CLIFFS

TRAN-COR® H

GRAIN ORIENTED ELECTRICAL STEELS

H-0 CARLITE® | H-0 CARLITE® DR®
H-1 CARLITE® | H-1 CARLITE® DR®
H-2 CARLITE® | H-2 CARLITE® DR®

Distribution Transformers

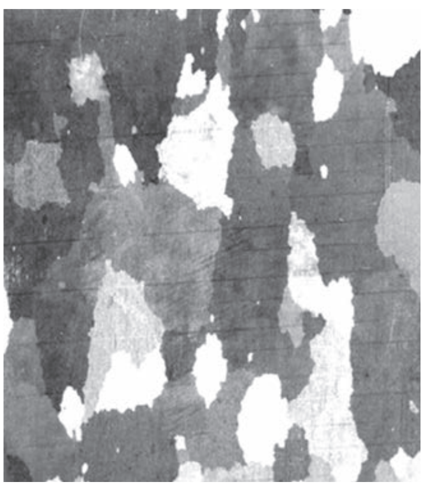
Medium Power Transformers

Large Power Transformers

TRAN-COR® H CARLITE® products are suitable for all types of transformers while TRAN-COR H DR® (Domain Refined) products are suitable for those types of transformers where a stress relief annealing treatment of the magnetic core is not used. Stress-relief annealing will result in the eradication of the effect provided by the laser treatment and will result in a significant increase in core loss.

Product Description

TRAN-COR H CARLITE® high-permeability electrical steels offer an outstanding degree of grain orientation, this combination of higher permeability with low residual stress offers the potential for lower core losses and less noisy transformer core structures, particularly at higher operating inductions, when compared to conventional grain oriented electrical steels. The core loss characteristics are further enhanced in the TRAN-COR H CARLITE DR (Domain Refined) products where laser scribing is employed. In this process, a precisely focused laser beam is rapidly scanned across the steel surface. The micro-strain imparted into the material forces the pre-existing magnetic domains to subdivide. The finer domain structure reduces the distance that the domain walls must move during AC magnetization, thereby reducing eddy current losses. The result is far lower core loss than possible with conventional grain oriented electrical steels of comparable thickness.



Sample chemically etched to reveal laser scribe trace.

DOING OUR PART

Cleveland-Cliffs' electrical steel products contain approximately 75 – 85% of post-consumer and post-industrial recycled materials. This content comes largely from the re-melting of scrap steel products. Not only does the electrical steel contain a high percentage of post-consumer and post-industrial recycled materials, at the end of its useful life, it is likely to be 100% recyclable.

FORMS AND STANDARD SIZES

Nominal Thickness

H-0: 0.23 mm (0.009 in.)
H-1: 0.27 mm (0.011 in.)
H-2: 0.30 mm (0.012 in.)

Width

Standard: 914 mm (36.00 in.)
Maximum: 920 mm (36.22 in.)
Minimum: 19 mm (0.75 in.)

Inside Coil Diameter

Master Coil 508 mm (20.0 in.)

Slit Width Coil 406 and 508 mm (16.0 and 20.0 in.)

CARLITE 3 SURFACE INSULATION

Cleveland-Cliffs' TRAN-COR H products are supplied with CARLITE 3 insulative coating, an inorganic coating equivalent to ASTM A976 C-5. CARLITE 3 insulation is ideal for materials that will be used in the form of sheared laminations for power transformers and other apparatus with high volts per turn. In addition to supplying all the benefits of C-5 insulation, CARLITE 3 provides other important advantages which include:

- Potential for reduced transformer building factor from added resistance to elastic strain damage.
- Potential for reduction of magnetostriction related transformer noise.
- High stacking factor.
- Easy assembly due to smoothness of coating (low coefficient of friction).

Specifications

In terms of maximum core loss, Cleveland-Cliffs CARLITE Grain-Oriented Electrical Steel specifications are determined at 15 kG and 17 kG at 60 Hz. Core loss grading is conducted using as-sheared single sheet test samples which are tested in accordance with ASTM test method A804. Peak permeability is specified at 10 Oe. Permeability grading is conducted using stress relief annealed Epstein samples tested in accordance with ASTM test method A343. Samples are secured from each end of the coil and the higher core loss and lower permeability values are used for certification of conformance to product grade guarantees.

TABLE 1 – GUARANTEED CORE LOSS AND LAMINATION FACTOR

Product	Approximate Equivalent International Grade	Nominal Thickness, mm (in.)	Assumed Density, gm/cm³	Resistivity, Ω-m, x10⁻⁸	Maximum Core Loss W/kg				Maximum Core Loss W/lb.				Minimum Induction at 800, A/m, T	Minimum Lamination Factor, %
					50 Hz		60 Hz		50 Hz		60 Hz			
					1.5T	1.7T	1.5T	1.7T	1.5T	1.7T	1.5T	1.7T		
H-0 CARLITE DR	M080-23P5	0.23 (0.009)	7.65	50	0.60	0.80	0.80	1.06	0.274	0.365	0.363	0.479	1.880	94.5
H-1 CARLITE DR	M090-27P5	0.27 (0.011)			0.67	0.90	0.90	1.20	0.306	0.410	0.407	0.543	1.880	95.0
H-2 CARLITE DR	M100-30P5	0.30 (0.012)			0.74	1.00	0.99	1.33	0.338	0.455	0.450	0.602	1.880	95.5
H-0 CARLITE	M090-23P5	0.23 (0.009)			0.65	0.90	0.86	1.19	0.297	0.410	0.391	0.537	1.880	94.5
H-1 CARLITE	M100-27P5	0.27 (0.011)			0.73	1.00	0.97	1.33	0.333	0.455	0.441	0.599	1.880	95.0
H-2 CARLITE	M105-30P5	0.30 (0.012)			0.77	1.05	1.03	1.40	0.351	0.478	0.468	0.633	1.890	95.5

TABLE 2 – TYPICAL CORE LOSS AND LAMINATION FACTOR

Product	Approximate Equivalent International Grade	Nominal Thickness, mm (in.)	Assumed Density, gm/cm³	Resistivity, Ω-m, x10⁻⁸	Maximum Core Loss W/kg				Maximum Core Loss W/lb.				Minimum Induction at 800, A/m, T	Minimum Lamination Factor, %
					50 Hz		60 Hz		50 Hz		60 Hz			
					1.5T	1.7T	1.5T	1.7T	1.5T	1.7T	1.5T	1.7T		
H-0 CARLITE DR	M080-23P5	0.23 (0.009)	7.65	50	0.56	0.77	0.75	1.01	0.257	0.350	0.339	0.460	1.916	96.6
H-1 CARLITE DR	M090-27P5	0.27 (0.011)			0.65	0.87	0.86	1.16	0.295	0.396	0.391	0.525	1.918	97.0
H-2 CARLITE DR	M100-30P5	0.30 (0.012)			0.70	0.95	0.93	1.26	0.320	0.431	0.423	0.570	1.917	97.3
H-0 CARLITE	M090-23P5	0.23 (0.009)			0.60	0.83	0.80	1.08	0.274	0.375	0.361	0.490	1.917	96.6
H-1 CARLITE	M100-27P5	0.27 (0.011)			0.70	0.95	0.92	1.25	0.316	0.431	0.419	0.567	1.918	97.0
H-2 CARLITE	M105-30P5	0.30 (0.012)			0.74	0.99	0.98	1.31	0.335	0.450	0.447	0.596	1.920	97.3

Typical single sheet core loss values versus test induction for TRAN-COR H CARLITE and CARLITE DR are provided on page 9. Typical SRA Epstein core loss values versus test induction for TRAN-COR H CARLITE are provided on page 11. SRA Epstein testing is not applicable to TRAN-COR CARLITE DR products since the domain refinement treatment is eradicated upon annealing at temperatures greater than 600 °C. The core loss and exciting power of the Cleveland-Cliffs TRAN-COR H grades are determined by magnetic tests performed in accordance with general procedures approved by the American Society for Testing and Materials. The following conditions apply:

1. Results for as-sheared single sheet specimens from fully processed material cut parallel to the rolling direction of the coil and tested per ASTM A804.

2. Density of all grades (7.65 gm/cm3) per ASTM A34.

ASTM A664 is a grade identification system for electrical steels. While this system has not been widely adopted by manufacturers and consumers of electrical steels, it is used in ASTM A876 to designate various grades of grain oriented electrical steel. The following is a listing of Cleveland-Cliffs and equivalent ASTM grades:

Cleveland-Cliffs grades H-0 CARLITE and H-0 CARLITE DR are approximately equivalent to ASTM Core Loss Types 23P060 and 23Q054, respectively.

Cleveland-Cliffs grades H-1 CARLITE and H-1 CARLITE DR are approximately equivalent to ASTM Core Loss Types 27P066 and 27Q057, respectively.

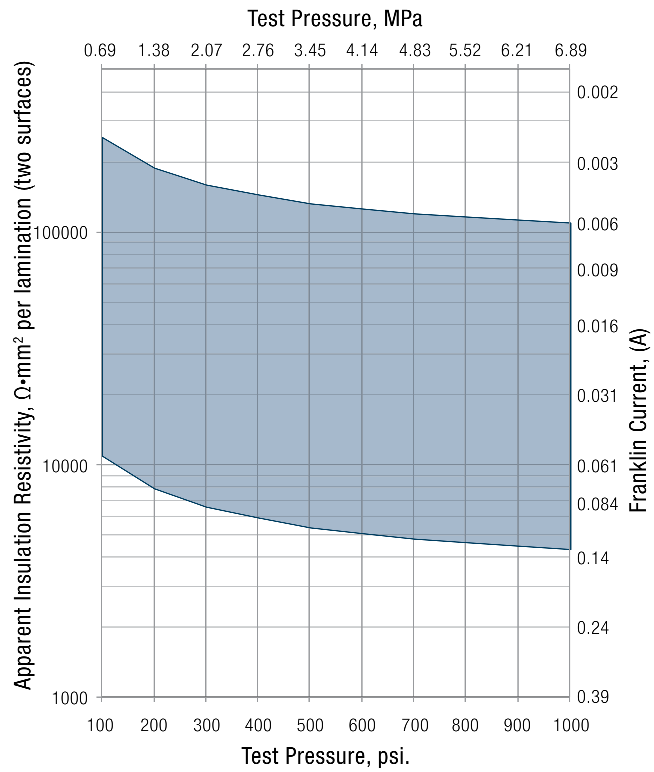
Cleveland-Cliffs grades H-2 CARLITE and H-2 CARLITE DR have no equivalent ASTM Core Loss Type designations.

Surface Insulation Curves

Figure 1 shows the variation of surface insulation resistivity versus pressure. The range of surface insulation resistivity values between the upper and lower lines are typical of those for CARLITE 3 insulated surfaces as determined by the Franklin Test method (ASTM A717). However, the user should recognize that the normally small variations in mill oxide and coating thickness within a lot necessitate allowing for test values lower as well as higher than those shown in the curves.

FIGURE 1

Typical surface insulation characteristics of Cleveland-Cliffs oriented electrical steels at various pressures as determined by the Franklin Test.



Typical surface insulation characteristics of Cleveland-Cliffs Grain-Oriented Electrical Steels at various pressures as determined by the Franklin Test.

Lamination Factors

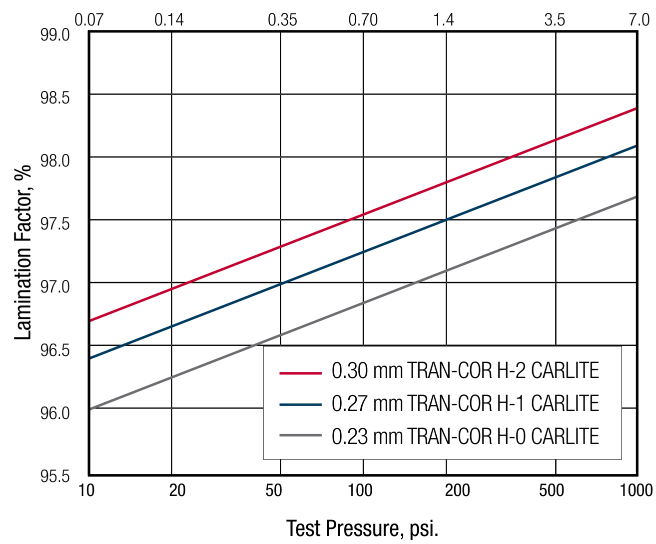
LAMINATION FACTOR

Lamination factor is the measure of compactness of an electrical steel core. This is also referred to as "stacking factor" and "space factor." Lamination factor is the ratio of the equivalent "solid" volume, calculated from weight and density of the steel, to the actual volume of the compressed pack, determined from its dimensions. Special processing gives Cleveland-Cliffs' Oriented Electrical Steels exceptionally and consistently high lamination factors.

TEST METHOD

The lamination factor of electrical steels is determined from measurements of a stack of Epstein strips under known pressure, 345 kPa (50 psi.), in accordance with ASTM A719. Figure 2 illustrates how the lamination factor varies as a function of pressure for Cleveland-Cliffs TRAN-COR H Electrical Steels. The values shown are representative of the lamination factor determined by this test. Lamination factors determined in accordance with IEC 60404-13 will be approximately 0.5 percent higher than these values due to the higher pressure specified in that test method 1 MPa (145 psi.).

FIGURE 2 – REPRESENTATIVE LAMINATION FACTORS



Representative lamination factors for Cleveland-Cliffs Oriented Electrical Steels at various pressures.

TABLE 3 – REPRESENTATIVE MECHANICAL PROPERTIES

Ultimate Tensile Strength in rolling direction, MPa (psi.)	359	(52,000)
Yield Strength in rolling direction, MPa (psi.)	345	(50,000)
Percent Elongation in 50.8 mm (2 in.) in rolling direction	11	–
Microhardness (Knoop Hardness Number, HK)	173	–
Equivalent Rockwell B Scale Hardness	83	–
Modulus of Elasticity, MPa (psi.)*		
in rolling direction	113,800	(16,500,000)
at 20° to rolling direction	138,000	(20,000,000)
at 45° to rolling direction	241,000	(35,000,000)
at 55° to rolling direction	276,000	(40,000,000)
at right angles to rolling direction	203,000	(29,500,000)

**Values may vary as much as plus or minus 5%.*

Magnetostriction

Low magnetostriction coefficients are inherent to TRAN-COR H owing to the combination of the high degree of grain orientation, low residual strain after thermal flattening and high degree of residual tension imparted by the CARLITE 3 coating. The information below, while purely comparative in nature, is considered to be representative of Cleveland-Cliffs' TRAN-COR H products.

TABLE 4 – COMPARATIVE MAGNETOSTRICTION

Grade	Thickness, mm (in.)	Magnetostriction x 10^8			
		1.4T	1.5T	1.6T	1.7T
H-0 CARLITE DR	0.23 (0.009)	-18	-20	-20	-21
H-1 CARLITE DR	0.27 (0.011)	-22	-25	-26	-28
H-2 CARLITE DR	0.30 (0.012)	-31	-32	-34	-34
H-0 CARLITE	0.23 (0.009)	-32	-37	-40	-44
H-1 CARLITE	0.27 (0.011)	-39	-40	-44	-48
H-2 CARLITE	0.30 (0.012)	-45	-48	-53	-55

TEST METHOD

The above data is meant for comparative purposes only and was developed using stress-relief Epstein specimens from representative samples which were prepared in accordance with ASTM A876. The samples were subjected to domain refinement (where required) and were tested using Cleveland-Cliffs Research laboratory facilities. While there are no agreed upon standard test methods for magnetostriction, these data were acquired using an accelerometer-based measurement of crossover-to-tip displacement of many individual Epstein strips which were tested at a frequency of 60 Hz over the range of induction shown above. The magnetostriction values are, to our best knowledge, believed to be representative of commercially produced materials.

