CLIFFS

DI-MAX® M-13

NON-ORIENTED ELECTRICAL STEEL

Electric Motors

Transformers

DI-MAX® M-13 is fully processed, high-alloy content, non-oriented electrical steel. DI-MAX M-13 is designed for use in high-efficiency 50 Hz and 60 Hz electric motors and power transformer applications. Nominal thickness of DI-MAX M-13 is 0.0197 in. (0.50 mm).

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Product Description

Composition (Typical)		(WT %)
Silicon	(Si)	3.1
Aluminum	(Al)	0.8

GUARANTEED MAXIMUM AND TYPICAL MAGNETIC PROPERTIES

Maximum core loss is 1.45 W/lb. (15 kG, 60 Hz) [2.50 W/kg (1.5 T, 50 Hz)]. Core loss guaranteed is based 50/50 (parallel/ transverse sheet rolling direction) as-sheared Epstein test (ASTM A343).

OTHER MAGNETIC PROPERTIES

Volume Resistivity	56 $\mu\Omega \cdot$cm
Saturation Induction	1.98 T
Magnetic Induction at 5000 A/m (B50)	1.64 T

INSULATIVE COATING

	C-5 PHOSPHATE	CARLITE® 3 ANTI-STICK™
Type	**ASTM A976 C-5**	**ASTM A976 C-5-AS**
Components	Inorganic with some organic material	Inorganic
Thickness	2.3 – 2.8 μm	0.25 – 0.76 μm
Space Factor	96.6% @ 1.0 MPa 96.4% @ 0.345 MPa	97.6% @ 1.0 MPa 97.4% @ 0.345 MPa
Franklin Current	0.02 A	0.3 – 0.9 A
Weldability	Good (minimal porosity)	Excellent (no porosity)

MECHANICAL AND PHYSICAL PROPERTIES

Density	7.60 gm/cm3
Yield Strength	400 MPa (58 ksi.)
Tensile Strength	500 MPa (72.5 ksi.)
Elongation, % in 2"	20% min.
Rockwell Hardness	B92
Vickers Hardness	193
Thickness Tolerance	±0.019 mm (±0.00075 in.)
Strip Crown	0.006 mm (0.00025 in.)

All values typical unless otherwise noted.

Tables

TABLE 1 – CORE LOSS AND EXCITING POWER TABLES, TYPICAL VALUES: AS-SHEARED, 50/50TYPE M250 50A

B (kG)	H (Oe)	CORE LOSS (W/lb.) @ Frequency (Hz)								
		50	60	100	400	800	1000	2000	5000	10000
3.0	0.340	0.056	0.070	0.141	1.090	3.22	4.55	13.5	57.8	24.7
4.0	0.394	0.093	0.118	0.236	1.850	5.43	7.70	23.2	104	84.4
5.0	0.452	0.137	0.174	0.352	2.78	8.25	11.8	36.2	172	187
6.0	0.515	0.188	0.239	0.486	3.90	11.8	16.9	53.5	–	–
7.0	0.591	0.244	0.312	0.639	5.24	16.1	23.3	76.5	–	–
8.0	0.686	0.308	0.393	0.812	6.83	21.4	31.2	106	–	–
9.0	0.808	0.378	0.483	1.010	8.70	28.0	41.1	143	–	–
10.0	0.977	0.455	0.583	1.220	10.9	36.0	53.3	–	–	–
11.0	1.225	0.542	0.696	1.460	13.5	45.6	67.9	–	–	–
12.0	1.695	0.643	0.826	1.740	16.5	57.1	85.5	–	–	–
13.0	2.74	0.767	0.984	2.07	20.0	70.8	106	–	–	–
14.0	6.67	0.929	1.190	2.49	24.1	88.9	133	–	–	–
15.0	20.5	1.110	1.430	2.98	28.9	–	–	–	–	–
16.0	48.6	1.260	1.640	3.46	33.9	–	–	–	–	–
17.0	92.4	1.440	1.810	3.97	39.6	–	–	–	–	–

