



CARLITE®

GRAIN ORIENTED
ELECTRICAL STEELS

M-3

M-4/120

M-4/125

M-5/125

M-5/130

M-5/140

M-6

PRODUCT DATA BULLETIN



Applications Potential

AK Steel Oriented Electrical Steels are used most effectively in transformer cores having wound or sheared and stamped laminations with the magnetic flux path entirely, or predominately, in the rolling direction. They also are used in large generators and other apparatus when the design permits the directional magnetic characteristics to be used efficiently.

CARLITE® GRAIN ORIENTED ELECTRICAL STEELS

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PRODUCT DESCRIPTION

Oriented Electrical Steels are iron-silicon alloys that were developed to provide the low core loss and high permeability required for efficient and economical electrical transformers. First produced commercially by AK Steel, these magnetic materials exhibit their superior magnetic properties in the rolling direction. This directionality occurs because the steels are specially processed to create a very high proportion of grains within the steel which have similarly oriented atomic crystalline structures relative to the rolling direction.

In iron-silicon alloys, this atomic structure is cubic and the crystals are most easily magnetized in a direction parallel to the cube edges. By a combination of precise steel composition, rigidly controlled cold rolling and annealing procedures, the crystals of these oriented electrical steels are aligned with their cube edges nearly parallel to the direction in which the steel is rolled. Consequently, they provide superior permeability and lower core loss when magnetized in this direction.

Since the inception of grain oriented electrical steels in 1933, AK Steel Research has continued to develop new and improved grades to provide the electrical industry with core materials for the manufacture of more efficient electrical apparatus.

FORMS AND STANDARD SIZES

Nominal Thickness

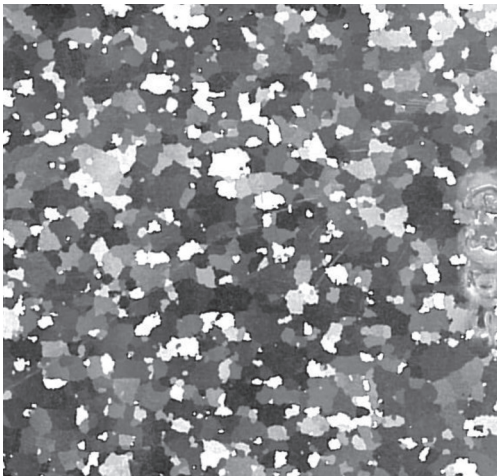
M-3:	0.23 mm (0.009 in.)
M-4:	0.27 mm (0.011 in.)
M-5:	0.30 mm (0.012 in.)
M-6:	0.35 mm (0.014 in.)

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.)



Sample chemically etched to reveal grain structure

CARLITE 3 SURFACE INSULATION

AK Steel's CARLITE Grain Oriented Electrical Steels (GOES) 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, AK Steel CARLITE Grain Oriented Electrical Steel specifications are determined at 1.5 T and 1.7 T at 50 Hz. Core loss grading is conducted using as-sheared single sheet test samples which are tested in accordance with ASTM test method A804. Induction is specified at 800 A/m. Induction 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 induction values are used for certification of conformance to product grade guarantees.

GUARANTEED CORE LOSS AND LAMINATION FACTOR

Product Name	Approximate Equivalent International Grade	Nominal Thickness, mm (in.)	Assumed Density, gm/cm³	Resistivity, Ω-m, x10 ⁻⁸	Maximum Core Loss Watts per kilogram		Maximum Core Loss Watts per pound		Minimum Induction at 800 A/m, T	Minimum Lamination Factor, %
					50 Hz		50 Hz			
					1.5 T	1.7 T	15 kg	17 kg		
M-3 CARLITE	M110-23S5	0.23 (0.009)	7.65	51	0.73	1.10	0.330	0.500	1.800	94.5%
M-4/120 CARLITE	M120-27S5	0.27 (0.011)			0.82	1.20	0.370	0.545	1.800	95.0%
M-4/125 CARLITE	M125-27S5	0.27 (0.011)			0.85	1.25	0.385	0.565	1.790	95.0%
M-5/125 CARLITE	M125-30S5	0.30 (0.012)			0.86	1.25	0.390	0.565	1.800	95.5%
M-5/130 CARLITE	M130-30S5	0.30 (0.012)			0.88	1.30	0.400	0.590	1.800	95.5%
M-5/140 CARLITE	M140-30S5	0.30 (0.012)			0.92	1.40	0.415	0.635	1.780	95.5%
M-6 CARLITE	M155-35S5	0.35 (0.014)			1.07	1.55	0.485	0.705	1.780	96.0%

TYPICAL CORE LOSS AND LAMINATION FACTOR

Product Name	Approximate Equivalent International Grade	Nominal Thickness, mm (in.)	Assumed Density, gm/cm³	Resistivity, Ω-m, x10 ⁻⁸	Typical Core Loss Watts per kilogram		Typical Core Loss Watts per pound		Typical Induction at 800 A/m, T	Typical Lamination Factor, %
					50 Hz		50 Hz			
					1.5 T	1.7 T	15 kg	17 kg		
M-3 CARLITE	M110-23S5	0.23 (0.009)	7.65	51	0.67	1.01	0.304	0.457	1.844	96.1%
M-4/120 CARLITE	M120-27S5	0.27 (0.011)			0.77	1.14	0.351	0.518	1.845	96.9%
M-4/125 CARLITE	M125-27S5	0.27 (0.011)			0.80	1.18	0.364	0.535	1.841	96.9%
M-5/125 CARLITE	M125-30S5	0.30 (0.012)			0.84	1.21	0.382	0.548	1.839	97.2%
M-5/130 CARLITE	M130-30S5	0.30 (0.012)			0.86	1.25	0.390	0.566	1.834	97.2%
M-5/140 CARLITE	M140-30S5	0.30 (0.012)			0.89	1.30	0.405	0.589	1.827	97.2%
M-6 CARLITE	M155-35S5	0.35 (0.014)			0.97	1.38	0.440	0.627	1.848	97.2%

The core loss and exciting power of the AK Steel 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:

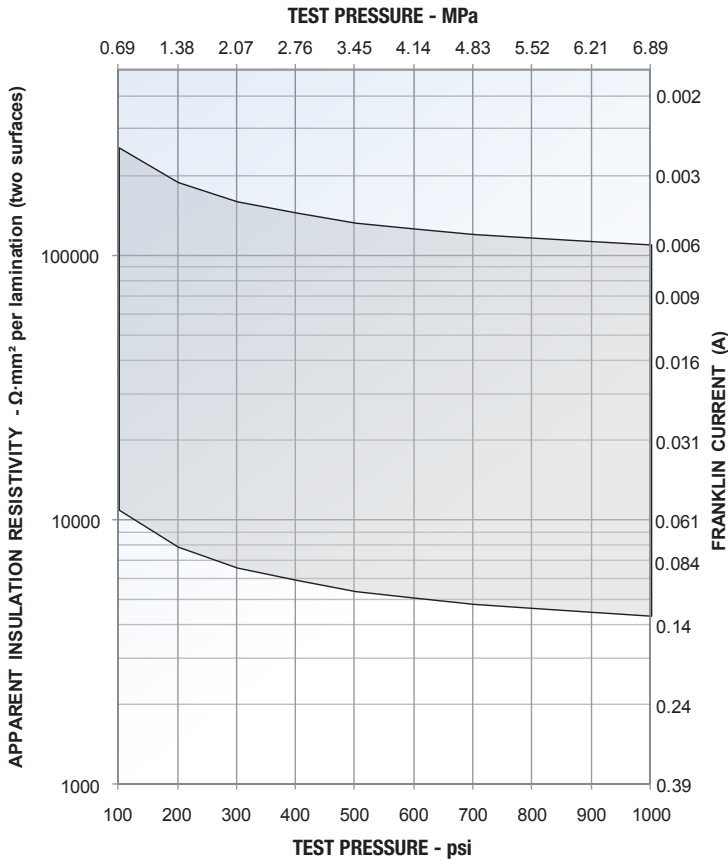
1. Results for as-sheared single sheet specimens from fully processed material cut parallel to the rolling direction of the coil and tested per ASTM A804

2. Density of all grades (7.65 gm/cm³) per ASTM A343

ASTM A664 is a grade identification system for electrical steels. While this system has not been widely adopted by the 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 AK Steel and equivalent ASTM grades:

AK Steel grade M-3 is approximately equivalent to ASTM Core Loss Types 23G045 and 23H070, AK Steel grade M-4/125 is approximately equivalent to ASTM Core Loss Types 27G051 and 27H074, AK Steel grade M-5/140 is approximately equivalent to ASTM Core Loss Types 30G058 and 30H083, AK Steel grade M-6 is approximately equivalent to ASTM Core Loss Types 35G066 and 35H094

SURFACE INSULATION & LAMINATION FACTOR CURVES



Typical surface insulation characteristics of AK Steel Oriented Electrical Steels at various pressures as determined by the Franklin Test.