Tolerances

TABLE 5 – THICKNESS TOLERANCES

Grade	Thickness, mm			
	Nominal	Aim	Minimum	Maximum
H-0	0.23	0.23	0.21	0.25
H-1	0.27	0.27	0.25	0.29
H-2	0.30	0.29	0.27	0.31

The aim thickness values are based on the test sample weight plus typical coating thickness such as would be measured using a contacting micrometer caliper. The typical coating thickness is 0.005 – 0.010 mm (0.0002 – 0.0004 in.). Thickness measured at any point on the sheet not less than 10 mm (0.375 in.) from an edge shall not deviate more than +/- 0.020 mm (0.0008 in.) from the average thickness of the test lot or coil.

TABLE 6 – WIDTH TOLERANCES

Specified Width, mm	Tolerance over, mm	Tolerance under, mm
To 100 incl.	0.00	0.25
Over 100 – 225, incl.	0.00	0.25
Over 225 – 375, incl.	0.00	0.38
Over 375 – 920, incl.	0.00	0.50
914 and 920, exact	1.50	1.50

Note: By agreement at the time of order, the tolerance on the specified width may be all over tolerance (positive tolerance).

CAMBER TOLERANCES

The deviation of a side edge from a straight line over a length of 2 m (80 in.), or a fraction thereof, shall not exceed 2.54 mm (0.1 in.).

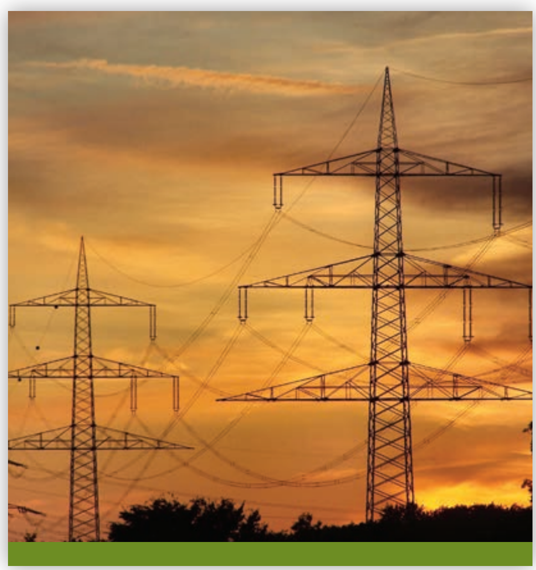
FLATNESS TOLERANCES

Because of the wide range of processing treatments employed to meet the published core loss values for the various types and classes of flat rolled electrical steels, and because ordinary supplemental flattening operations employed on other steel products cannot be used due to their effects on magnetic quality, it has not been feasible to prepare flatness tolerance tables for flat-rolled electrical steel. Some applications, and certain types of fabricating techniques for construction of magnetic cores, are tolerant of certain flatness deviations. However, it is generally recognized that sharp, short waves and buckles are objectionable and should be avoided as much as possible. The producer should determine the flatness requirements for its particular application and the suitability of this electrical steel.

Manufacturing Limits

TABLE 7

Thickness	0.23 mm (0.009 in.) H-0 0.27 mm (0.011 in.) H-1 0.30 mm (0.012 in.) H-2	
Width	Master coils are available in widths of 914 mm (36.0 in.) and 920 mm (36.22 in.)	
Coils-Slit	Minimum width Narrower Inside diameters	19 mm (0.75 in.) Inquire 406 mm (16.0 in.) 508 mm (20.0 in.)
Coils-Not Slit	Inside diameter	508 mm (20.0 in.)
Approximate Coil Weight	600 kg per 100 mm of width (335 lb. per in. of width)	



Page Finder For Design Tables And Curves

Product Thickness	H-0 0.23 mm		H-1 0.27 mm		H-2 0.30 mm	
Magnetic Characteristic	Carlite	DR	Carlite	DR	Carlite	DR
TABLES						
Core Loss	10, 12	10	10, 12	10	10, 12	10
Exciting Power	11, 12	11	11, 12	11	11, 12	11
CURVES						
Core Loss	13	14	15	16	17	18
Exciting Power	19	20	21	22	23	24
D-C Magnetization Curve	25	26	27	28	29	30
D-C Hysteresis Loop	31	32	33	34	35	36

TABLE 8 – TYPICAL VALUES OF CORE LOSS
At 50 and 60 Hz for Typical Sheet Specimens of Cleveland-Cliffs Tran-Cor H Electrical Steels

Flux Density (T)	Core Loss (W/kg) – ASTM A804 (Sheet Specimens)					
	0.23 mm H-0 CARLITE DR		0.27 mm H-1 CARLITE DR		0.30 mm H-2 CARLITE DR	
	50 Hz	60 Hz	50 Hz	60 Hz	50 Hz	60 Hz
0.1	0.00289	0.00385	0.00328	0.00441	0.00361	0.00487
0.2	0.01082	0.01451	0.01246	0.01680	0.01382	0.01871
0.3	0.0236	0.0317	0.0274	0.0370	0.0305	0.0413
0.4	0.0413	0.0554	0.0479	0.0647	0.0533	0.0720
0.5	0.0635	0.0852	0.0738	0.0996	0.0818	0.1103
0.6	0.0903	0.1210	0.1050	0.1413	0.1159	0.1559
0.7	0.1218	0.1628	0.1415	0.1900	0.1556	0.209
0.8	0.1578	0.211	0.1837	0.246	0.201	0.269
0.9	0.1984	0.265	0.231	0.309	0.252	0.337
1.0	0.244	0.325	0.284	0.380	0.310	0.413
1.1	0.296	0.394	0.344	0.459	0.374	0.498
1.2	0.354	0.470	0.410	0.547	0.444	0.592
1.3	0.418	0.555	0.483	0.644	0.522	0.696
1.4	0.487	0.648	0.562	0.749	0.607	0.809
1.5	0.565	0.750	0.649	0.865	0.702	0.936
1.6	0.655	0.867	0.748	0.994	0.811	1.079
1.7	0.773	1.017	0.872	1.154	0.946	1.252
1.8	0.967	1.264	1.067	1.405	1.145	1.506
1.9	1.365	1.766	1.440	1.876	1.551	2.02
	0.23 mm H-0 CARLITE		0.27 mm H-1 CARLITE		0.30 mm H-2 CARLITE	
0.1	0.00317	0.00419	0.00362	0.00486	0.00423	0.00569
0.2	0.01191	0.01587	0.01390	0.01873	0.01586	0.0214
0.3	0.0262	0.0349	0.0308	0.0414	0.0343	0.0463
0.4	0.0458	0.0609	0.0539	0.0723	0.0593	0.0799
0.5	0.0702	0.0934	0.0826	0.1105	0.0902	0.1211
0.6	0.0995	0.1321	0.1168	0.1558	0.1267	0.1699
0.7	0.1337	0.1770	0.1563	0.208	0.1687	0.226
0.8	0.1726	0.228	0.201	0.267	0.216	0.289
0.9	0.217	0.286	0.252	0.334	0.269	0.360
1.0	0.266	0.351	0.308	0.409	0.329	0.439
1.1	0.320	0.423	0.371	0.492	0.395	0.527
1.2	0.381	0.503	0.441	0.584	0.468	0.625
1.3	0.447	0.591	0.518	0.686	0.548	0.732
1.4	0.521	0.687	0.602	0.798	0.636	0.849
1.5	0.604	0.796	0.698	0.924	0.737	0.982
1.6	0.697	0.916	0.805	1.064	0.846	1.126
1.7	0.826	1.080	0.950	1.250	0.992	1.313
1.8	1.037	1.348	1.168	1.523	1.222	1.596
1.9	1.496	1.92	1.622	2.09	1.718	2.22

TABLE 9 – TYPICAL VALUES OF RMS EXCITING POWER

At 50 and 60 Hz for Typical Sheet Specimens of Cleveland-Cliffs Tran-Cor H Electrical Steels

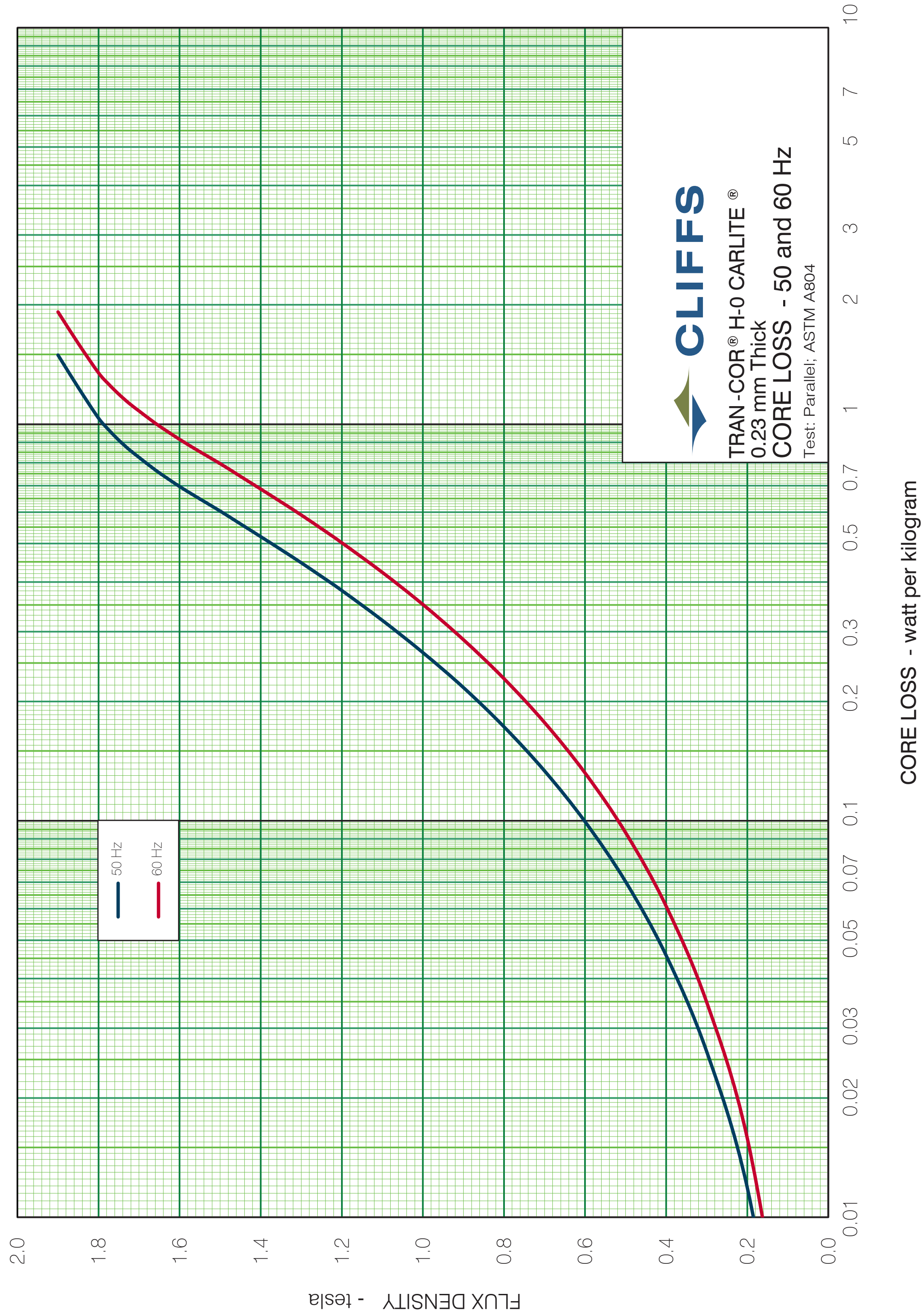
Flux Density (T)	Exciting Power (rms VA/kg) – ASTM A804					
	0.23 mm H-0 CARLITE DR		0.27 mm H-1 CARLITE DR		0.30 mm H-2 CARLITE DR	
	50 Hz	60 Hz	50 Hz	60 Hz	50 Hz	60 Hz
0.1	0.00578	0.00717	0.00542	0.00683	0.00583	0.00741
0.2	0.02000	0.0250	0.01918	0.0244	0.0208	0.0268
0.3	0.0417	0.0523	0.0405	0.0518	0.0438	0.0566
0.4	0.0693	0.0873	0.0681	0.0874	0.0736	0.0952
0.5	0.1022	0.1293	0.1015	0.1306	0.1092	0.1416
0.6	0.1402	0.1776	0.1402	0.1808	0.1505	0.1954
0.7	0.1834	0.233	0.1845	0.238	0.1974	0.257
0.8	0.232	0.295	0.235	0.303	0.251	0.326
0.9	0.288	0.367	0.292	0.377	0.312	0.405
1.0	0.354	0.450	0.359	0.463	0.383	0.498
1.1	0.433	0.551	0.439	0.565	0.466	0.605
1.2	0.529	0.671	0.534	0.685	0.563	0.730
1.3	0.648	0.819	0.650	0.829	0.679	0.877
1.4	0.795	1.000	0.789	0.999	0.818	1.053
1.5	0.980	1.225	0.954	1.200	0.993	1.271
1.6	1.228	1.524	1.162	1.453	1.234	1.566
1.7	1.660	2.04	1.526	1.887	1.635	2.05
1.8	2.87	3.48	2.64	3.21	2.70	3.31
1.9	9.93	12.19	9.17	11.15	9.88	12.25
	0.23 mm H-0 CARLITE		0.27 mm H-1 CARLITE		0.30 mm H-2 CARLITE	
0.1	0.00676	0.00844	0.00724	0.00912	0.00742	0.00946
0.2	0.0231	0.0290	0.0252	0.0319	0.0251	0.0323
0.3	0.0472	0.0595	0.0517	0.0657	0.0512	0.0659
0.4	0.0772	0.0976	0.0847	0.1079	0.0839	0.1083
0.5	0.1121	0.1420	0.1229	0.1569	0.1224	0.1584
0.6	0.1513	0.1921	0.1659	0.212	0.1660	0.215
0.7	0.1948	0.248	0.213	0.273	0.215	0.279
0.8	0.243	0.309	0.265	0.341	0.269	0.350
0.9	0.295	0.377	0.322	0.414	0.328	0.429
1.0	0.352	0.451	0.384	0.495	0.394	0.515
1.1	0.414	0.531	0.451	0.583	0.465	0.609
1.2	0.485	0.621	0.526	0.680	0.544	0.713
1.3	0.565	0.725	0.612	0.791	0.633	0.830
1.4	0.658	0.840	0.708	0.915	0.732	0.960
1.5	0.781	0.996	0.830	1.069	0.856	1.120
1.6	0.922	1.168	0.989	1.268	1.024	1.331
1.7	1.264	1.581	1.309	1.664	1.311	1.683
1.8	2.29	2.82	2.22	2.75	2.17	2.71
1.9	9.57	11.70	9.03	11.02	9.38	11.62