B (kG)	EXCITING POWER (VA/lb.) @ Frequency (Hz)								
	50	60	100	400	800	1000	2000	5000	10000
3.0	0.0925	0.114	0.209	1.329	3.64	5.11	14.9	63.4	26
4.0	0.144	0.177	0.330	2.17	6.06	8.54	25.4	114	88
5.0	0.204	0.253	0.474	3.22	9.16	13.0	39.9	190	196
6.0	0.275	0.341	0.642	4.48	13.0	18.7	59.2	–	–
7.0	0.357	0.443	0.838	5.99	17.9	25.8	85.0	–	–
8.0	0.454	0.563	1.070	7.80	23.9	34.8	118	–	–
9.0	0.570	0.706	1.330	9.98	31.3	46.0	161	–	–
10.0	0.714	0.883	1.660	12.5	40.4	59.9	–	–	–
11.0	0.904	1.110	2.07	15.6	51.4	76.7	–	–	–
12.0	1.190	1.460	2.67	19.5	64.9	97.0	–	–	–
13.0	1.760	2.15	3.82	25.1	82.4	123	–	–	–
14.0	3.79	4.58	7.87	40.7	123	178	–	–	–
15.0	12.2	14.7	24.8	108	–	–	–	–	–
16.0	33.4	40.1	67.4	283	–	–	–	–	–
17.0	71.6	86.9	145	608	–	–	–	–	–

7.60 gm/cm3 test density
ASTM A343; AS-sheared, 50/50
B = Magnetic induction
H = Applied field

Tables

TABLE 2 – CORE LOSS AND EXCITING POWER TABLES, TYPICAL VALUES: AS-SHEARED, 50/50 TYPE M250 50A

B (T)	H (A/m)	CORE LOSS (W/kG) @ Frequency (Hz)								
		50	60	100	400	800	1000	2000	5000	10000
0.3	27.1	0.122	0.155	0.310	2.41	7.10	10.0	30	127	54.5
0.4	31.3	0.206	0.259	0.521	4.07	12.0	17.0	51	229	186
0.5	36.0	0.302	0.384	0.776	6.12	18.2	26.0	80	379	412
0.6	41.0	0.413	0.527	1.070	8.60	26.0	37.3	118	–	–
0.7	47.0	0.539	0.687	1.410	11.6	35.5	51.4	169	–	–
0.8	54.6	0.678	0.866	1.790	15.1	47.2	68.8	234	–	–
0.9	64.3	0.832	1.070	2.22	19.2	61.7	90.6	315	–	–
1.0	77.8	1.000	1.290	2.69	24.0	79.4	118	–	–	–
1.1	97.5	1.200	1.530	3.22	29.7	101	150	–	–	–
1.2	135	1.420	1.820	3.83	36.4	126	188	–	–	–
1.3	218	1.690	2.17	4.55	44.0	156	234	–	–	–
1.4	531	2.05	2.63	5.50	53.0	196	293	–	–	–
1.5	1630	2.44	3.15	6.58	63.6	–	–	–	–	–
1.6	3870	2.79	3.61	7.64	74.8	–	–	–	–	–
1.7	7350	3.18	3.98	8.76	87.3	–	–	–	–	–

B (kG)	EXCITING POWER (VA/kG) @ Frequency (Hz)								
	50	60	100	400	800	1000	2000	5000	10000
0.3	0.204	0.251	0.460	2.93	8.02	11.3	32.8	140	57.3
0.4	0.317	0.39	0.727	4.79	13.4	18.8	56.0	251	194
0.5	0.450	0.56	1.040	7.09	20.2	28.7	88.0	419	432
0.6	0.606	0.75	1.420	9.88	28.7	41.2	131	–	–
0.7	0.787	0.98	1.850	13.2	39.5	56.9	187	–	–
0.8	1.000	1.240	2.35	17.2	52.7	76.7	260	–	–
0.9	1.260	1.560	2.94	22.0	69.0	101	355	–	–
1.0	1.570	1.950	3.66	27.6	89.1	132	–	–	–
1.1	1.990	2.46	4.57	34.5	113	169	–	–	–
1.2	2.62	3.21	5.88	42.9	143	214	–	–	–
1.3	3.88	4.73	8.41	55.3	182	271	–	–	–
1.4	8.37	10.1	17.3	89.7	271	392	–	–	–
1.5	26.9	32.3	54.7	237	–	–	–	–	–
1.6	73.6	88.4	149	624	–	–	–	–	–
1.7	158	192	320	1340	–	–	–	–	–