SURFACE INSULATION CURVES

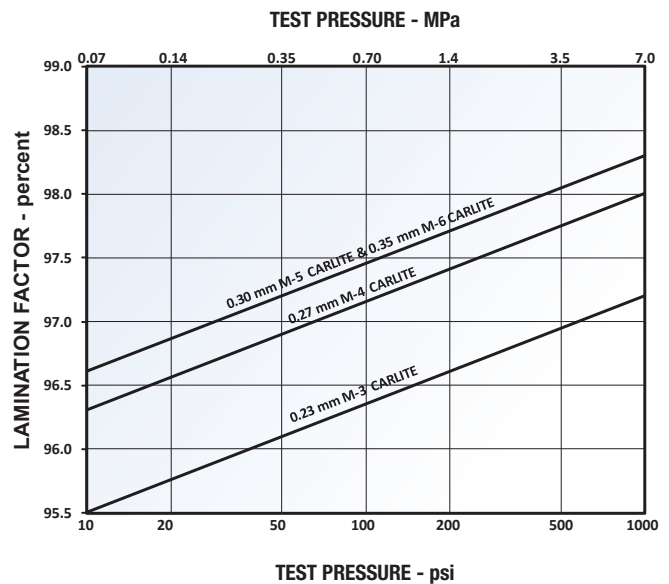
Figure 1 (left) shows the variation of surface insulation resistivity versus pressure. The range of surface insulation resistivity values between the upper and lower lines are typical of those for CARLITE 3 insulated surfaces as determined by the Franklin Test method (ASTM A717). However, the user should 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.

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 AK Steel's 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 in accordance with ASTM A719. Figure 2 (below) illustrates how the ASTM lamination factor varies as a function of pressure for AK Steel Oriented Electrical Steels. The values shown are representative of the lamination factor determined by this test.



Representative lamination factors for AK Steel Oriented Electrical Steels at various pressures.

REPRESENTATIVE MECHANICAL PROPERTIES

Ultimate Tensile Strength in rolling direction, MPa (psi)	352	(51,000)
Yield Strength in rolling direction, MPa (psi)	331	(48,000)
Percent Elongation in 50.8 mm (2 in.) in rolling direction	9	
Microhardness (Knoop Hardness Number, HK)	167	
Equivalent Rockwell B Scale Hardness	81	
Modulus of Elasticity, MPa (psi)*		
in rolling direction	122,000	(17,700,000)
at 20° to rolling direction	143,000	(20,800,000)
at 45° to rolling direction	236,000	(34,300,000)
at 55° to rolling direction	258,000	(37,500,000)
at right angles to rolling direction	200,000	(29,000,000)

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

MAGNETOSTRICTION

The magnetostriction coefficients are inherent to CARLITE Grain Oriented Electrical Steel owing to the 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 AK Steel's CARLITE Grain Oriented Electrical Steel products.

COMPARATIVE MAGNETOSTRICTION

Grade	Thickness, mm (in.)	Magnetostriction x 10 ⁸	
		60 Hz	
		1.5 T	1.7 T
M-3 CARLITE	0.23 (0.009)	-80	-94
M-4 CARLITE	0.27 (0.011)	-93	-116
M-5 CARLITE	0.30 (0.012)	-94	-125
M-6 CARLITE	0.35 (0.014)	-97	-124

TEST METHOD

The above data is meant for comparative purposes only and was developed using Epstein specimens from representative samples which were prepared in accordance with ASTM A876 and tested in accordance with ASTM A343. While there are no agreed upon standard testing methods for magnetostriction, the data was 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 at the inductions shown above. The magnetostriction values are, to our best knowledge, believed to be representative of commercially produced materials.

THICKNESS, WIDTH, CAMBER & FLATNESS TOLERANCES

THICKNESS TOLERANCES

Grade	Nominal Thickness, mm	Thickness, mm		
		Aim	Minimum	Maximum
M-3 CARLITE	0.23	0.21	0.19	0.23
M-4 CARLITE	0.27	0.27	0.25	0.29
M-5 CARLITE	0.30	0.29	0.27	0.31
M-6 CARLITE	0.35	0.36	0.34	0.38

The aim thickness values are based on the test sample weight plus typical coating thickness such as would be measured using a contacting micrometer. 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.

WIDTH TOLERANCES

Specified Width, mm	Tolerance over, mm	Tolerance under, mm
To 100 mm inclusive	0.00	0.25
Over 100 mm to 225 mm, inclusive	0.00	0.25
Over 225 mm to 375 mm, inclusive	0.00	0.38
Over 375 mm to 914 mm, inclusive	0.00	0.50
914 mm, exact	1.50	1.50

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 SPECIFICATIONS

Thickness	0.23 mm (0.009 in.) M-3	
	0.27 mm (0.011 in.) M-4	
	0.30 mm (0.012 in.) M-5	
	0.35 mm (0.014 in.) M-6	
Width	Master coils are available in widths of 914 mm (36.0 in.) and 920 mm (36.22 in.).	
	For the 920 mm width, we reserve the option of furnishing cutdowns, in 900 mm (35.43 in.) and 880 mm (34.65 in.) widths, not to exceed 10% of the ordered quantity. For the 914 mm width, we reserve the option of furnishing cutdowns, in 890 mm (33.07 in.) and 870 mm (34.25 in.) widths, not to exceed 10% of the ordered quantity.	
Coils-Slit	Minimum width	19 mm (0.75 in.)
		Narrower - Inquire
	Inside diameters	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)	

TYPICAL VALUES OF CORE LOSS

AT 50 AND 60 Hz FOR TYPICAL SHEET SPECIMENS OF AK STEEL ORIENTED CARLITE COATED ELECTRICAL STEELS

Flux Density (T)	Core Loss (W/kg) - ASTM A804							
	0.23 mm M-3 CARLITE GOES		0.27 mm M-4/120 CARLITE GOES		0.27 mm M-4/125 CARLITE GOES		0.30 mm M-5/125 CARLITE GOES	
	50 Hz	60 Hz	50 Hz	60 Hz	50 Hz	60 Hz	50 Hz	60 Hz
0.1	0.00324	0.00424	0.00404	0.00533	0.00442	0.0058	0.00426	0.00567
0.2	0.0125	0.0164	0.0155	0.0205	0.0166	0.0219	0.0165	0.0219
0.3	0.0275	0.0360	0.0336	0.0444	0.0357	0.0470	0.0359	0.0478
0.4	0.0481	0.0629	0.0584	0.0765	0.0613	0.0805	0.0621	0.0827
0.5	0.0740	0.0965	0.0882	0.116	0.0928	0.122	0.0948	0.126
0.6	0.105	0.137	0.124	0.164	0.130	0.171	0.134	0.178
0.7	0.141	0.184	0.166	0.218	0.173	0.227	0.180	0.238
0.8	0.183	0.238	0.213	0.281	0.222	0.292	0.232	0.307
0.9	0.229	0.298	0.267	0.351	0.278	0.365	0.291	0.385
1.0	0.281	0.366	0.327	0.430	0.340	0.447	0.358	0.473
1.1	0.339	0.441	0.395	0.519	0.410	0.539	0.432	0.570
1.2	0.404	0.525	0.471	0.620	0.489	0.642	0.515	0.680
1.3	0.477	0.621	0.558	0.734	0.580	0.760	0.608	0.803
1.4	0.562	0.731	0.657	0.863	0.682	0.893	0.714	0.942
1.5	0.668	0.866	0.778	1.02	0.806	1.05	0.842	1.11
1.6	0.799	1.03	0.921	1.20	0.955	1.24	0.993	1.30
1.7	1.00	1.28	1.13	1.47	1.18	1.52	1.21	1.57
1.8	1.34	1.70	1.45	1.86	1.51	1.94	1.53	1.98
1.9	1.75	2.20	1.70	2.18	1.91	2.42	1.92	2.45