TABLE 10 – TYPICAL VALUES OF CORE LOSS

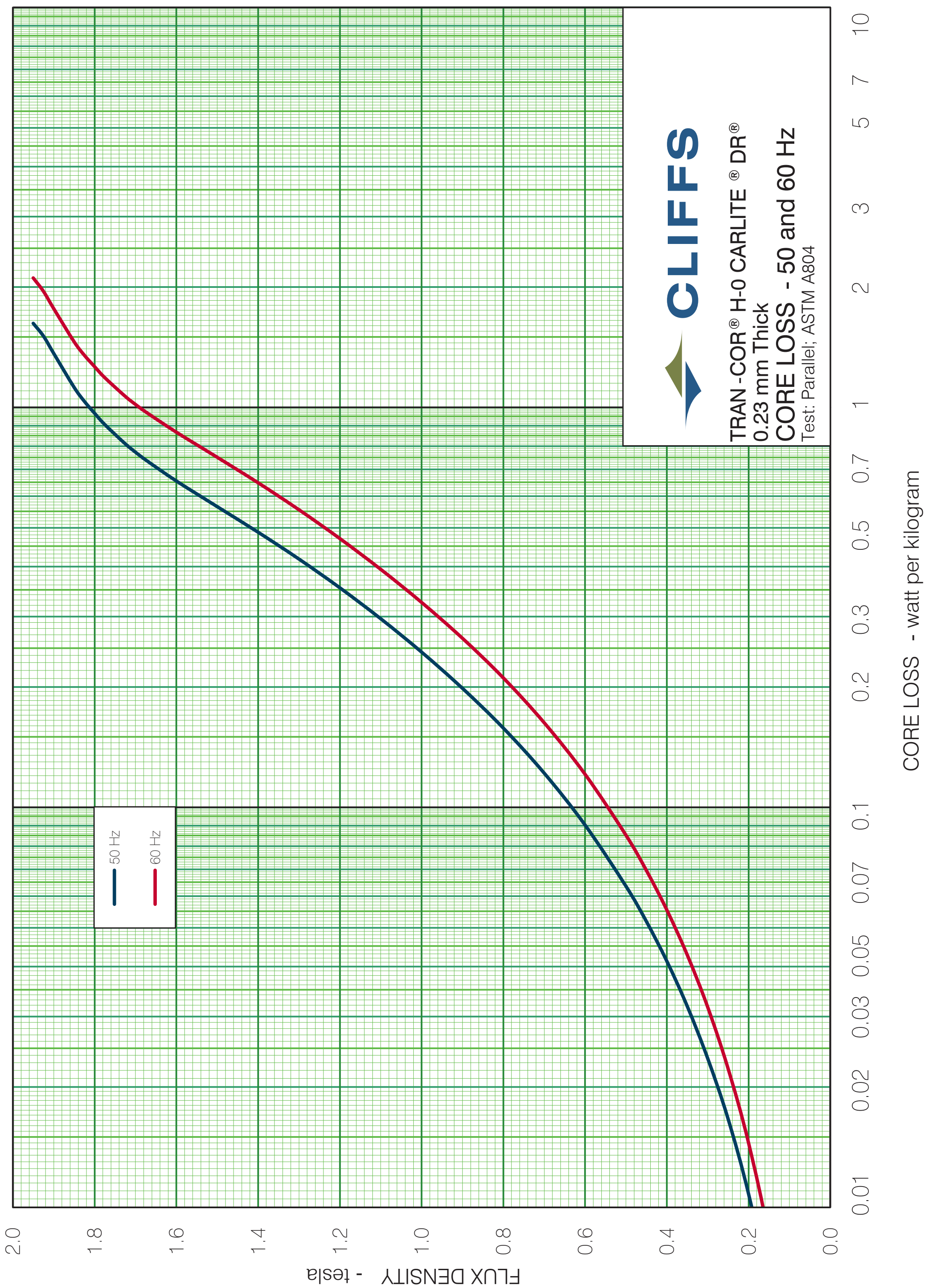
At 50 and 60 Hz for Typical Epstein Specimens of Cleveland-Cliffs Tran-Cor H Electrical Steels

Flux Density (T)	Core Loss (W/kg) – ASTM A343					
	0.23 mm H-0 CARLITE		0.27 mm H-1 CARLITE		0.30 mm H-2 CARLITE	
	50 Hz	60 Hz	50 Hz	60 Hz	50 Hz	60 Hz
0.1	0.00351	0.00464	0.00383	0.00514	0.00436	0.00586
0.2	0.01260	0.01680	0.01439	0.01938	0.01613	0.0218
0.3	0.0274	0.0365	0.0317	0.0426	0.0350	0.0472
0.4	0.0476	0.0633	0.0551	0.0739	0.0603	0.0812
0.5	0.0728	0.0969	0.0844	0.1129	0.0917	0.1232
0.6	0.1031	0.1368	0.1192	0.1589	0.1288	0.1727
0.7	0.1383	0.1831	0.1593	0.212	0.1717	0.230
0.8	0.1785	0.236	0.205	0.272	0.220	0.295
0.9	0.224	0.296	0.257	0.341	0.275	0.368
1.0	0.275	0.363	0.314	0.417	0.337	0.450
1.1	0.331	0.438	0.378	0.502	0.405	0.540
1.2	0.394	0.520	0.449	0.595	0.479	0.640
1.3	0.463	0.611	0.526	0.698	0.561	0.748
1.4	0.539	0.711	0.612	0.811	0.650	0.868
1.5	0.624	0.822	0.707	0.936	0.750	0.999
1.6	0.724	0.952	0.817	1.080	0.864	1.149
1.7	0.852	1.116	0.956	1.258	1.007	1.333
1.8	1.064	1.383	1.177	1.534	1.245	1.629
1.9	1.545	1.98	1.637	2.11	1.746	2.26
	Exciting Power (rms VA/kg) – ASTM A343					
0.1	0.00628	0.00785	0.00677	0.00853	0.00689	0.00878
0.2	0.0219	0.0275	0.0242	0.0307	0.0242	0.0311
0.3	0.0457	0.0575	0.0507	0.0645	0.0502	0.0647
0.4	0.0757	0.0957	0.0841	0.1071	0.0831	0.1073
0.5	0.1110	0.1406	0.1233	0.1574	0.1218	0.1577
0.6	0.1510	0.1917	0.1676	0.214	0.1660	0.215
0.7	0.1953	0.249	0.217	0.278	0.215	0.280
0.8	0.244	0.311	0.270	0.347	0.270	0.352
0.9	0.297	0.380	0.329	0.424	0.330	0.431
1.0	0.355	0.455	0.393	0.507	0.396	0.518
1.1	0.419	0.537	0.463	0.597	0.469	0.614
1.2	0.490	0.628	0.539	0.697	0.549	0.720
1.3	0.570	0.732	0.625	0.809	0.638	0.837
1.4	0.667	0.853	0.725	0.937	0.741	0.972
1.5	0.788	1.005	0.848	1.092	0.867	1.134
1.6	0.954	1.209	1.017	1.304	1.039	1.351
1.7	1.260	1.576	1.309	1.665	1.329	1.706
1.8	2.19	2.69	2.08	2.58	2.17	2.71
1.9	9.35	11.43	8.04	9.82	9.36	11.62