7.60 gm/cm3 test density
ASTM A343; AS-sheared, 50/50
B = Magnetic induction
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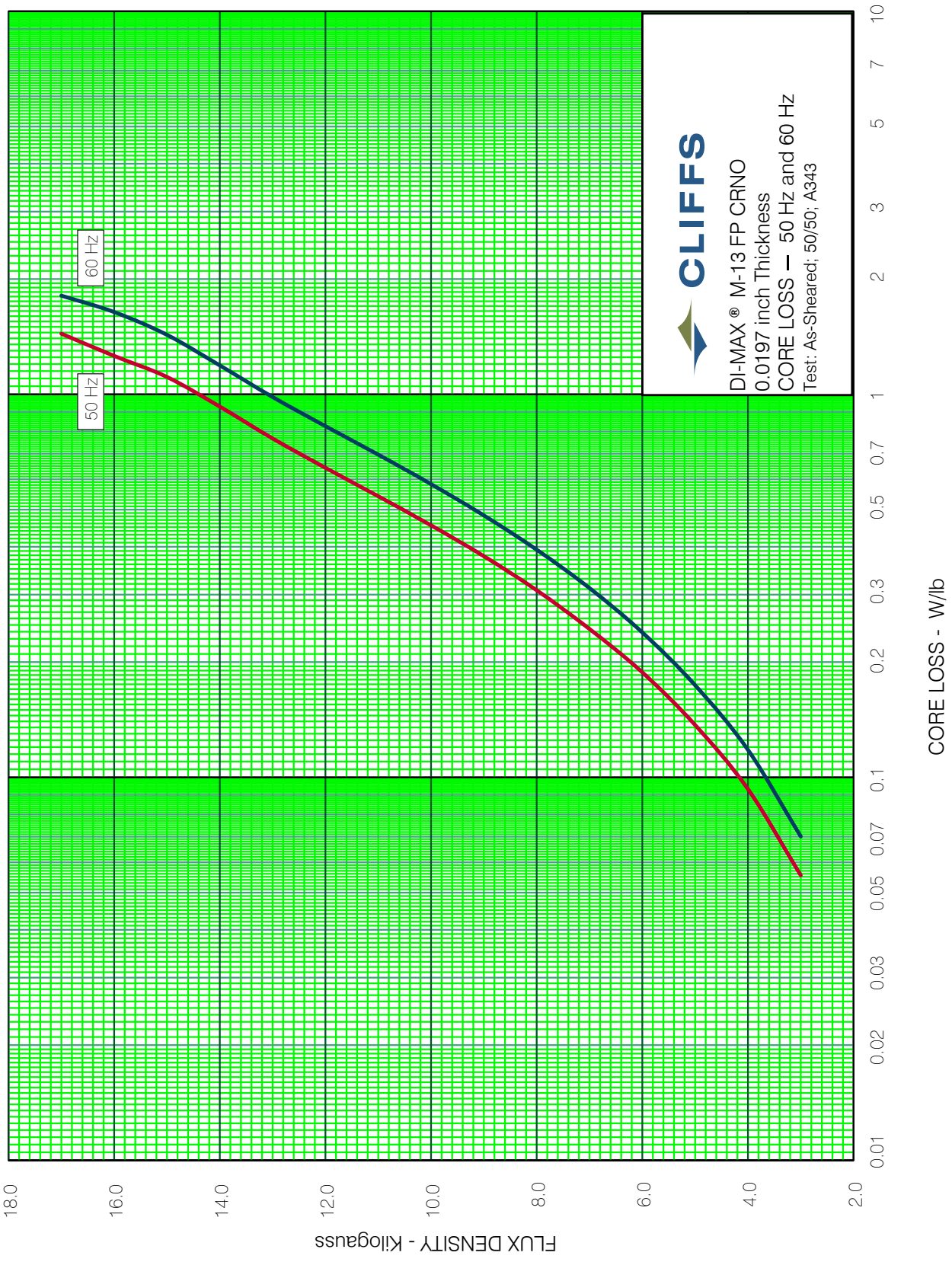
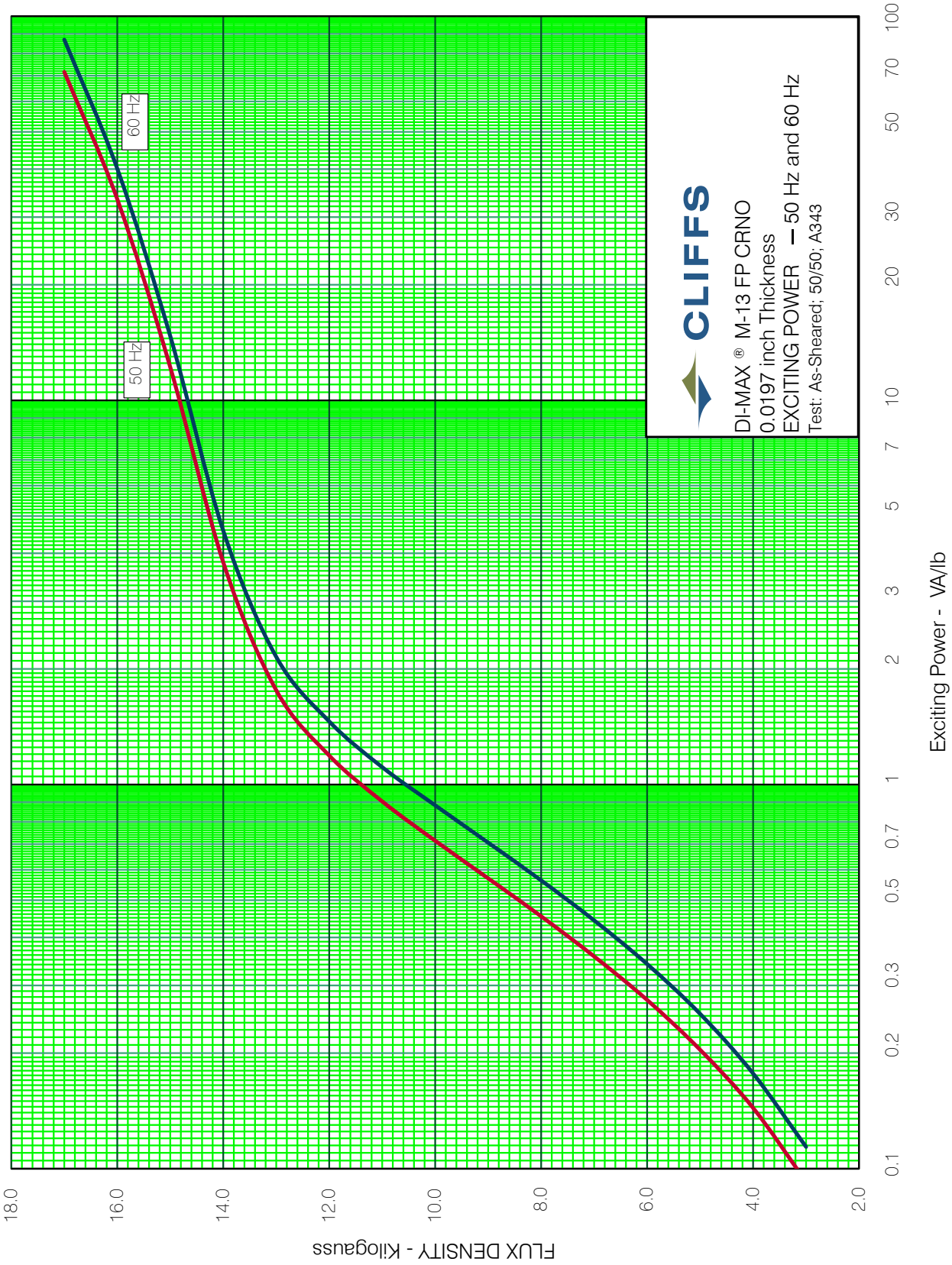