Flux Density (T)	Core Loss (W/kg) - ASTM A804					
	0.30 mm M-5/130 CARLITE GOES		0.30 mm M-5/140 CARLITE GOES		0.35 mm M-6 CARLITE GOES	
	50 Hz	60 Hz	50 Hz	60 Hz	50 Hz	60 Hz
0.1	0.00430	0.00572	0.00473	0.00629	0.00544	0.00725
0.2	0.0167	0.0222	0.0180	0.0240	0.0205	0.0274
0.3	0.0364	0.0485	0.0389	0.0519	0.0439	0.0589
0.4	0.0630	0.0839	0.0669	0.0892	0.0753	0.101
0.5	0.0963	0.128	0.102	0.135	0.114	0.153
0.6	0.136	0.181	0.143	0.190	0.160	0.214
0.7	0.183	0.242	0.191	0.253	0.214	0.286
0.8	0.236	0.312	0.246	0.326	0.275	0.367
0.9	0.296	0.392	0.308	0.408	0.344	0.458
1.0	0.364	0.481	0.378	0.500	0.421	0.560
1.1	0.439	0.580	0.456	0.602	0.507	0.673
1.2	0.524	0.692	0.543	0.718	0.602	0.799
1.3	0.620	0.818	0.643	0.849	0.709	0.940
1.4	0.728	0.960	0.756	0.997	0.829	1.10
1.5	0.860	1.13	0.894	1.18	0.970	1.28
1.6	1.02	1.33	1.06	1.39	1.14	1.51
1.7	1.25	1.62	1.30	1.69	1.38	1.81
1.8	1.59	2.05	1.66	2.14	1.71	2.24
1.9	1.98	2.54	2.07	2.66	2.03	2.62

TYPICAL VALUES OF RMS EXCITING POWER

AT 50 AND 60 Hz FOR TYPICAL SHEET SPECIMENS OF AK STEEL ORIENTED CARLITE COATED ELECTRICAL STEELS

Flux Density (T)	Exciting Power (rms VA/kg) - ASTM A804							
	0.23 mm M-3 CARLITE GOES		0.27 mm M-4/120 CARLITE GOES		0.27 mm M-4/125 CARLITE GOES		0.30 mm M-5/125 CARLITE GOES	
	50 Hz	60 Hz	50 Hz	60 Hz	50 Hz	60 Hz	50 Hz	60 Hz
0.1	0.0101	0.0123	0.0104	0.0129	0.0109	0.0134	0.00918	0.0114
0.2	0.0334	0.0411	0.0340	0.0424	0.0354	0.0440	0.0302	0.0380
0.3	0.0662	0.0814	0.0671	0.0840	0.0693	0.0867	0.0603	0.0762
0.4	0.106	0.131	0.108	0.135	0.111	0.139	0.0978	0.124
0.5	0.151	0.187	0.154	0.194	0.158	0.199	0.142	0.181
0.6	0.201	0.249	0.206	0.261	0.212	0.267	0.193	0.246
0.7	0.256	0.318	0.265	0.335	0.270	0.342	0.250	0.320
0.8	0.316	0.394	0.329	0.417	0.335	0.425	0.314	0.403
0.9	0.382	0.478	0.400	0.509	0.407	0.517	0.386	0.495
1.0	0.457	0.572	0.480	0.611	0.487	0.620	0.467	0.600
1.1	0.538	0.674	0.569	0.725	0.577	0.734	0.558	0.717
1.2	0.634	0.794	0.674	0.857	0.681	0.867	0.666	0.854
1.3	0.757	0.946	0.804	1.02	0.811	1.03	0.799	1.02
1.4	0.905	1.13	0.964	1.22	0.969	1.23	0.971	1.24
1.5	1.15	1.42	1.22	1.53	1.22	1.53	1.22	1.54
1.6	1.51	1.86	1.57	1.95	1.57	1.95	1.61	2.01
1.7	2.64	3.19	2.75	3.36	2.78	3.38	2.87	3.51
1.8	7.04	8.47	7.71	9.36	8.05	9.64	8.03	9.76
1.9	25.9	31.1	27.3	33.3	28.8	34.4	27.9	34.1

Flux Density (T)	Exciting Power (rms VA/kg) - ASTM A804					
	0.30 mm M-5/130 CARLITE GOES		0.30 mm M-5/140 CARLITE GOES		0.35 mm M-6 CARLITE GOES	
	50 Hz	60 Hz	50 Hz	60 Hz	50 Hz	60 Hz
0.1	0.00922	0.0115	0.0105	0.0131	0.00895	0.0114
0.2	0.0304	0.0383	0.0341	0.0430	0.0296	0.0381
0.3	0.0607	0.0768	0.0675	0.0852	0.0595	0.0771
0.4	0.0985	0.125	0.108	0.138	0.0977	0.127
0.5	0.143	0.182	0.157	0.199	0.144	0.187
0.6	0.194	0.248	0.211	0.270	0.197	0.257
0.7	0.252	0.323	0.273	0.349	0.257	0.336
0.8	0.317	0.407	0.341	0.438	0.326	0.426
0.9	0.391	0.502	0.419	0.538	0.403	0.527
1.0	0.474	0.609	0.506	0.650	0.490	0.639
1.1	0.569	0.730	0.605	0.777	0.587	0.767
1.2	0.681	0.872	0.723	0.926	0.700	0.913
1.3	0.821	1.05	0.870	1.11	0.836	1.09
1.4	1.01	1.28	1.07	1.35	1.01	1.30
1.5	1.28	1.62	1.36	1.71	1.26	1.62
1.6	1.73	2.15	1.83	2.28	1.68	2.13
1.7	3.20	3.92	3.43	4.20	3.05	3.76
1.8	9.06	11.0	9.66	11.7	9.18	11.0
1.9	30.4	37.1	31.6	38.7	33.5	40.1

TYPICAL VALUES OF CORE LOSS

AT 50 AND 60 Hz FOR TYPICAL EPSTEIN SPECIMENS OF AK STEEL ORIENTED CARLITE COATED ELECTRICAL STEELS

Flux Density (T)	Core Loss (W/kg) - ASTM A343							
	0.23 mm M-3 CARLITE GOES		0.27 mm M-4/120 CARLITE GOES		0.27 mm M-4/125 CARLITE GOES		0.30 mm M-5/125 CARLITE GOES	
	50 Hz	60 Hz	50 Hz	60 Hz	50 Hz	60 Hz	50 Hz	60 Hz
0.1	0.00339	0.00443	0.00417	0.00550	0.00464	0.00608	0.00435	0.00579
0.2	0.0128	0.0168	0.0156	0.0206	0.0170	0.0224	0.0165	0.0220
0.3	0.0280	0.0367	0.0337	0.0445	0.0364	0.0479	0.0360	0.0480
0.4	0.0490	0.0640	0.0581	0.0762	0.0623	0.0819	0.0623	0.0831
0.5	0.0756	0.0986	0.0887	0.117	0.0945	0.124	0.0954	0.127
0.6	0.108	0.140	0.125	0.165	0.133	0.174	0.135	0.180
0.7	0.145	0.189	0.168	0.221	0.177	0.232	0.182	0.241
0.8	0.188	0.245	0.216	0.284	0.228	0.299	0.235	0.312
0.9	0.237	0.308	0.271	0.356	0.285	0.374	0.296	0.391
1.0	0.290	0.378	0.333	0.437	0.349	0.457	0.364	0.481
1.1	0.350	0.456	0.401	0.527	0.420	0.550	0.439	0.580
1.2	0.417	0.543	0.477	0.628	0.498	0.654	0.523	0.691
1.3	0.492	0.640	0.563	0.740	0.588	0.771	0.617	0.815
1.4	0.579	0.753	0.662	0.870	0.689	0.904	0.725	0.957
1.5	0.685	0.887	0.779	1.02	0.810	1.06	0.85	1.12
1.6	0.824	1.06	0.928	1.21	0.966	1.26	1.01	1.32
1.7	1.03	1.32	1.15	1.48	1.19	1.53	1.22	1.60
1.8	1.39	1.76	1.50	1.92	1.55	1.98	1.56	2.02
1.9	1.82	2.28	1.86	2.39	1.95	2.48	1.95	2.50

