, FPM	**CHIP LOAD, IN PER TOOTH**	**TOOL MATERIAL**
30	.004	M-2, M-7

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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 and/or feeds should be increased or decreased in small steps.

For additional information, please contact your nearest sales office:

electrification@cartech.com | 610 208 2000