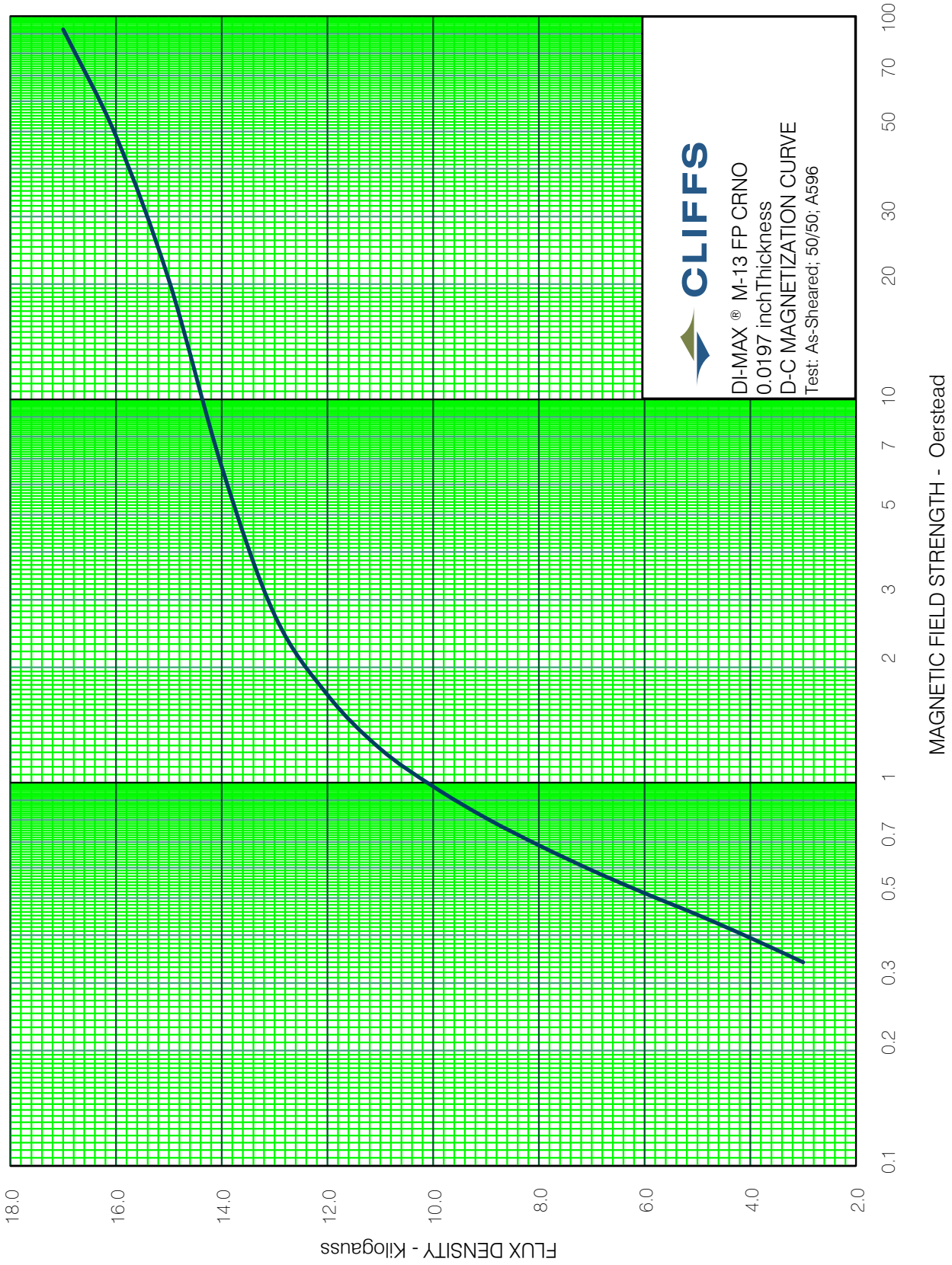
Core Loss Curve – Fully Processed CRNO