Flux Density (T)	Core Loss (W/kg) - ASTM A343					
	0.30 mm M-5/130 CARLITE GOES		0.30 mm M-5/140 CARLITE GOES		0.35 mm M-6 CARLITE GOES	
	50 Hz	60 Hz	50 Hz	60 Hz	50 Hz	60 Hz
0.1	0.00430	0.00574	0.00470	0.00623	0.00553	0.00737
0.2	0.0165	0.0221	0.0177	0.0235	0.0203	0.0272
0.3	0.0362	0.0483	0.0383	0.0510	0.0435	0.0583
0.4	0.0628	0.0839	0.0662	0.0879	0.0745	0.0999
0.5	0.0963	0.128	0.101	0.134	0.113	0.151
0.6	0.137	0.181	0.143	0.189	0.159	0.213
0.7	0.184	0.244	0.191	0.253	0.212	0.284
0.8	0.238	0.315	0.247	0.327	0.274	0.365
0.9	0.299	0.396	0.310	0.410	0.343	0.456
1.0	0.367	0.486	0.381	0.503	0.420	0.558
1.1	0.444	0.587	0.459	0.606	0.506	0.671
1.2	0.528	0.698	0.547	0.721	0.601	0.797
1.3	0.623	0.824	0.644	0.850	0.707	0.937
1.4	0.732	0.966	0.756	0.995	0.826	1.09
1.5	0.860	1.13	0.887	1.17	0.962	1.27
1.6	1.02	1.34	1.05	1.38	1.13	1.49
1.7	1.24	1.62	1.29	1.67	1.35	1.78
1.8	1.58	2.04	1.66	2.13	1.69	2.21
1.9	1.97	2.54	2.07	2.65	2.08	2.69