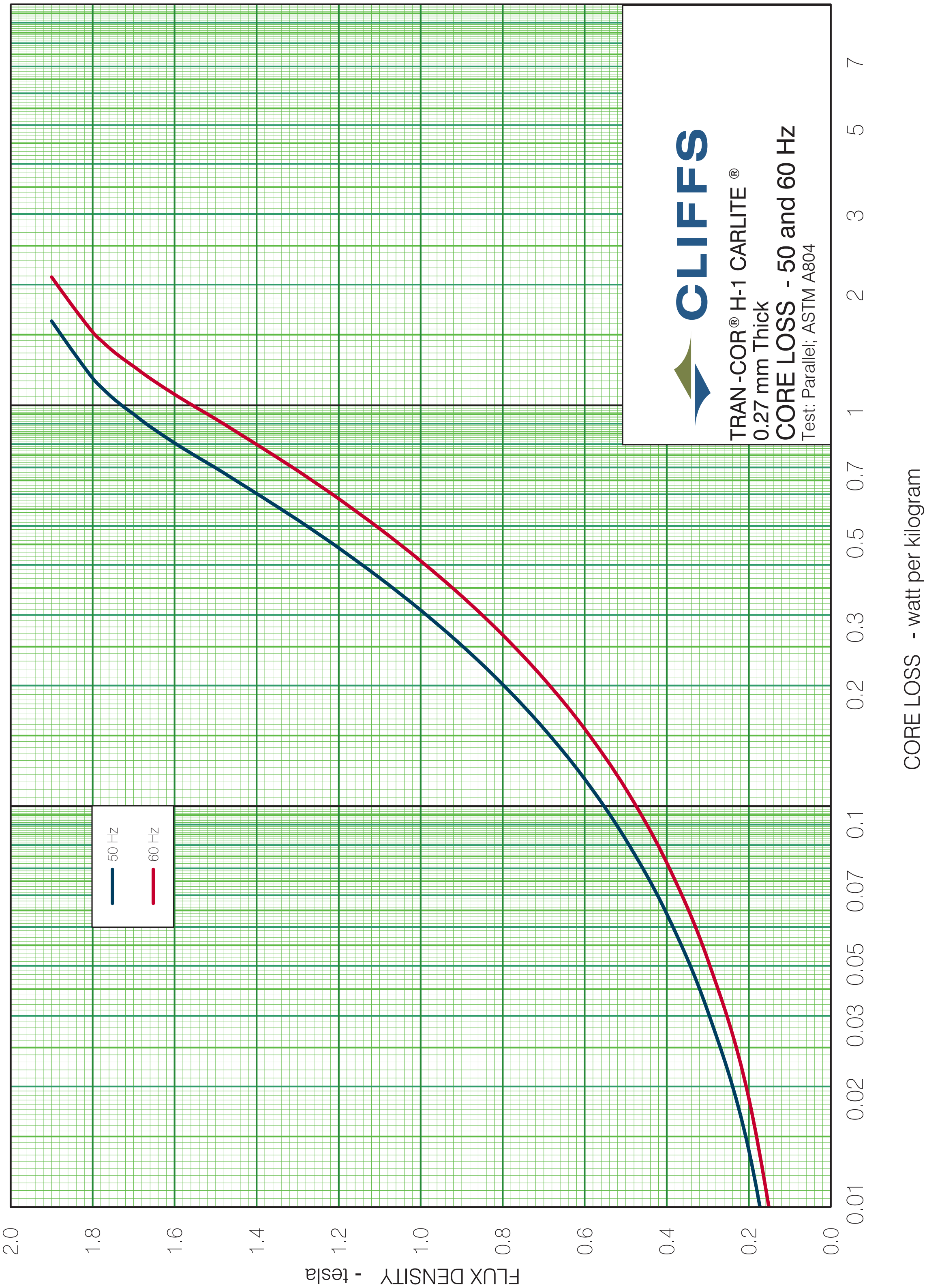
Core Loss Curve – H-0 CARLITE



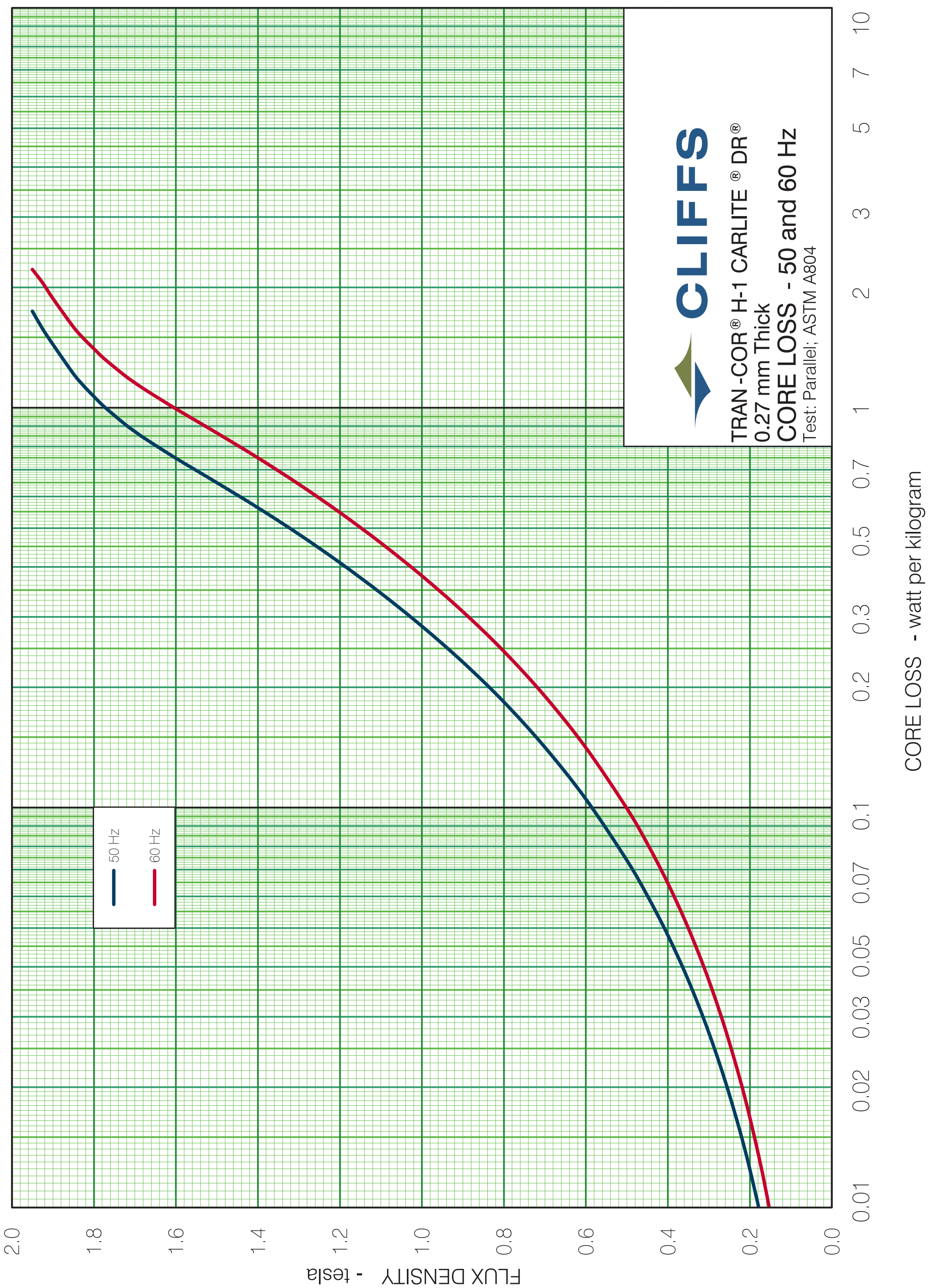
Core Loss Curve – H-0 CARLITE DR



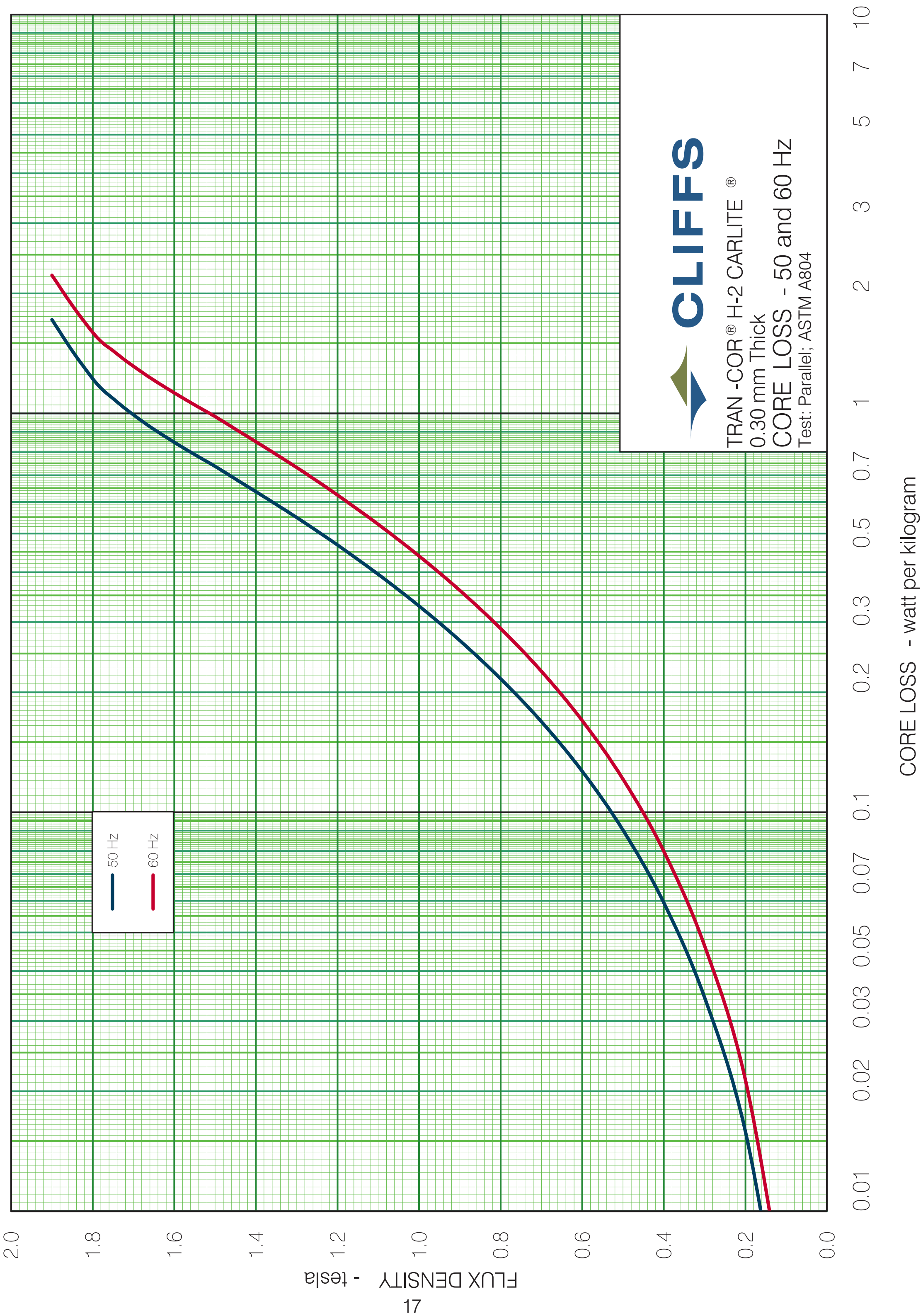
Core Loss Curve – H-1 CARLITE



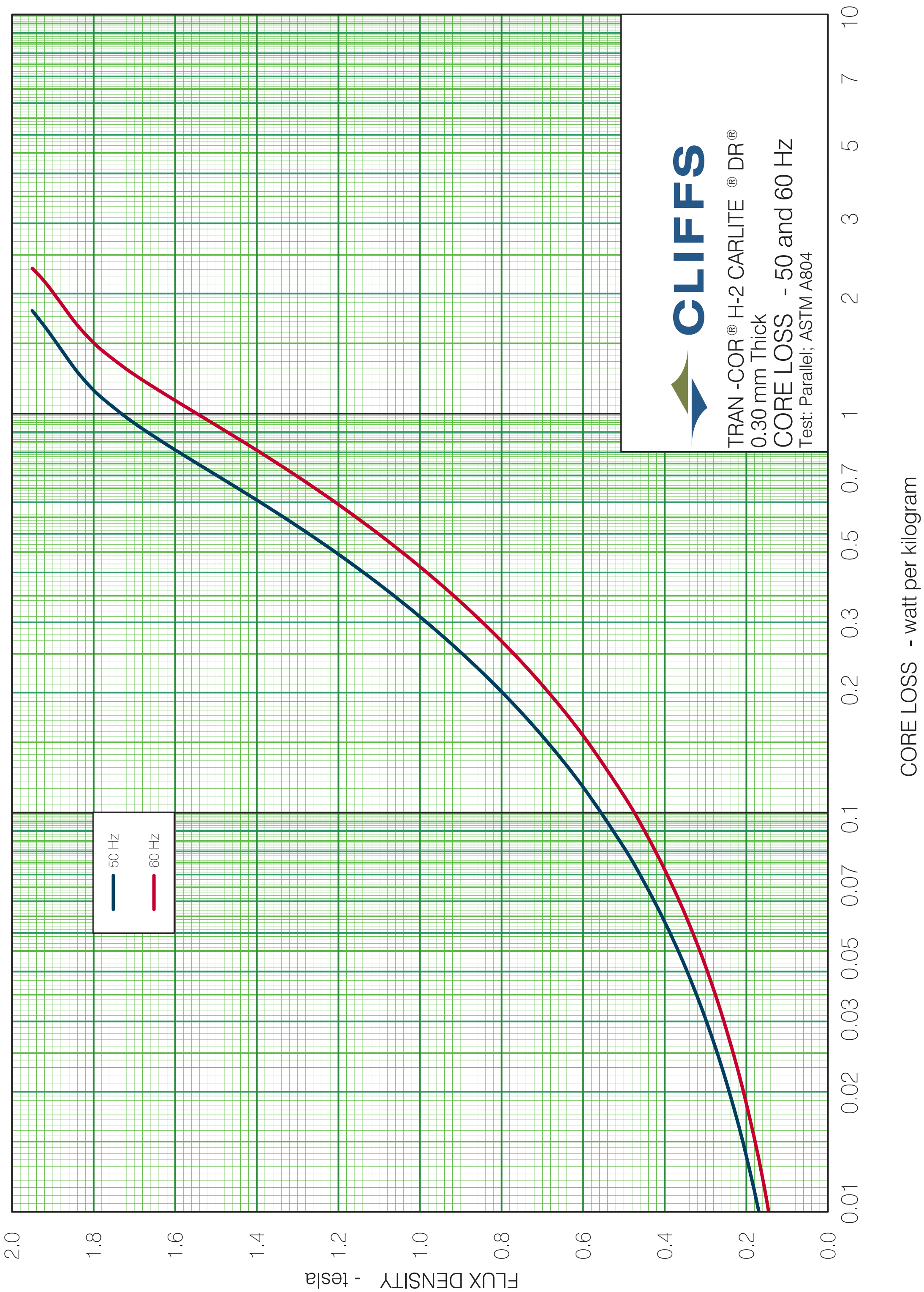
Core Loss Curve – H-1 CARLITE DR



Core Loss Curve – H-2 CARLITE



Core Loss Curve – H-2 CARLITE DR



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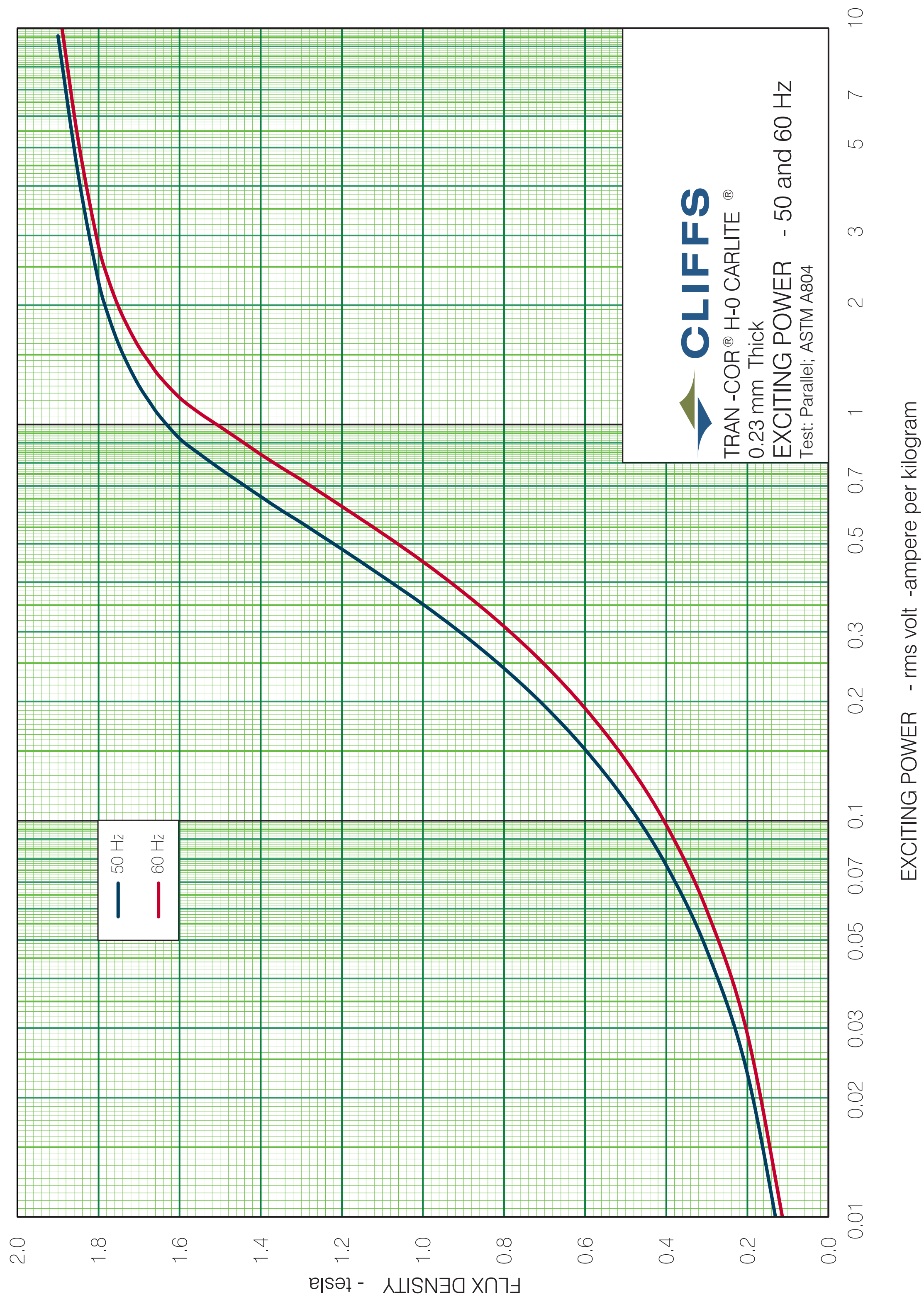
Exciting Power Curve – H-0 CARLITE



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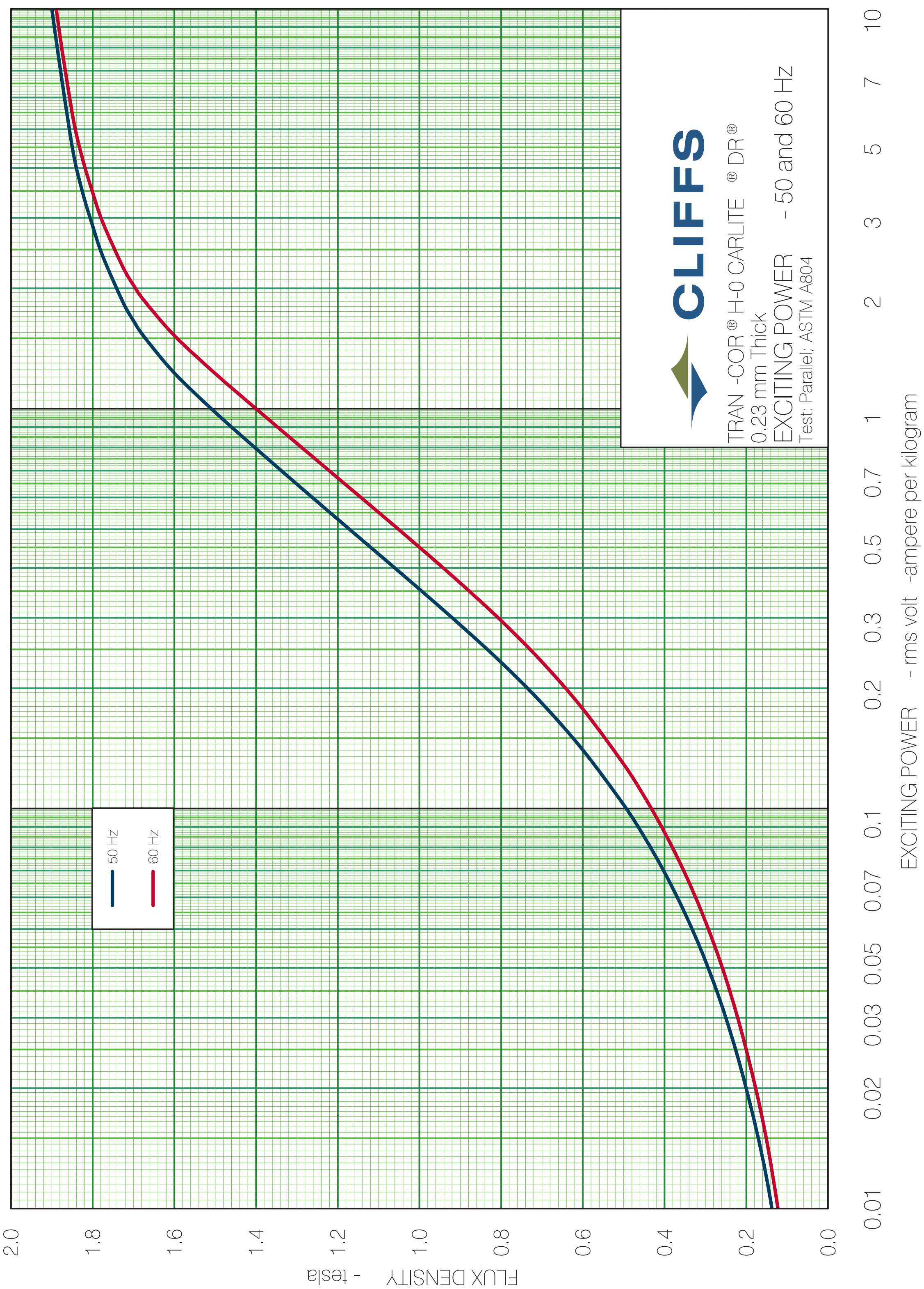
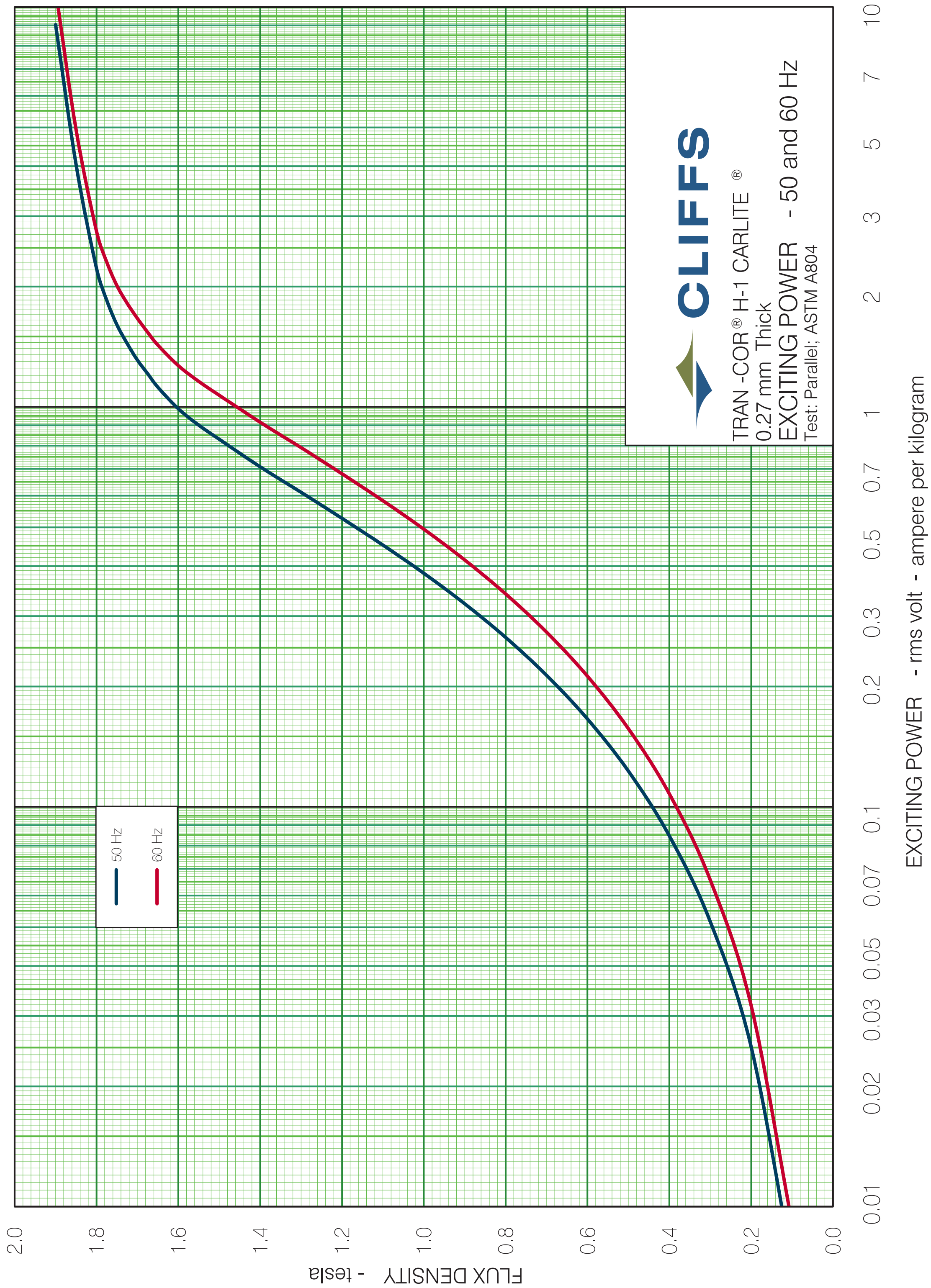


