CARPENTER ELECTRIFICATION®

DATASHEET

430FR SOLENOID QUALITY STAINLESS

Type analysis

Single figures are nominal except where noted

Iron	Balance	**Chromium**	17.25 to 18.25 %	**Silicon**	1.00 to 1.50 %
Manganese (Maximum)	0.80 %	**Nickel (Maximum)**	0.60 %	**Molybdenum (Maximum)**	0.50 %
Sulfur	0.250 to 0.400 %	**Carbon (Maximum)**	0.07 %	**Phosphorus (Maximum)**	0.030 %

Forms manufactured

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

Description

430FR Solenoid Quality Stainless is a ferritic chromium-iron alloy specially developed for soft magnetic components that must operate in corrosive environments. The corrosion resistance of this alloy is similar to that of 430F Solenoid Quality Stainless.

The increased silicon content of 430FR Solenoid Quality Stainless results in higher electrical resistivity and annealed hardness as compared to 430F Solenoid Quality Stainless. The higher hardness reduces deformation (peening) that can occur during impacts between moving and stationary parts of AC and DC magnetic circuits.

When supplied in the mill annealed condition (approximately Rockwell B 83), the DC magnetic properties of 430FR Solenoid Quality Stainless bars are similar to those of the 430F Solenoid Quality Stainless product mill annealed to approximately Rockwell B 78 hardness.

Key Properties:

- High electrical resistivity
- High annealed hardness
- Reduced deformation
- Corrosion resistance

Markets:

- Aerospace
- Automotive
- Consumer
- Industrial

Applications:

- Soft magnetic components that must operate in corrosive environments

electrification@cartech.com | 610 208 2000

> 430FR SOLENOID QUALITY STAINLESS

In applications involving AC excitation, 430FR Solenoid Quality Stainless has exhibited superior performance due to its higher electrical resistivity. This advantage increases as the magnetic component diameter and frequency increase due to the suppression of eddy current losses.

430FR Solenoid Quality Stainless is available in the unannealed condition when the size ordered cannot be supplied in the mill annealed condition and/or in the most magnetically soft condition. Depending on the requirement of the application, parts may have to be heat treated to render them more magnetically soft than as supplied.

Mill annealed material is supplied in the form of centerless ground bar items made to standard tolerances 0.250 in. (6.35 mm) round and larger at a hardness range of Rockwell B 80/88. In this condition, AC and DC magnetic properties are in the same range as those obtained when applying the suggested heat treatment to the unannealed alloy.

Precision ground bars 0.250 in. (6.35mm) and larger can be supplied with a slightly higher hardness and somewhat "harder" magnetic properties.

Magnetic core components can be machined to size, chemically passivated if necessary, then assembled into the finished product.

Corrosion resistance

Like Stainless Type 430F Solenoid Quality, Stainless Type 430FR Solenoid Quality has resisted corrosion from atmosphere, fresh water, gasses, common beverages, dairy products, etc.

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.

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

> 430FR SOLENOID QUALITY STAINLESS

Physical properties

PROPERTY	At or From	English Units	Metric Units
SPECIFIC GRAVITY	—	7.59	7.59
DENSITY	—	0.2740 lb/in^3	7584 kg/m^3
MEAN COEFFICIENT OF THERMAL EXPANSION	32 to 1200°F (0 to 649°C)	6.61 x 10^{-6} length/length/°F	11.90 x 10^{-6} length/length/°C
ELECTRICAL RESISTIVITY	70°F (21°C)	460.0 ohm-cir-mil/ft	76.5 microohm·cm
CURIE TEMPERATURE	—	1220°F	660°C