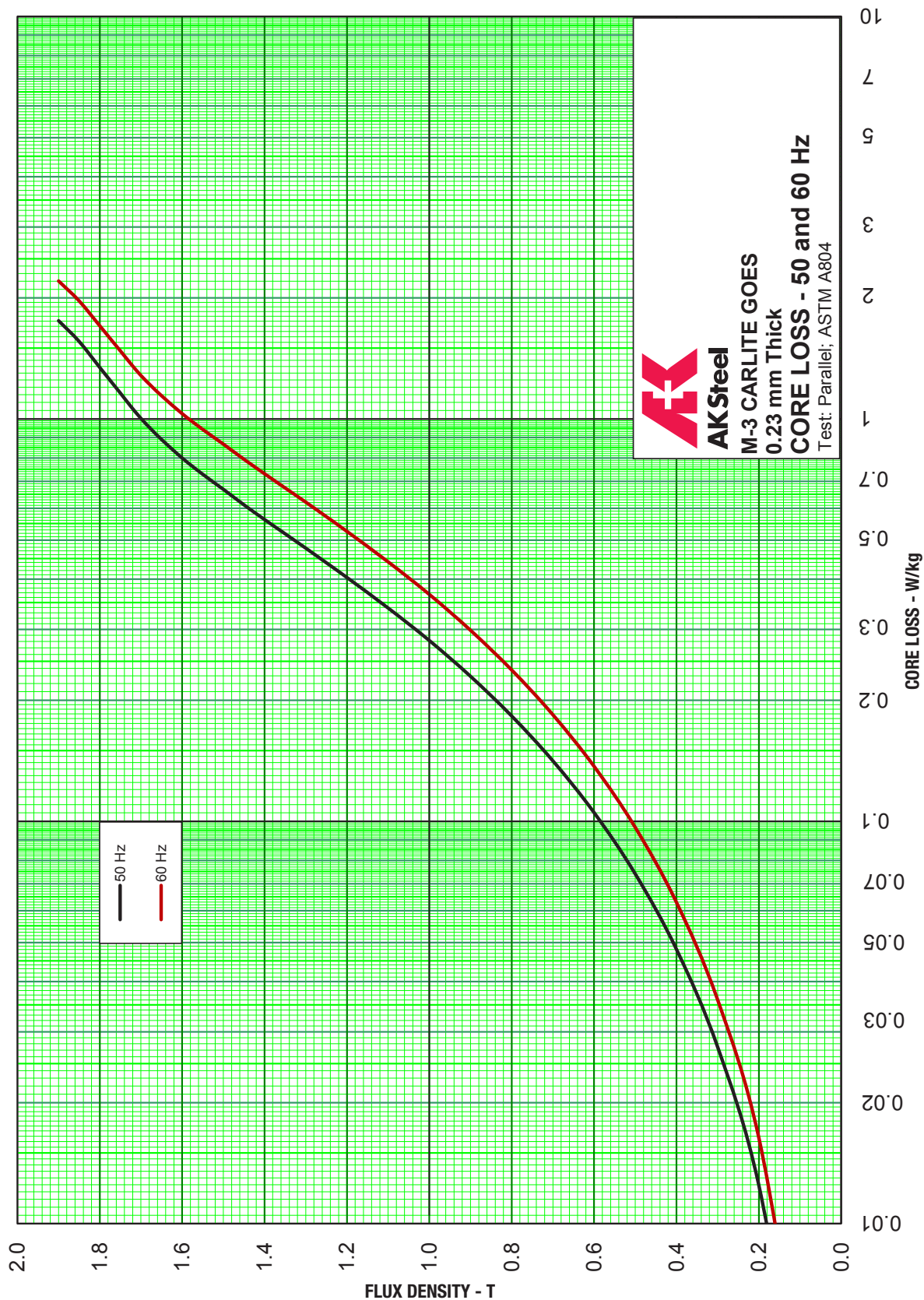
TYPICAL VALUES OF RMS EXCITING POWER

AT 50 AND 60 Hz FOR TYPICAL EPSTEIN SPECIMENS OF AK STEEL ORIENTED CARLITE COATED ELECTRICAL STEELS

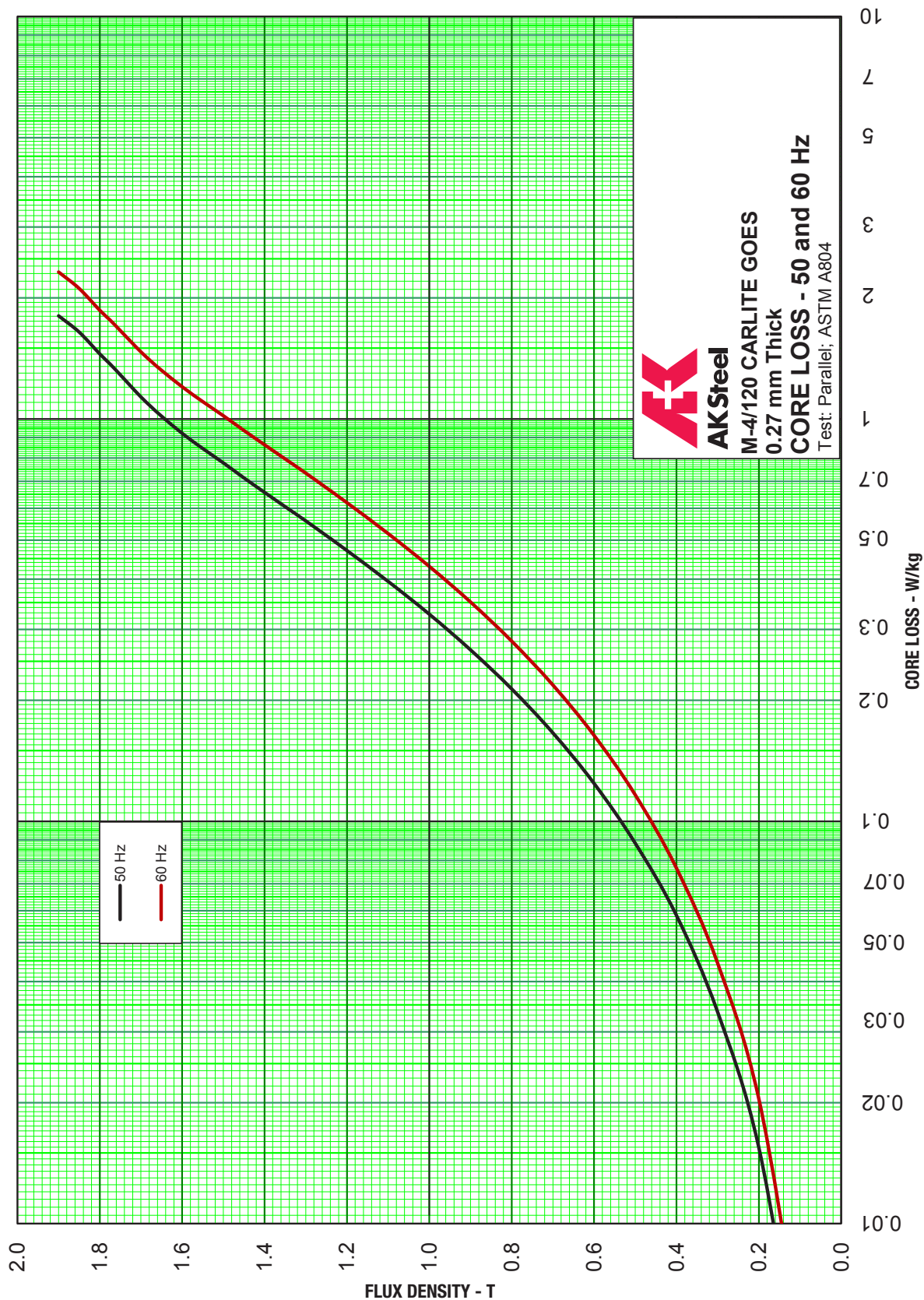
Flux Density (T)	Exciting Power (rms VA/kg) - ASTM A343							
	0.23 mm M-3 CARLITE GOES		0.27 mm M-4/120 CARLITE GOES		0.27 mm M-4/125 CARLITE GOES		0.30 mm M-5/125 CARLITE GOES	
	50 Hz	60 Hz	50 Hz	60 Hz	50 Hz	60 Hz	50 Hz	60 Hz
0.1	0.00910	0.0111	0.00934	0.0116	0.0101	0.0124	0.00871	0.0109
0.2	0.0306	0.0376	0.0312	0.0389	0.0332	0.0412	0.0294	0.0371
0.3	0.0614	0.0756	0.0624	0.0781	0.0657	0.0822	0.0596	0.0754
0.4	0.0991	0.122	0.101	0.127	0.106	0.132	0.0972	0.124
0.5	0.142	0.176	0.145	0.183	0.151	0.190	0.142	0.181
0.6	0.190	0.236	0.196	0.247	0.203	0.256	0.192	0.246
0.7	0.243	0.302	0.251	0.319	0.259	0.328	0.250	0.320
0.8	0.300	0.374	0.313	0.398	0.322	0.409	0.314	0.403
0.9	0.363	0.454	0.382	0.486	0.391	0.497	0.386	0.496
1.0	0.433	0.542	0.459	0.585	0.468	0.596	0.467	0.600
1.1	0.512	0.641	0.547	0.696	0.555	0.706	0.559	0.719
1.2	0.604	0.756	0.649	0.825	0.656	0.834	0.667	0.856
1.3	0.716	0.895	0.773	0.981	0.777	0.986	0.799	1.02
1.4	0.865	1.08	0.935	1.18	0.934	1.18	0.971	1.24
1.5	1.09	1.35	1.17	1.48	1.16	1.46	1.22	1.55
1.6	1.51	1.85	1.60	1.99	1.57	1.95	1.68	2.09
1.7	2.58	3.12	2.73	3.34	2.65	3.22	2.85	3.50
1.8	7.15	8.60	8.20	9.96	7.89	9.46	8.07	9.83
1.9	32.4	39.0	36.2	44.1	34.7	41.4	33.0	40.5

Flux Density (T)	Exciting Power (rms VA/kg) - ASTM A343					
	0.30 mm M-5/130 CARLITE GOES		0.30 mm M-5/140 CARLITE GOES		0.35 mm M-6 CARLITE GOES	
	50 Hz	60 Hz	50 Hz	60 Hz	50 Hz	60 Hz
0.1	0.00877	0.0109	0.00953	0.0119	0.00867	0.0110
0.2	0.0298	0.0376	0.0318	0.0400	0.0290	0.0373
0.3	0.0605	0.0765	0.0640	0.0807	0.0589	0.0762
0.4	0.0987	0.125	0.104	0.132	0.0970	0.126
0.5	0.144	0.183	0.151	0.192	0.143	0.186
0.6	0.196	0.250	0.205	0.260	0.196	0.256
0.7	0.254	0.325	0.264	0.338	0.256	0.335
0.8	0.319	0.410	0.332	0.425	0.325	0.424
0.9	0.393	0.504	0.408	0.523	0.401	0.524
1.0	0.475	0.611	0.493	0.633	0.487	0.636
1.1	0.570	0.732	0.591	0.757	0.582	0.760
1.2	0.681	0.873	0.706	0.903	0.691	0.902
1.3	0.817	1.04	0.848	1.08	0.820	1.07
1.4	0.997	1.27	1.04	1.31	0.979	1.27
1.5	1.26	1.59	1.31	1.65	1.20	1.54
1.6	1.74	2.16	1.82	2.25	1.57	1.99
1.7	2.96	3.63	3.15	3.85	2.55	3.15
1.8	8.30	10.10	9.26	11.20	7.56	9.10
1.9	32.5	39.7	37.7	45.9	31.6	37.9