Exciting Power Curve – H-1 CARLITE



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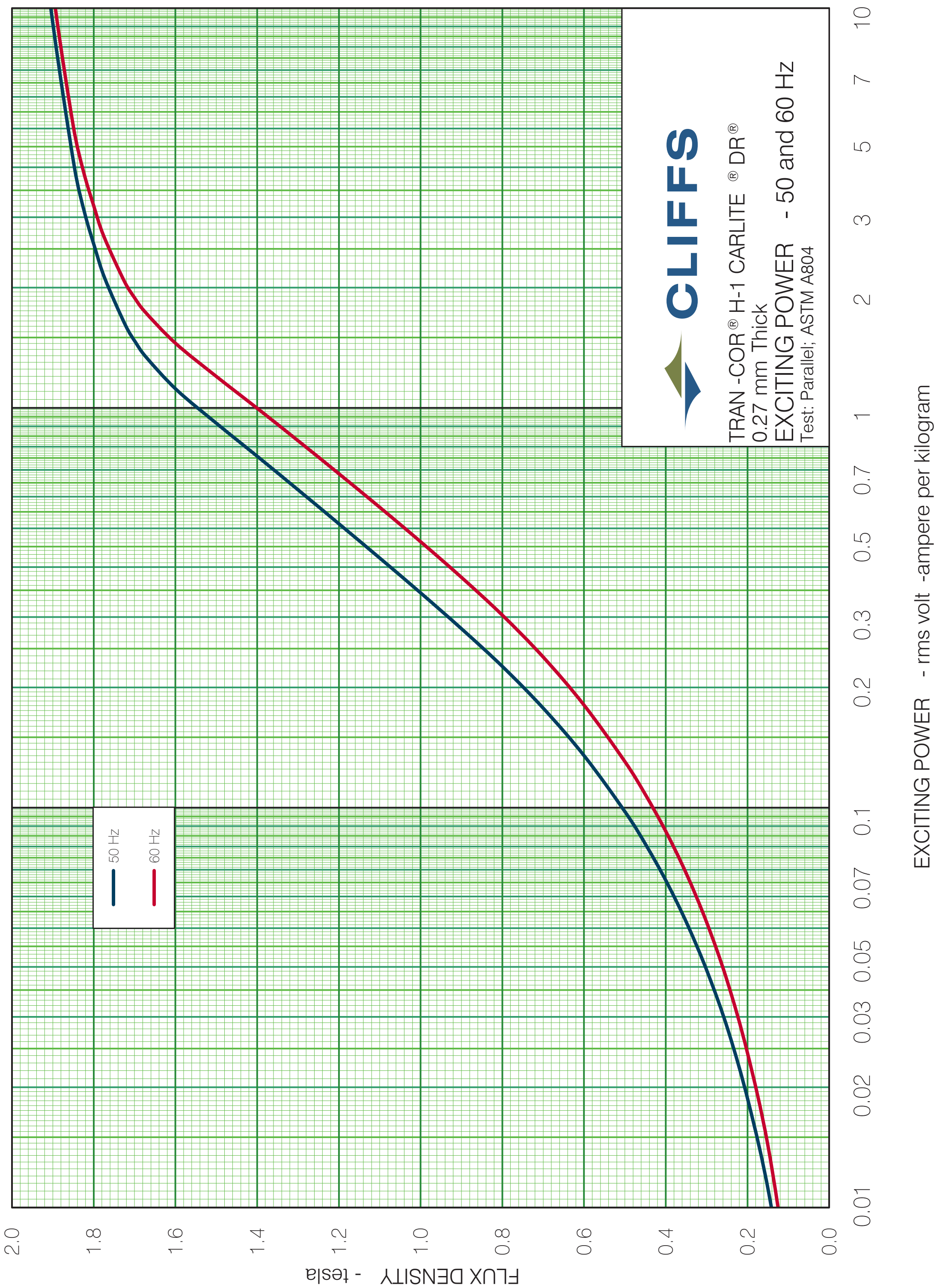

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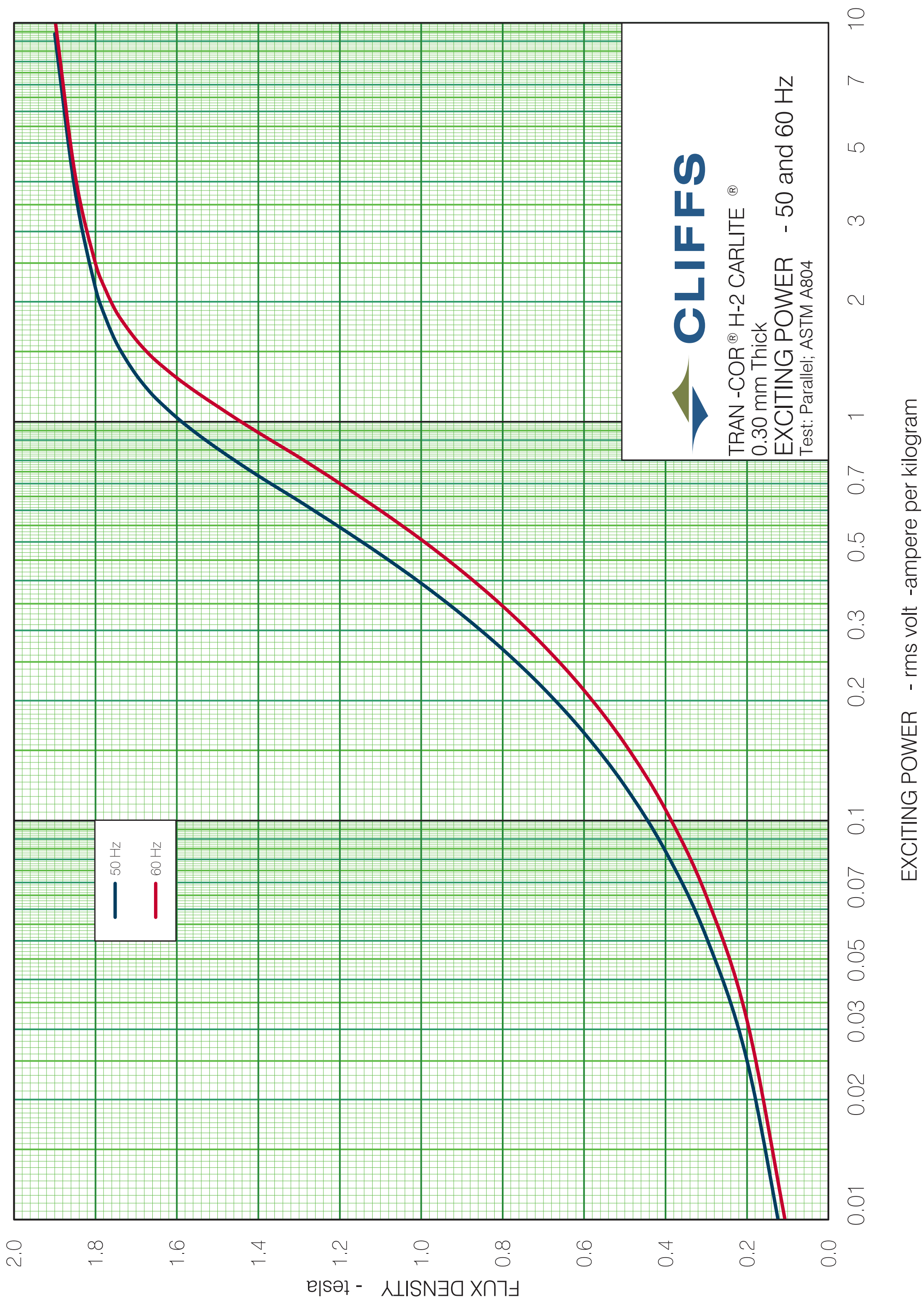