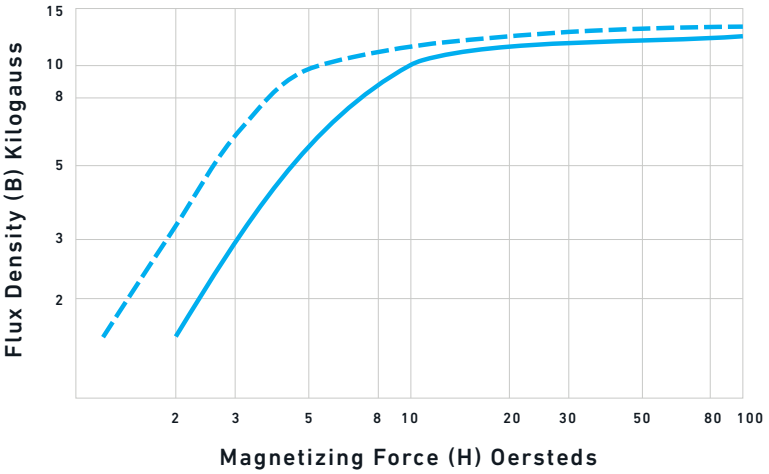
Magnetic properties

SATURATION FLUX DENSITY (Bs)	15200 G	15.2 kG

TYPCAL DC MAGNETIZATION CURVES — BAR MILL ANNEALED ROCKWELL B 80/88

——— greater than 0.625 in (15.88 mm) diameter

— — — 0.375 in (9.53 mm) to 0.625 in (15.88 mm) diameter



> 430FR SOLENOID QUALITY STAINLESS

Typical direct current (DC) magnetic properties

ASTM A341 METHOD[1]						
CONDITION	ROCKWELL B HARDNESS MID-RADIUS	MAXIMUM RELATIVE PERMEABILITY	FROM 10,000 Gauss (1 Tesla)			
			COERCIVITY Hc (Oe)	COERCIVITY Hc (A/m)	REMANENCE Br (G)	REMANENCE Br (T)
Unannealed	92 minimum	300/500	5.0/7.0	400/560	2000/6500	0.20/0.65
Mill annealed CG	80/88	1100/2500	1.2/2.5	95/200	2500/8000	0.25/0.80
Mill annealed PG	82/91	500/800	4.0/5.5	320/440	2500/8000	0.25/0.80
Full anneal[2]	80/88	1100/2500	1.2/2.5	95/200	2500/8000	0.25/0.80

[1] ASTM A341 method covers straight length DC magnetic testing of bars. Mill annealed bars 0.250/1.250 in. (6.35/32 mm) diameter generally exhibit higher permeability, lower Hc and higher Br values as the bar diameter decreases from 1.250 to 0.250 in. (32 to 6.35 mm) diameter within the permeability Hc and Br ranges shown). The variation in Br is primarily a function of the test method rather than material variability. Bars larger than 1.250 in. (32 mm) round are tested using machined ring specimens and ASTM A596 or ASTM A773.

[2] Dry hydrogen annealed at 1550°F (845°C) for 2 hours, then cooled nominally at 100°F (56°C) per hour to below 800°F (427°C).

Typical mechanical properties

TYPICAL ROOM TEMPERATURE MECHANICAL PROPERTIES.

1 IN (25.4 MM) DIAMETER BAR								
HEAT TREATMENT	0.2% YIELD STRENGTH		ULTIMATE TENSILE STRENGTH		ELONGATION IN 2 IN (50.8 MM)	REDUCTION OF AREA	HARDNESS	
	ksi	MPa	ksi	MPa	%	%	BRINELL	ROCKWELL B
Mill annealed	50	345	78	538	30	60	174	86

> 430FR SOLENOID QUALITY STAINLESS

Heat treatment

Annealing	**Annealing for magnetic properties** Heat at 1550/1830°F (843/1000°C) for two hours, then cool at 100°F (56°C) per hour to 800°F (427°C). A dry hydrogen or vacuum atmosphere is recommended to prevent oxidation. **Annealing to soften** Heat uniformly to 1250/1400°F (677/760°C), then air cool. Brinell hardness is approximately 170.
Hardening	Stainless Type 430FR Solenoid Quality does not respond to hardening by heat treatment.

Workability

Forging	Stainless Type 430FR Solenoid Quality should be heated uniformly to a temperature of 1500/1600°F (816/871°C), then taken to the forging temperature of 1950/2100°F (1066/1149°C) as rapidly as possible. Do not soak at the forging temperature as this promotes excessive grain growth. Hot working operations should not be continued when the temperature has dropped below 1500°F (816°C). Forgings should be air cooled.
Cold working	Stainless Type 430FR Solenoid Quality will withstand moderate cold work, but is not recommended for cold upsetting. The main application for this steel is in magnetic components that are to be machined to shape.
Machinability	Stainless Type 430FR Solenoid Quality cuts freely in automatic screw machines. It machines in turning operations at speeds of about 150 surface feet per minute (sfpm) when cut with high-speed tool steels.

> 430FR SOLENOID QUALITY STAINLESS

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	160	.015	M-2	525	600	.015	C-6
.025	175	.007	M-3	575	650	.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	
150	.002	.0025	.003	.0025	.002	.0015	.001	M-2
350	.004	.0055	.007	.005	.004	.0035	.0035	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	
160	.001	.003	.006	.010	.014	.017	.021	.025	M-1, 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	140	.001	.002	.004	.005	M-2; M-7	400	.001	.002	.005	.007	C-6

> 430FR SOLENOID QUALITY STAINLESS

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.

Weldability

Welding Stainless Type 430FR Solenoid Quality is generally not recommended. The high sulfur content may cause hot cracking and, when welded to a stainless steel with low sulfur content, may cause the weld to shift off center.

If the alloy must be welded, the use of a filler material, along with minimum heat inputs and minimum base metal dilution, will improve the chances of success.

AWS E/ER430 welding consumable should be considered, however, the weldments should be post-weld annealed to restore the ductility in the weld metal and heat affected zones.

The use of austenitic weld metals, like E/ER309, has provided welds of good ductility. However, in this case, the heat affected zone may have limited ductility unless the weldment is given a post-weld anneal. Note, also, that the use of an austenitic weld metal will significantly alter the magnetic characteristics of the weldment

Other information

Applicable specifications	ASTM A838 Alloy 2, "Free Machining Ferritic Stainless Soft Magnetic Alloys for Relay Applications." ASTM A838 Alloy 2

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