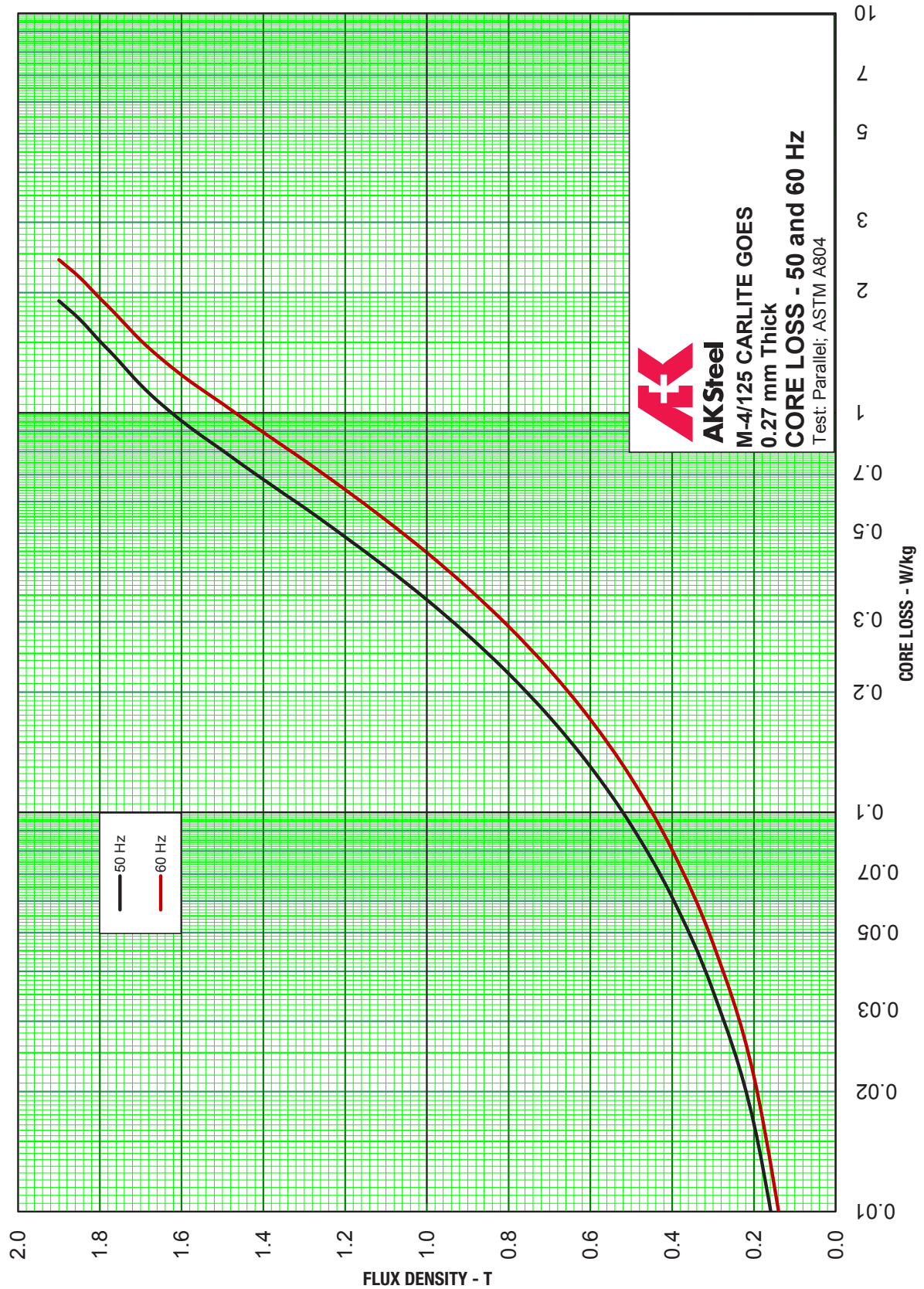
CORE LOSS CURVE – M-3 CARLITE



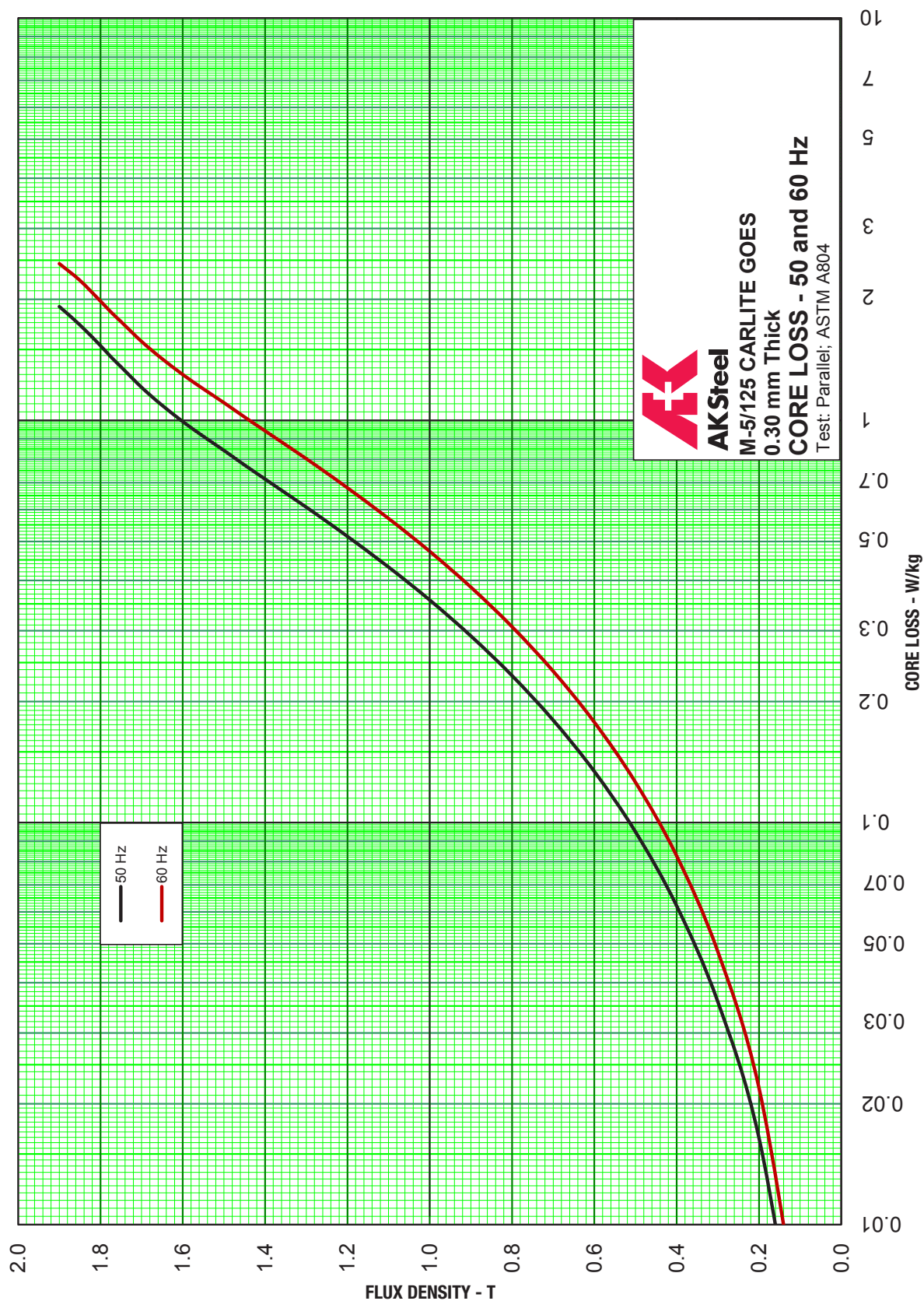
CORE LOSS CURVE – M-4/120 CARLITE



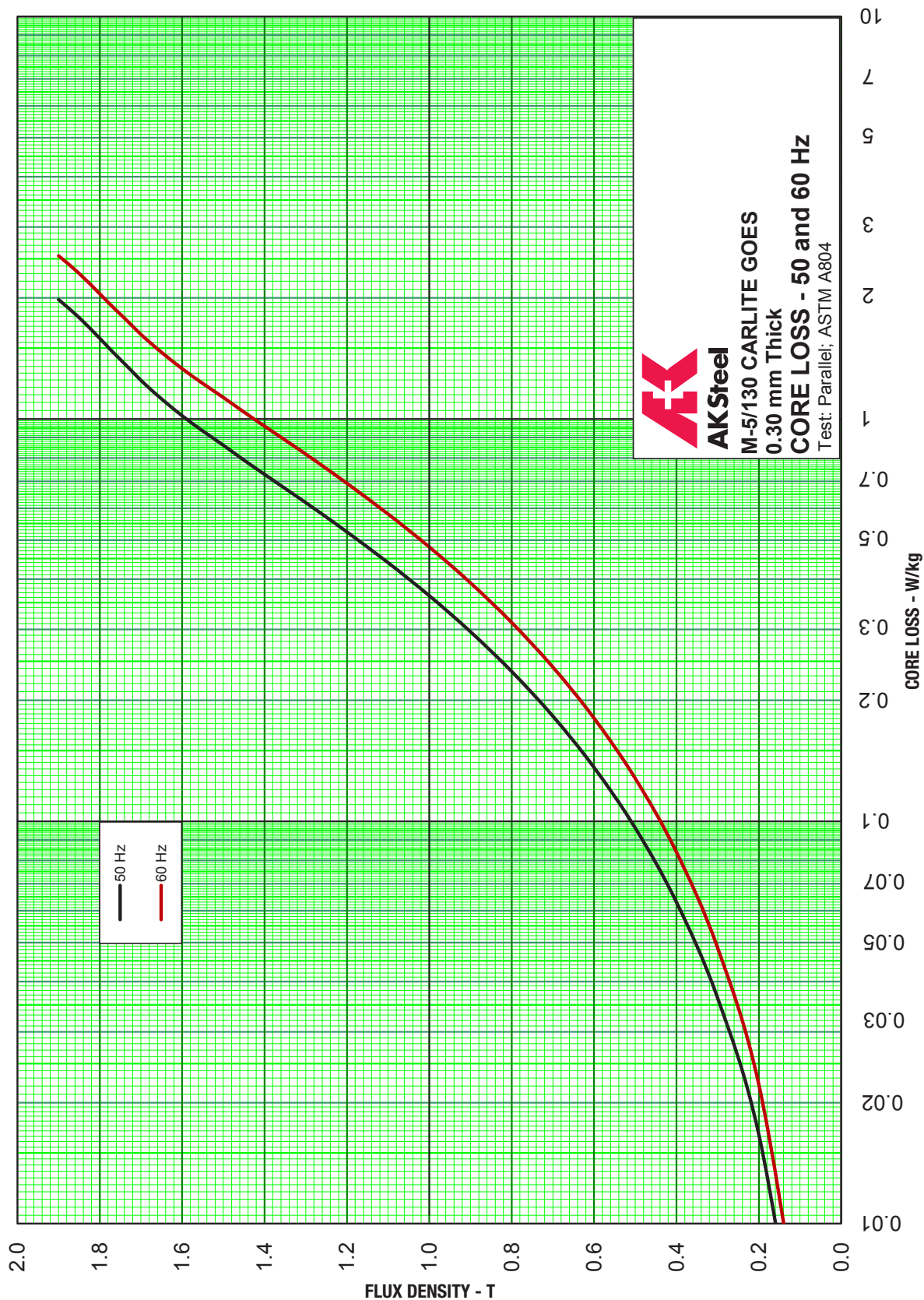