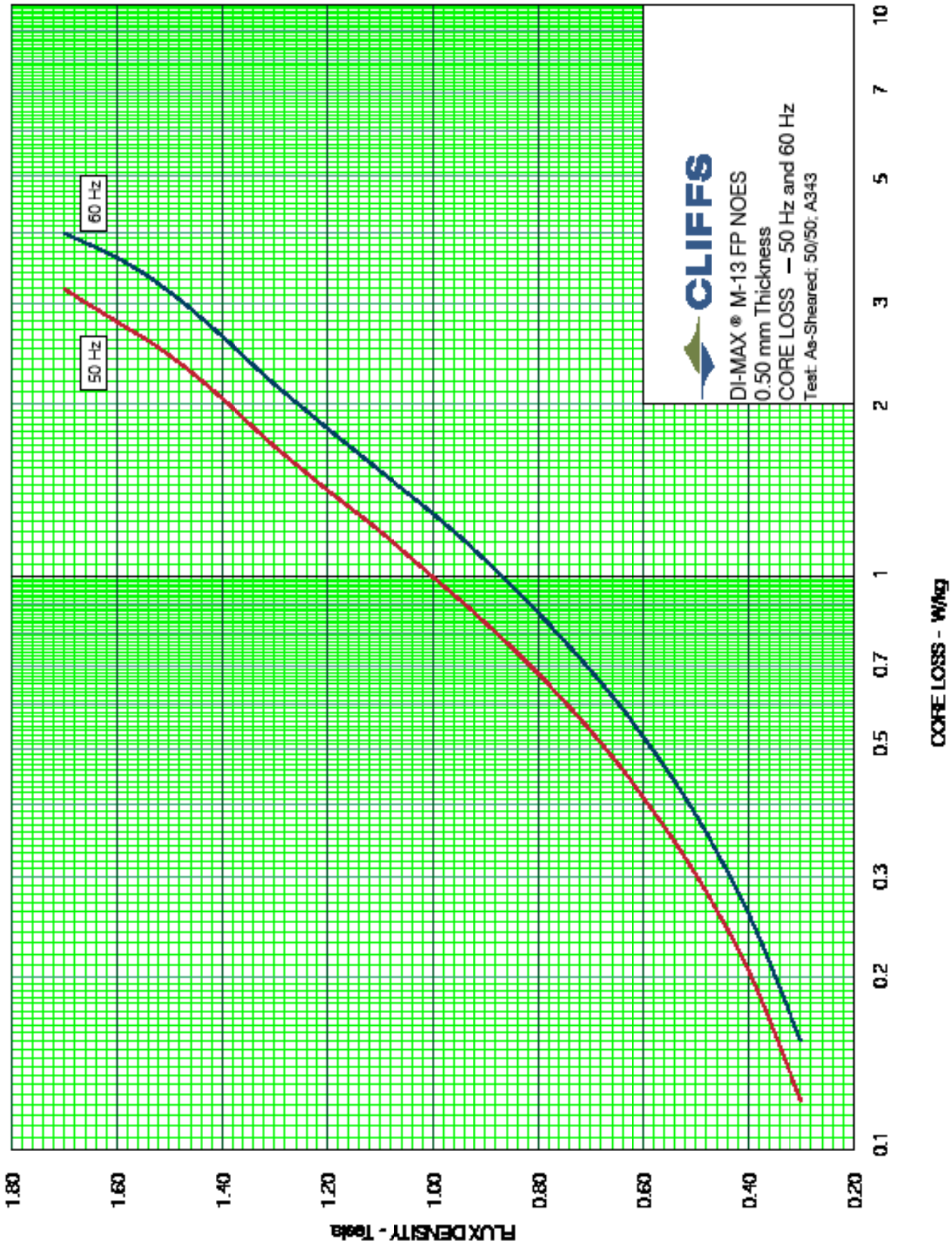
Exciting Power Curve – Fully Processed CRNO