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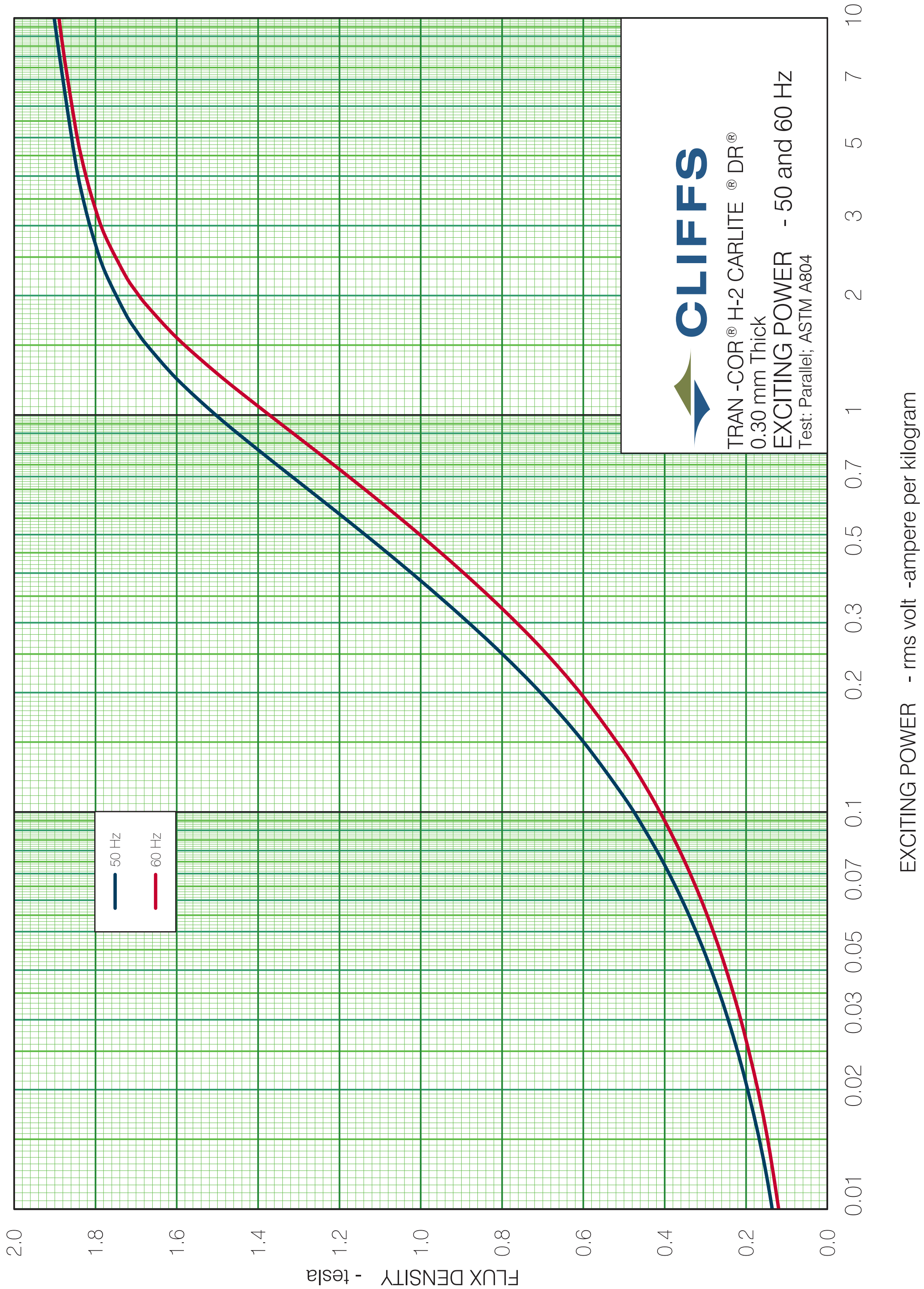
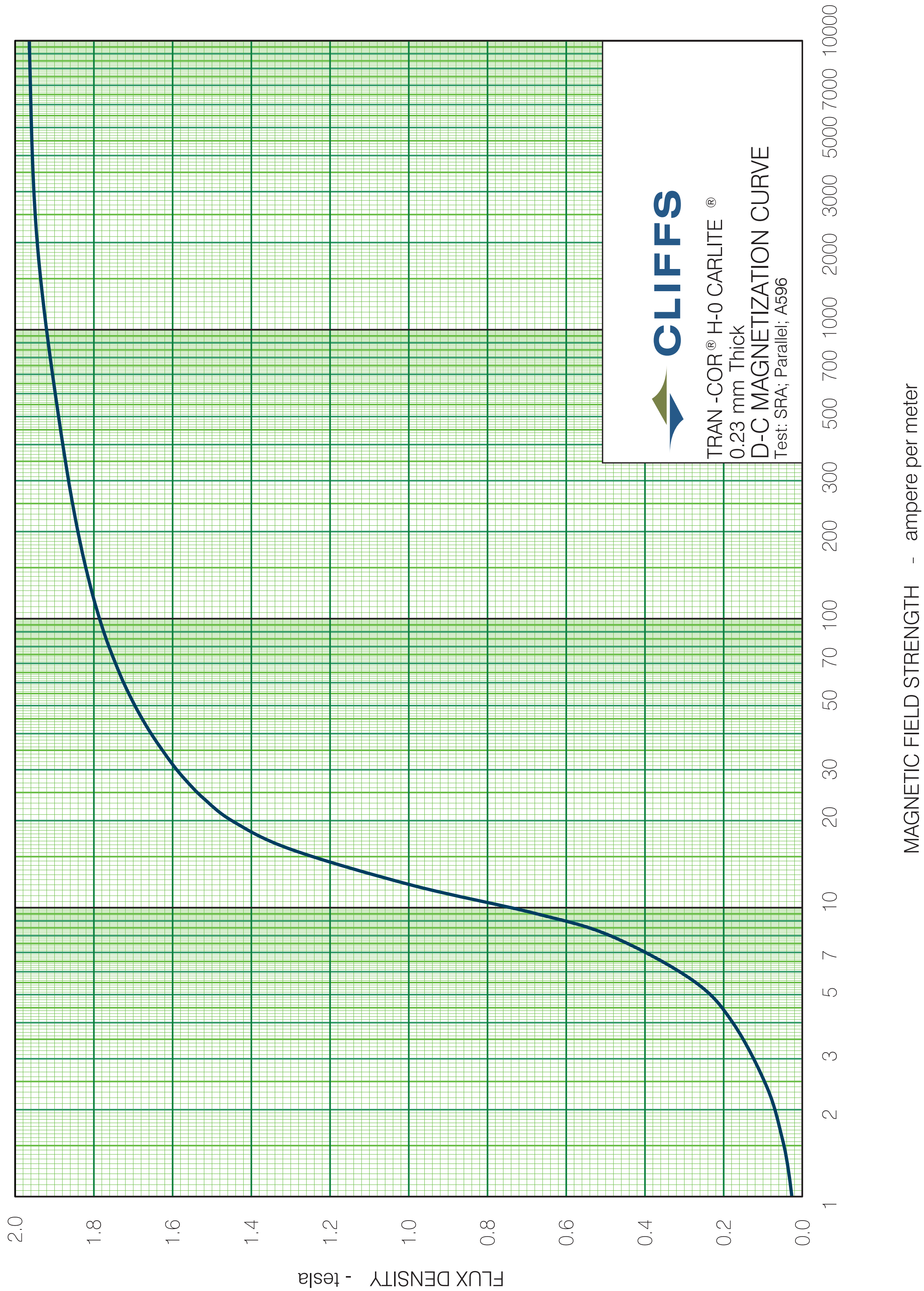
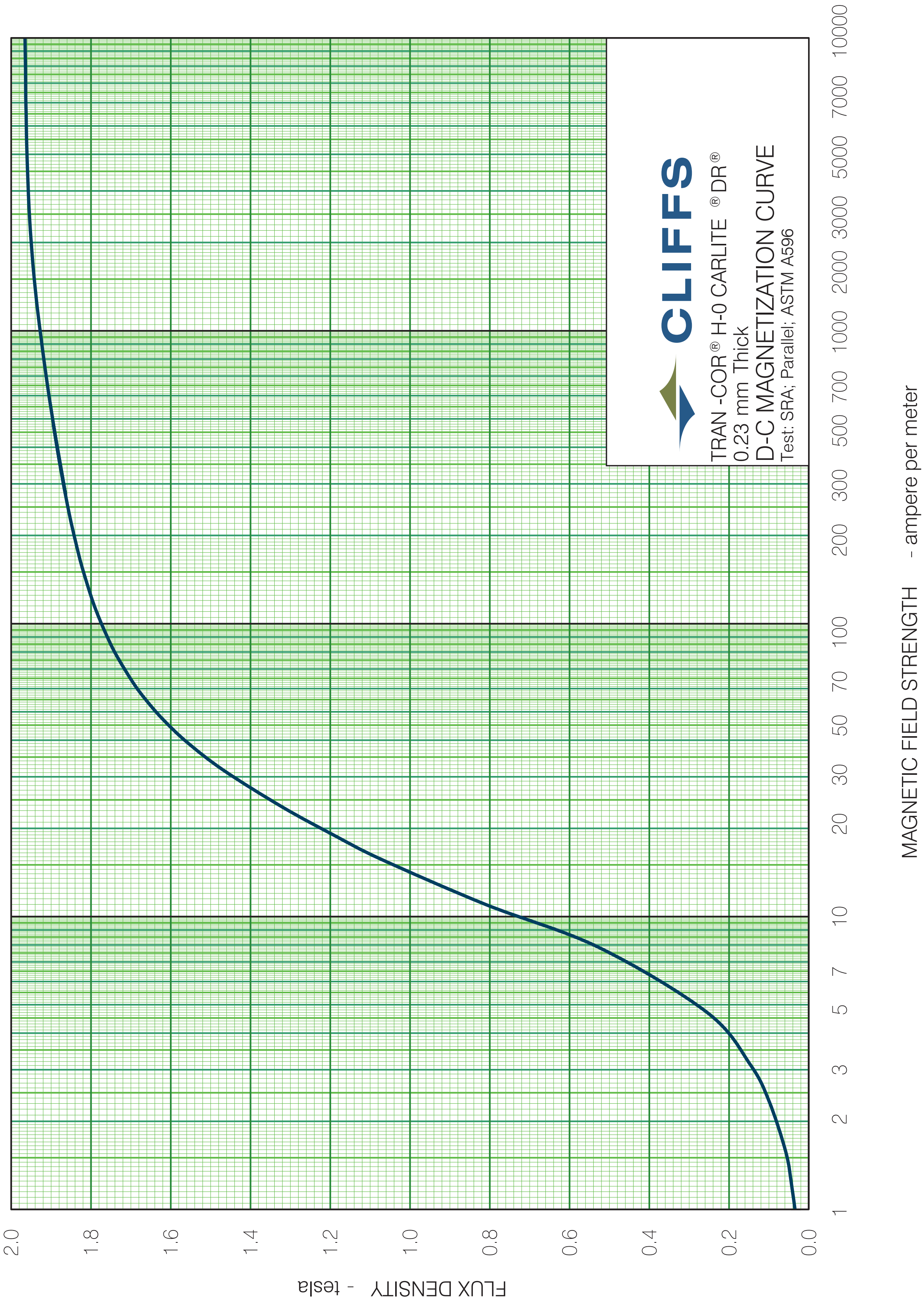
Exciting Power Curve – H-2 CARLITE DR



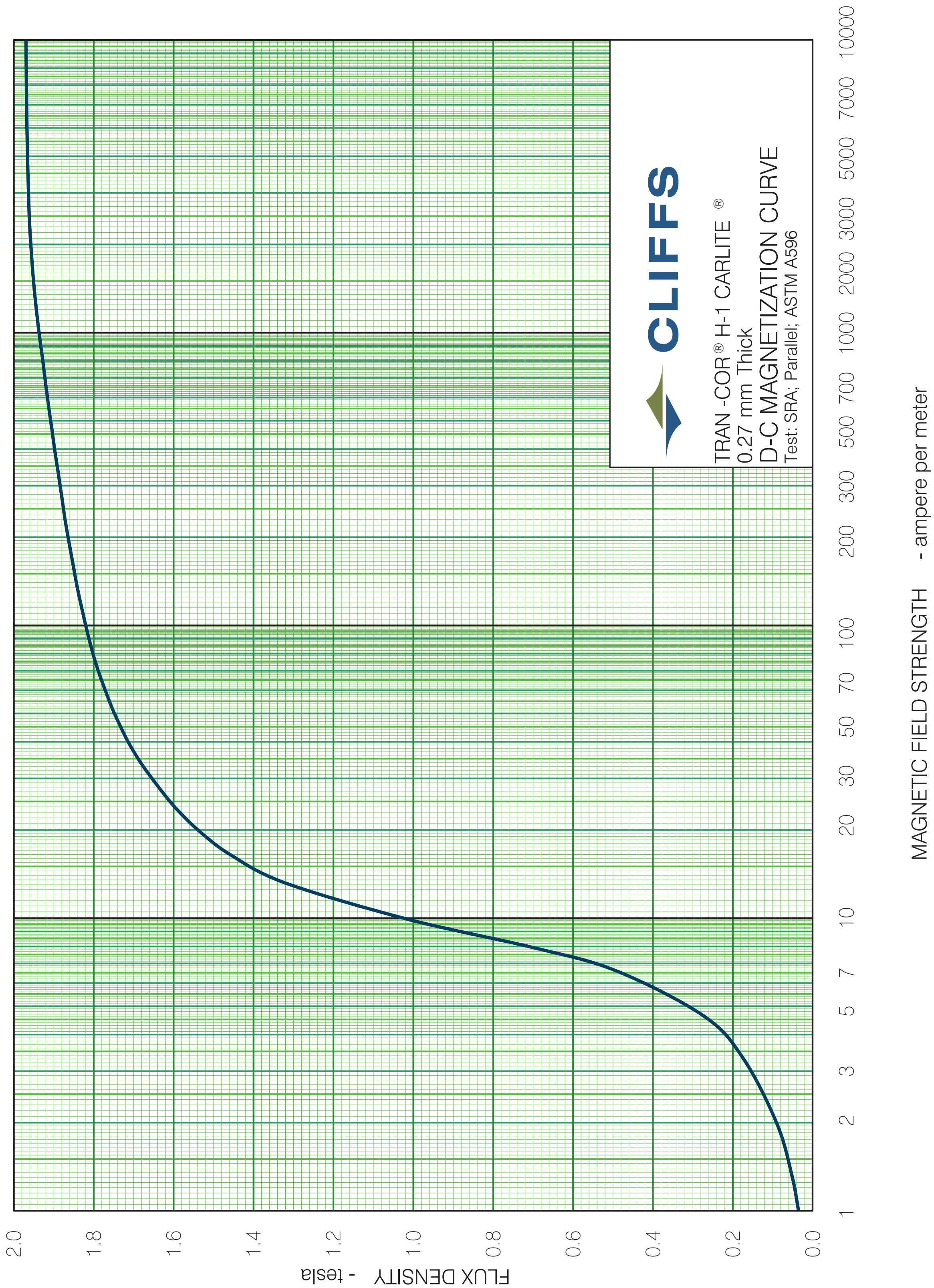
D-C Magnetization Curve – H-0 CARLITE



D-C Magnetization Curve – H-0 CARLITE DR



D-C Magnetization Curve – H-1 CARLITE



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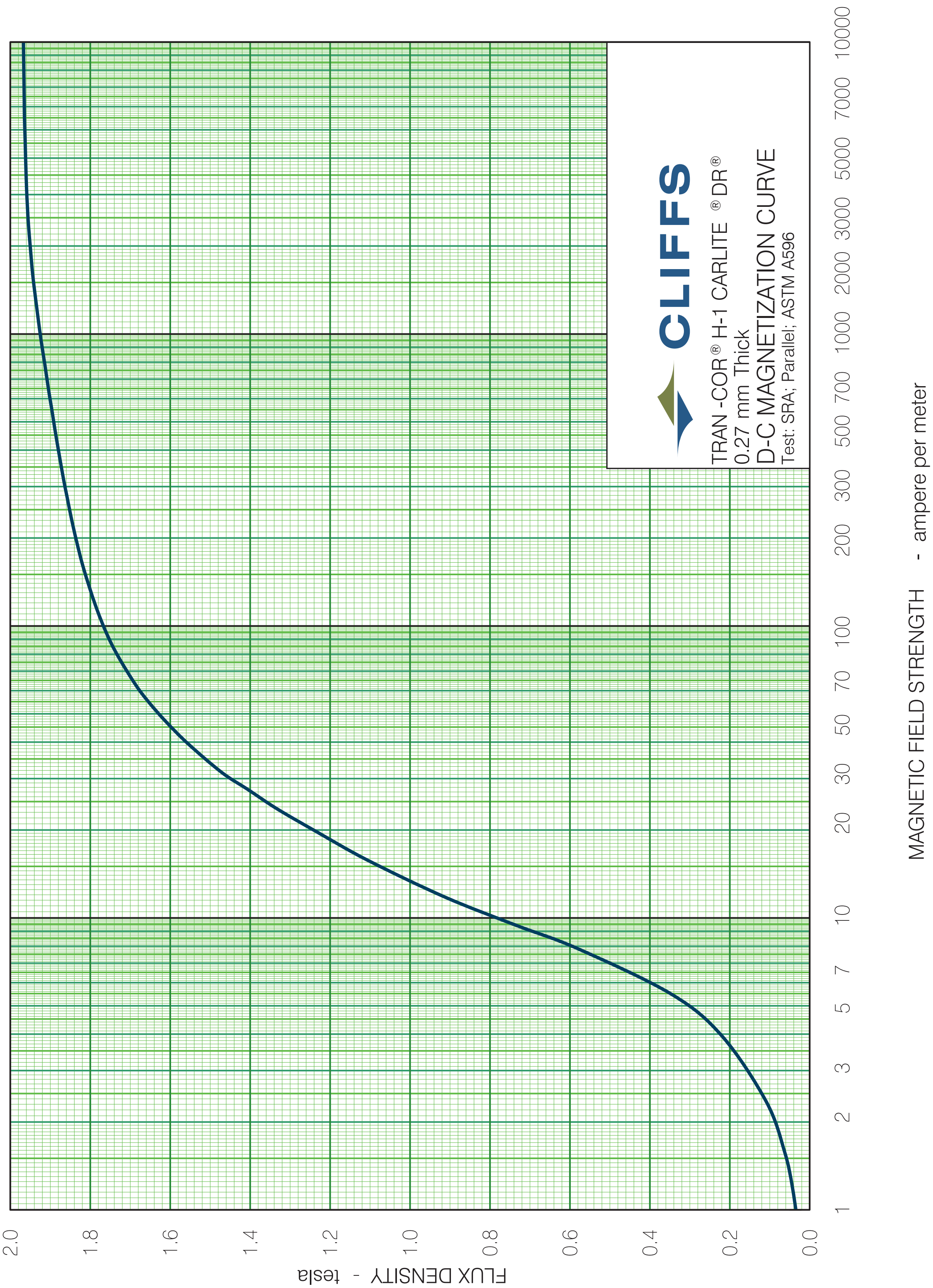