CORE LOSS CURVE – M-4/125 CARLITE



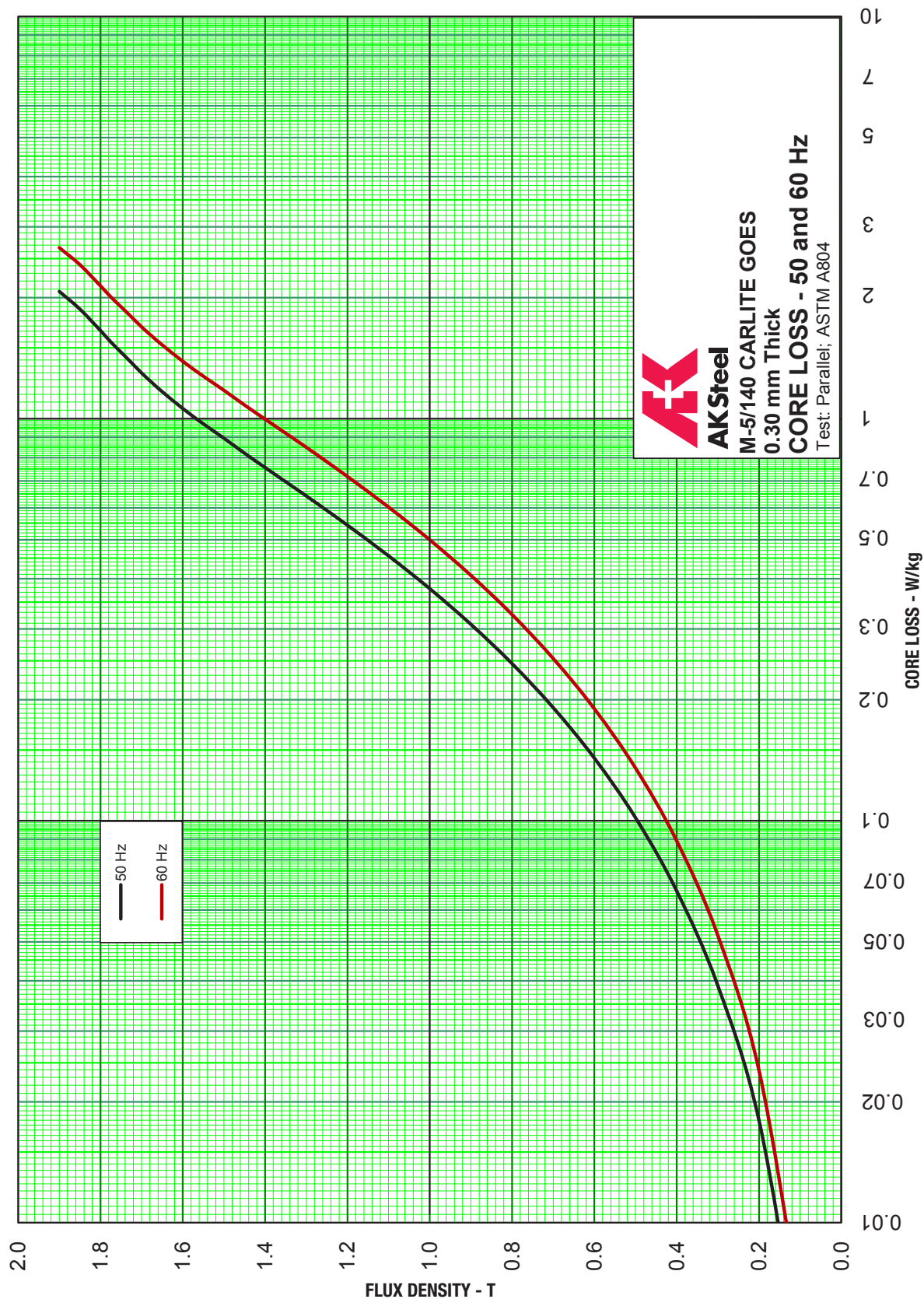
CORE LOSS CURVE – M-5/125 CARLITE



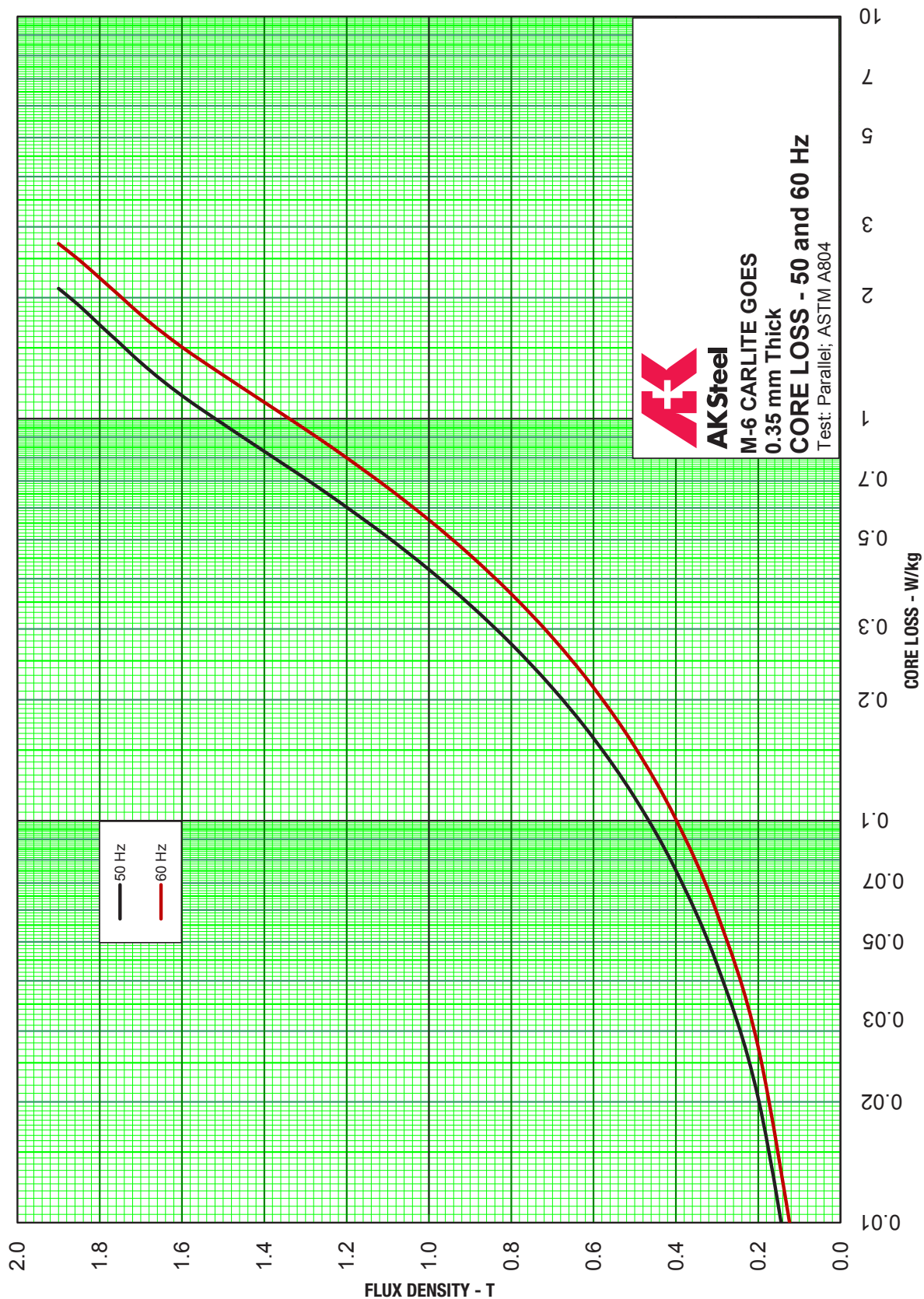