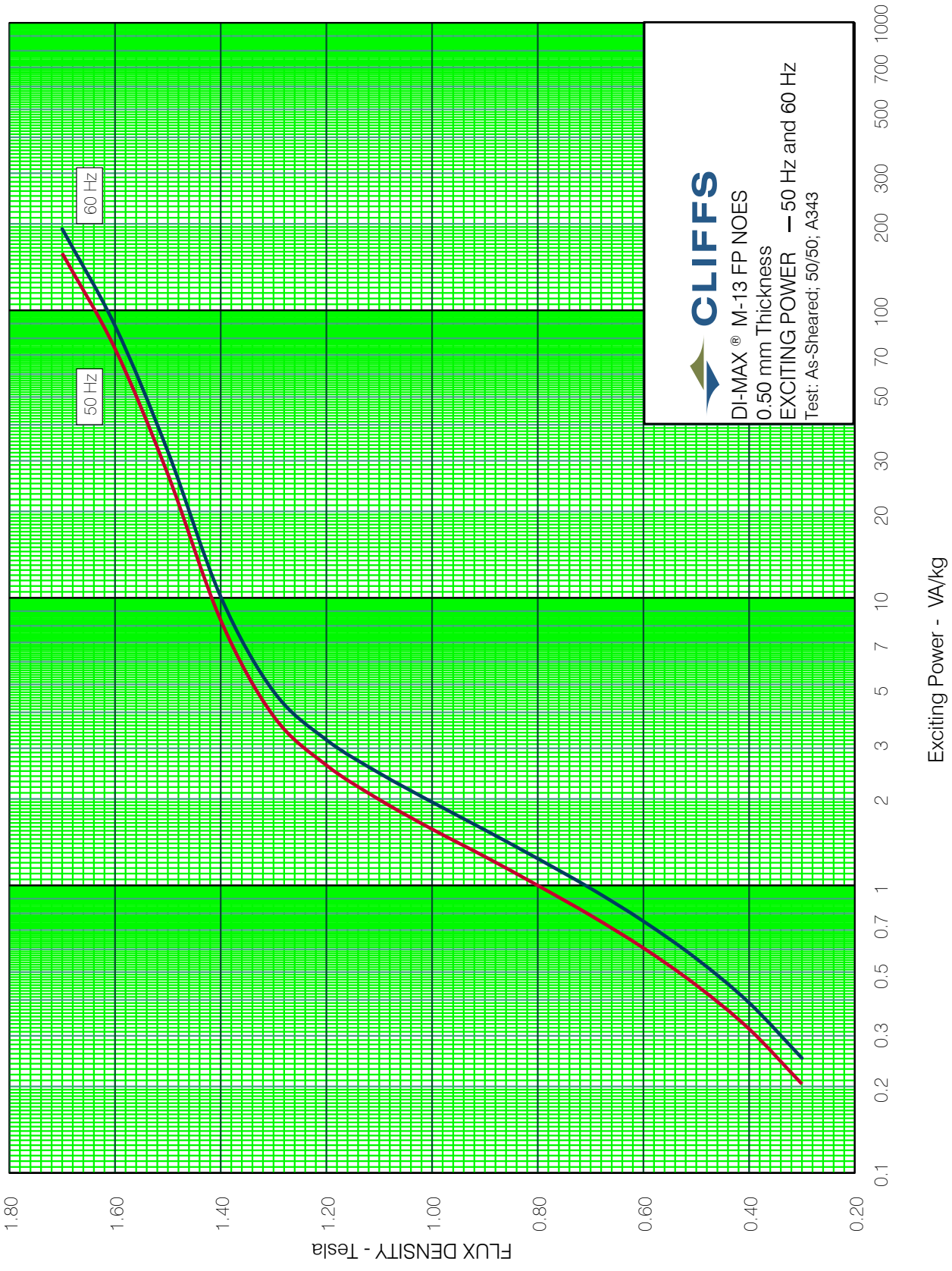
D-C Magnetization Curve – Fully Processed CRNO