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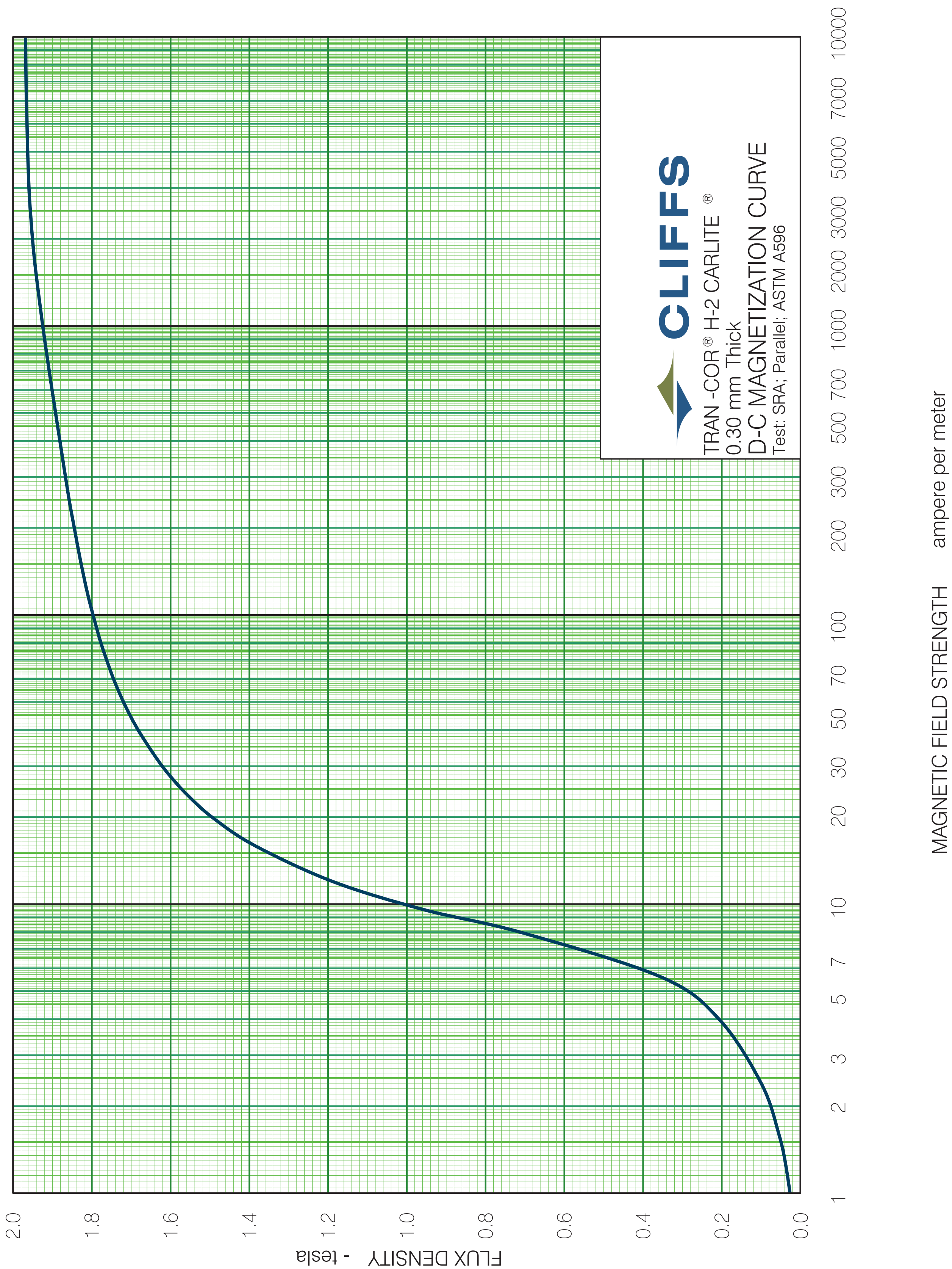

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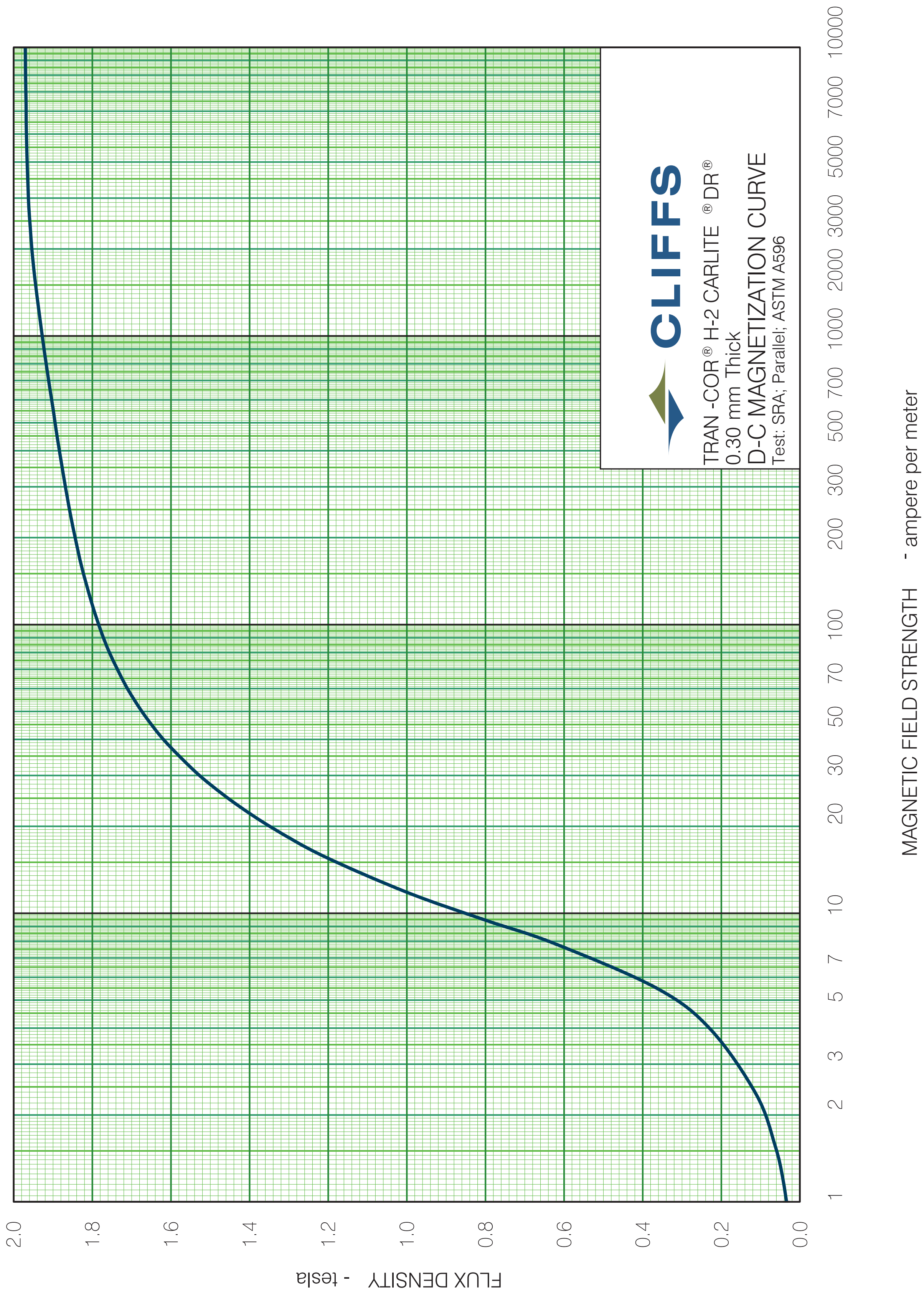
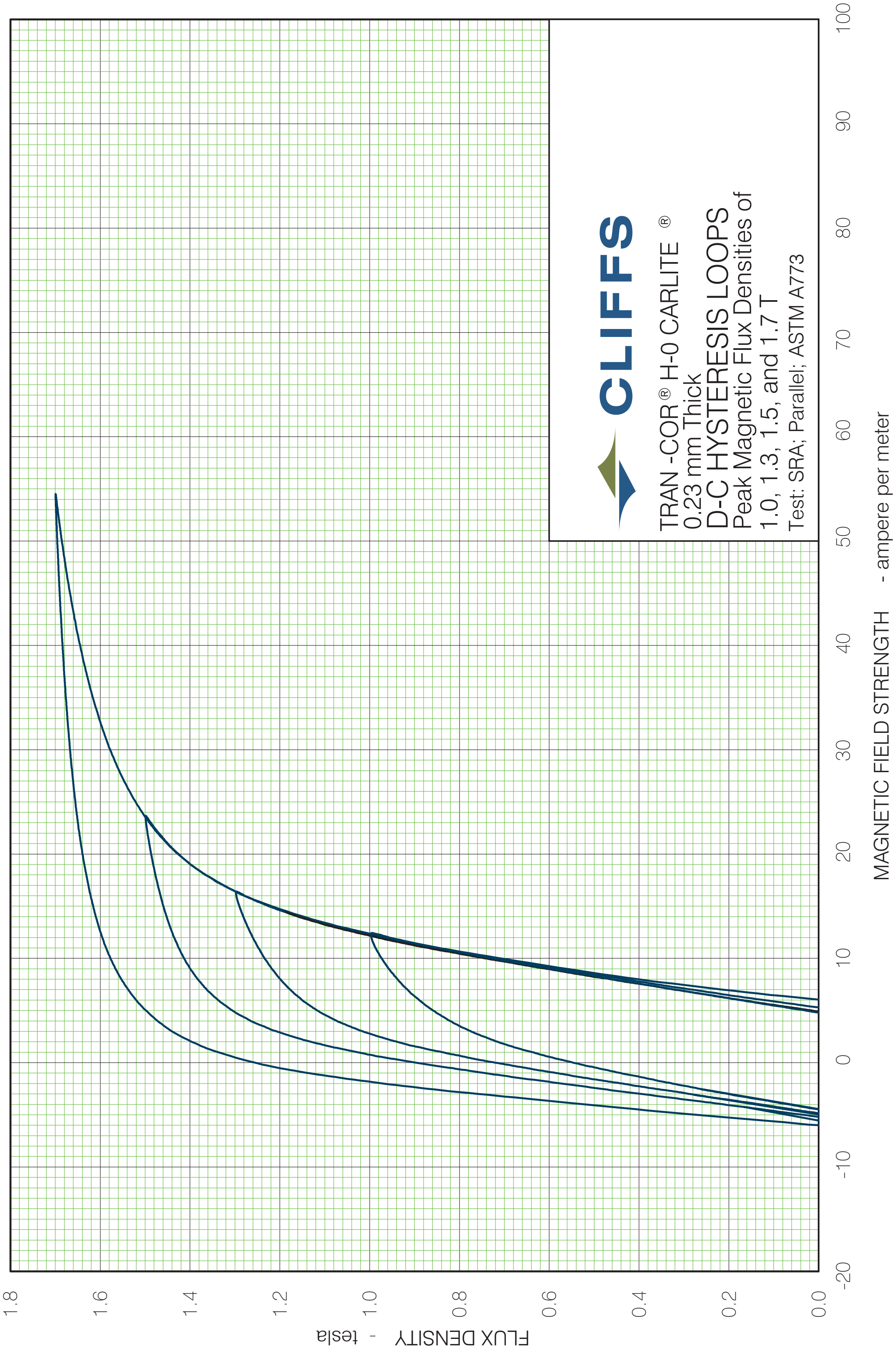
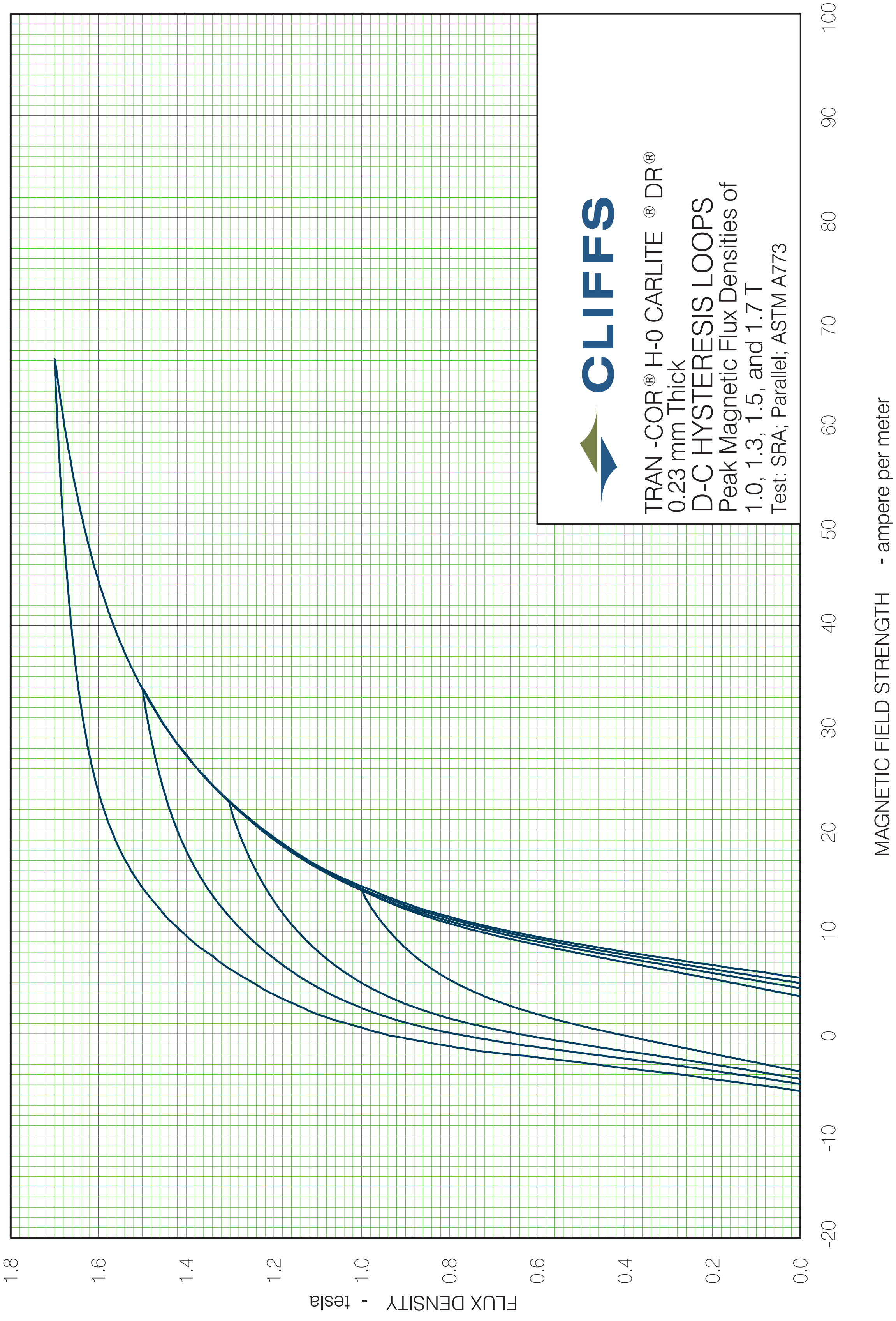


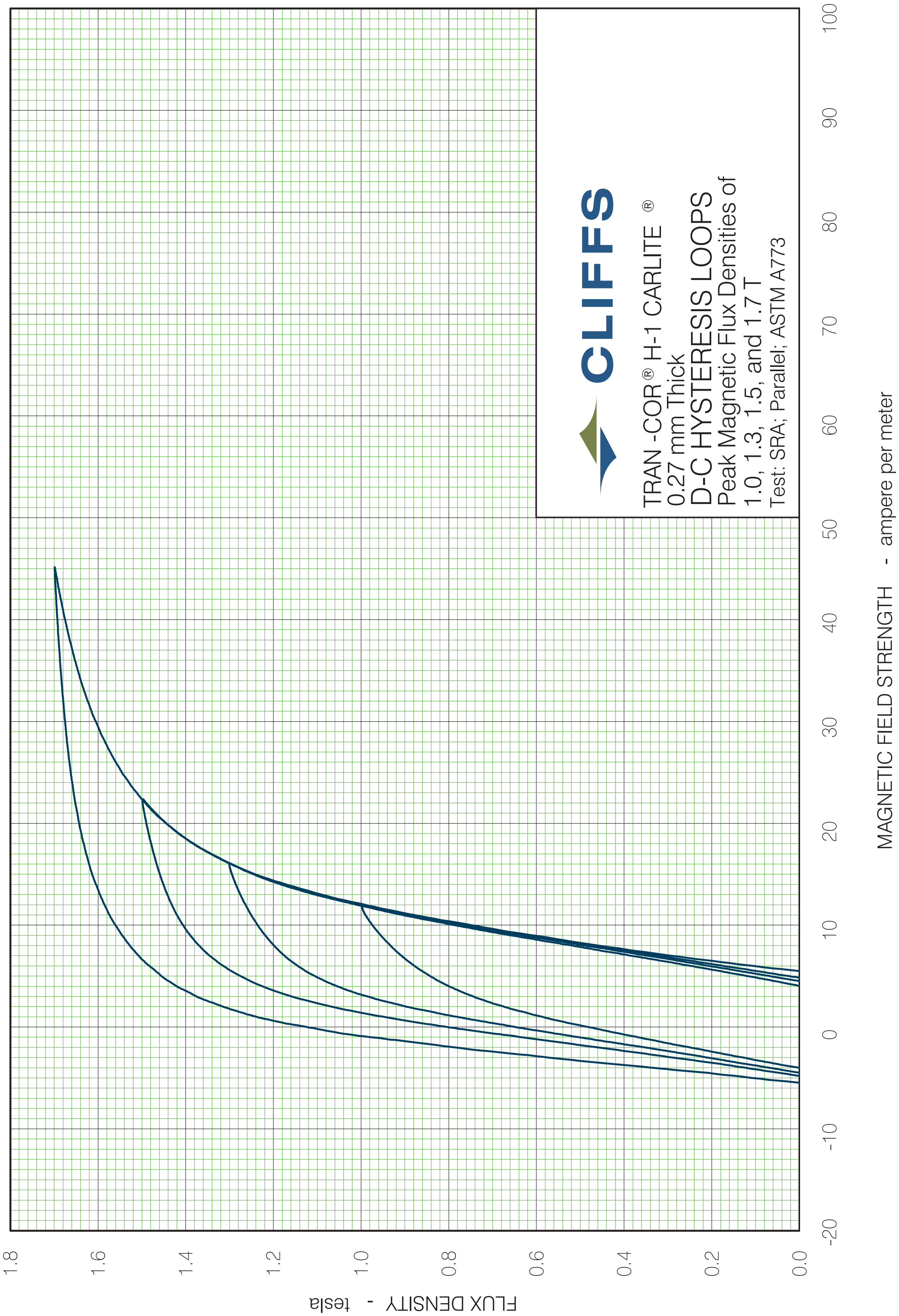
D-C Hysteresis Loops – H-0 CARLITE



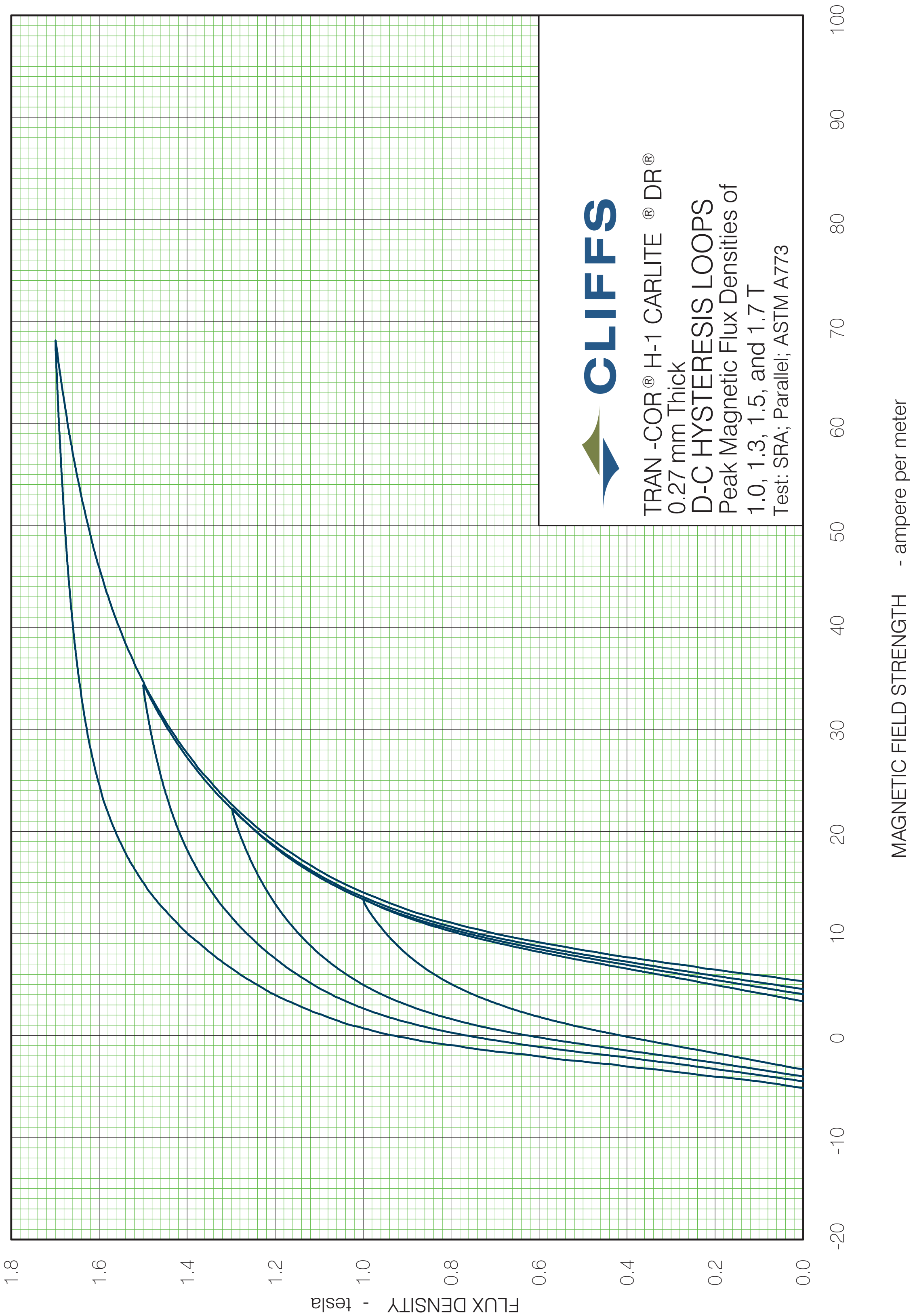
D-C Hysteresis Loops – H-0 CARLITE DR



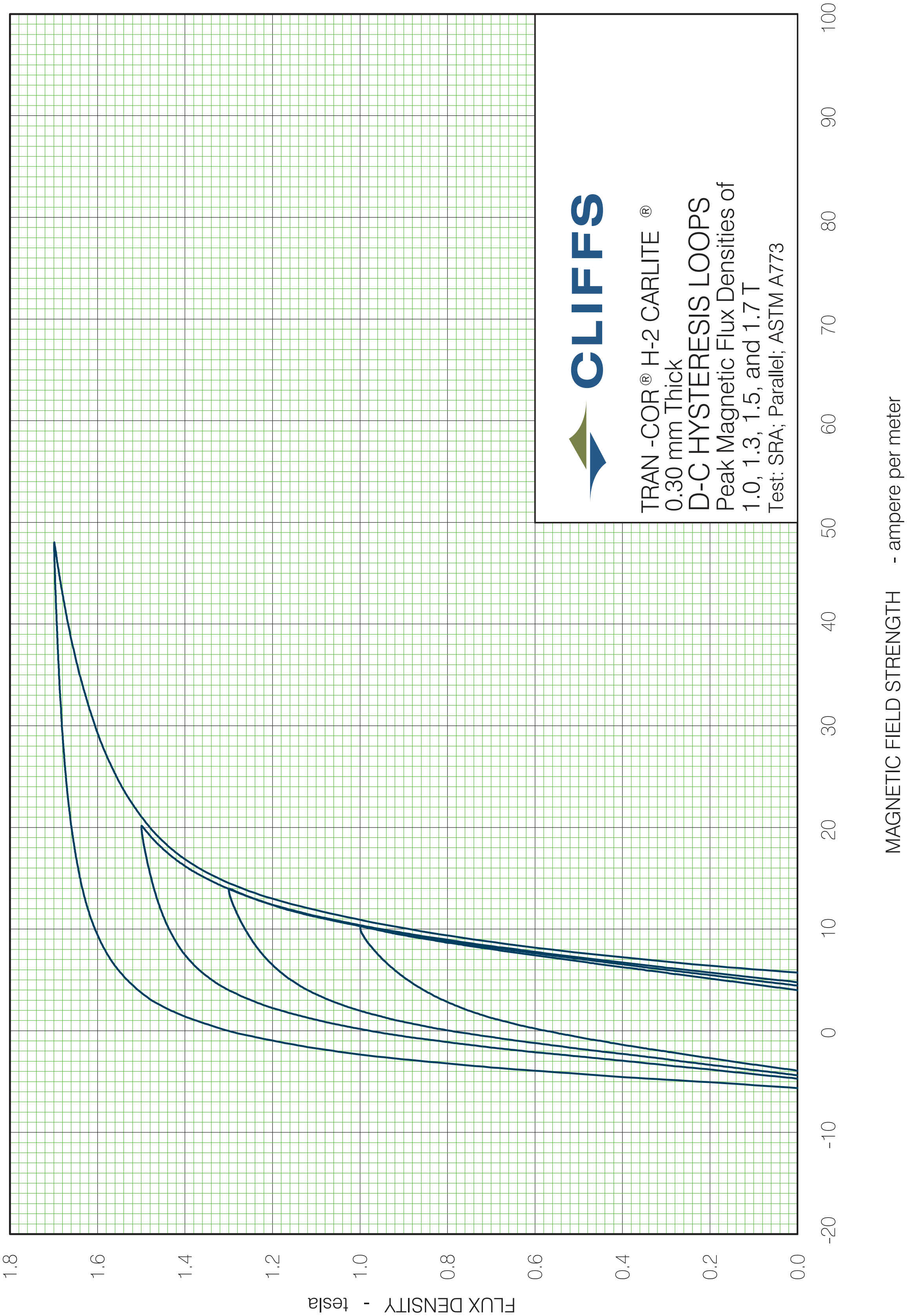
D-C Hysteresis Loops – H-1 CARLITE



D-C Hysteresis Loops – H-1 CARLITE DR



D-C Hysteresis Loops – H-2 CARLITE



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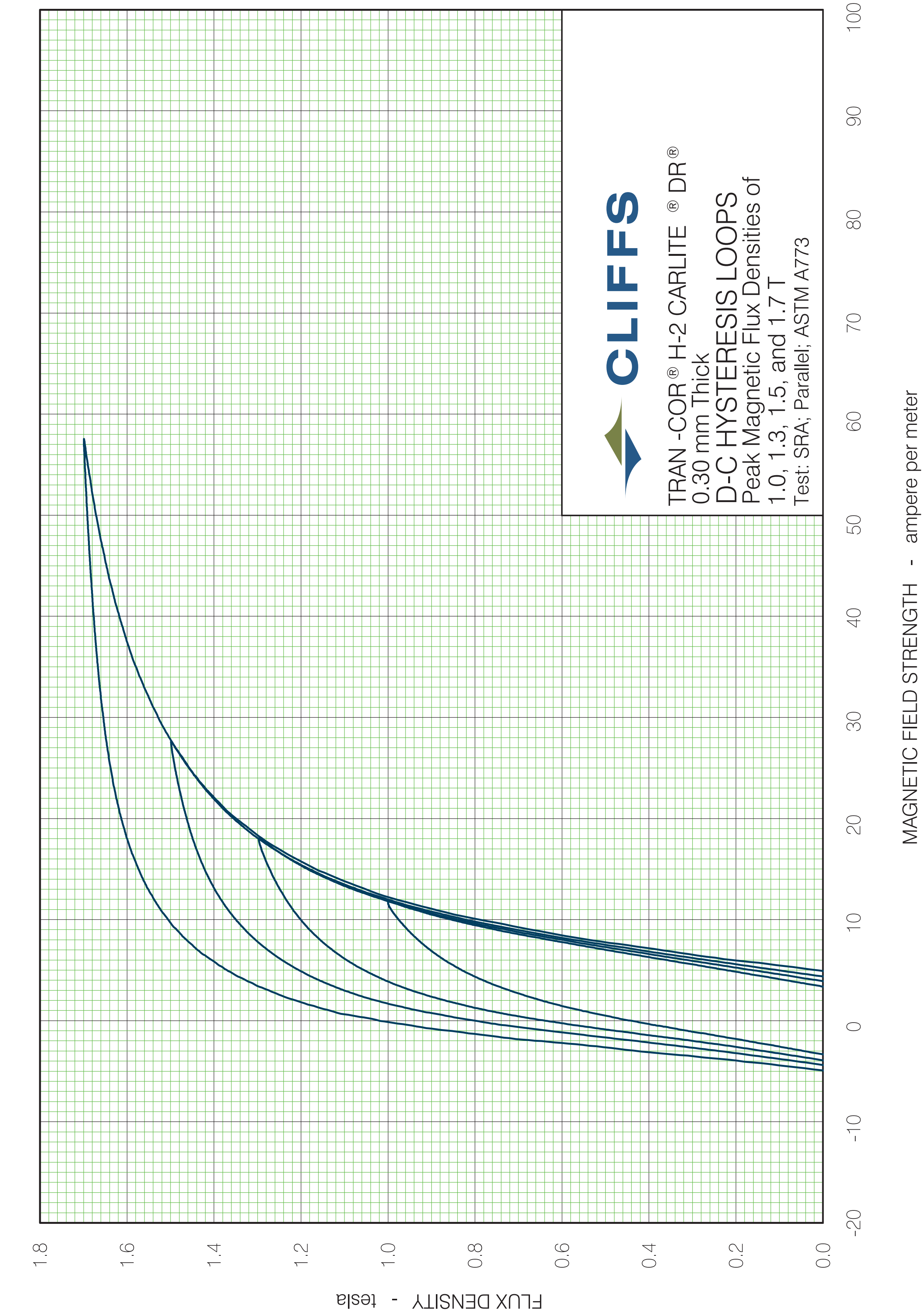

About Cleveland-Cliffs Inc.

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, direct reduced iron, and ferrous scrap 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 supplier of steel to the automotive industry in North America. The Company is headquartered in Cleveland, Ohio with mining, steel and downstream manufacturing operations located across the United States and in Canada. For more information, visit www.clevelandcliffs.com.

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