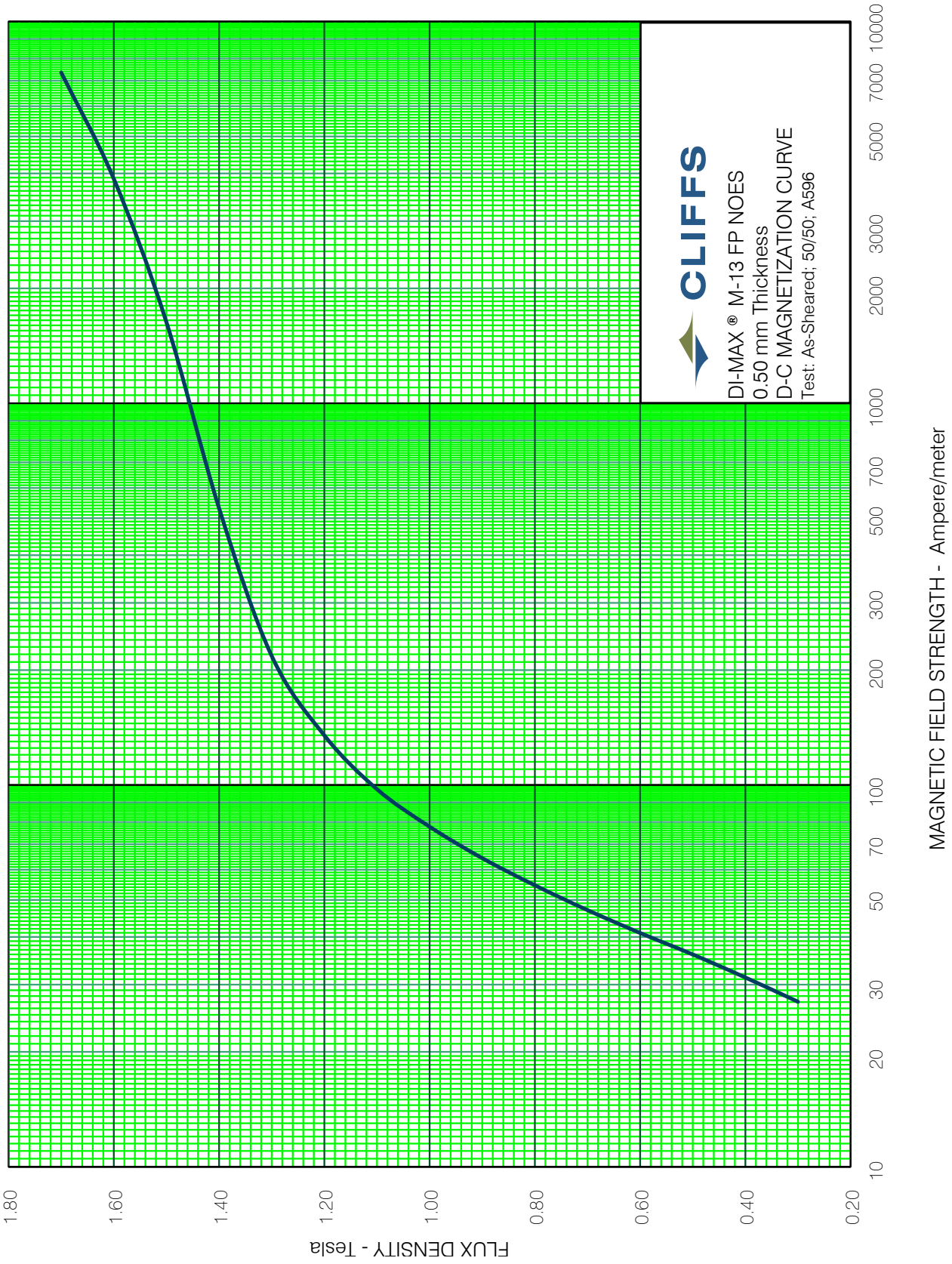
Core Loss Curve – Fully Processed NOES



Exciting Power Curve – Fully Processed NOES



D-C Magnetization Curve – Fully Processed NOES



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About Cleveland-Cliffs Inc.

Cleveland-Cliffs is the largest flat-rolled steel producer in North America. Founded in 1847 as a mine operator, Cliffs also is the largest manufacturer of iron ore pellets in North America. The Company is vertically integrated from mined raw materials and direct reduced iron to primary steelmaking and downstream finishing, stamping, tooling, and tubing. The Company serves a diverse range of markets due to its comprehensive offering of flat-rolled steel products and is the largest steel supplier to the automotive industry in North America. Headquartered in Cleveland, Ohio, Cleveland-Cliffs employs approximately 25,000 people across its mining, steel and downstream manufacturing operations in the United States and Canada.

CLIFFS

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May 2021