CORE LOSS CURVE – M-5/130 CARLITE



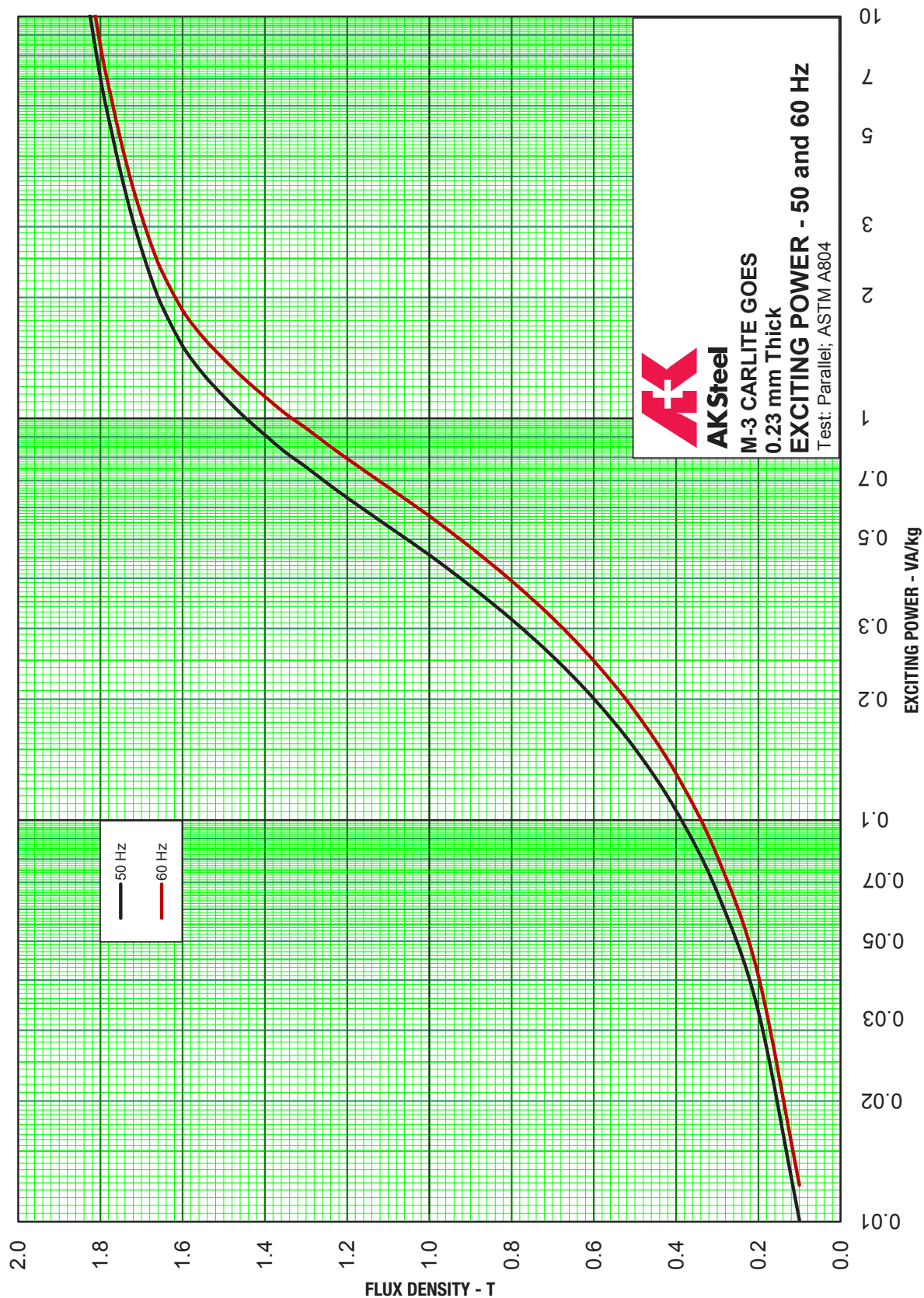
CORE LOSS CURVE – M-5/140 CARLITE



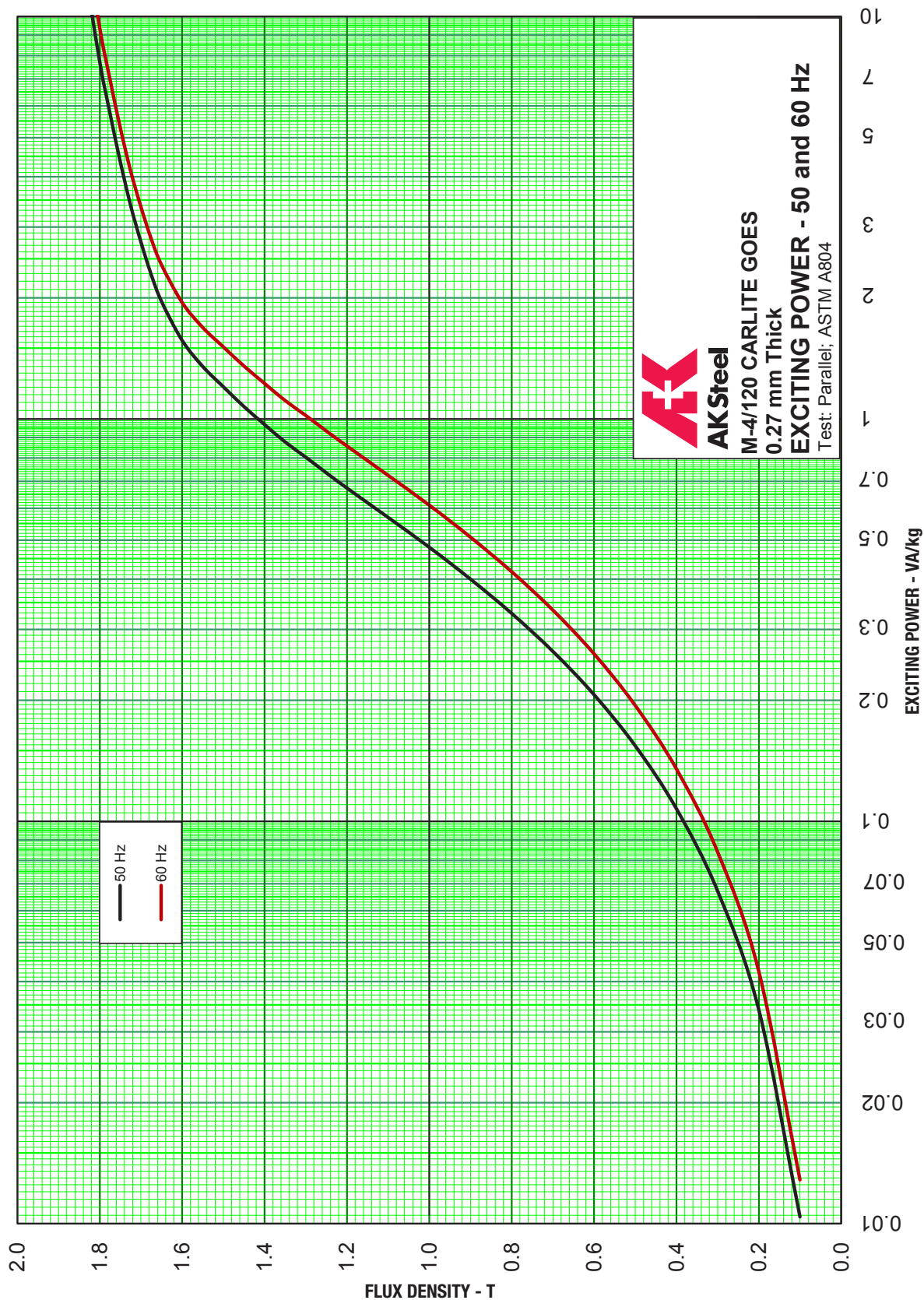
CORE LOSS CURVE – M-6 CARLITE



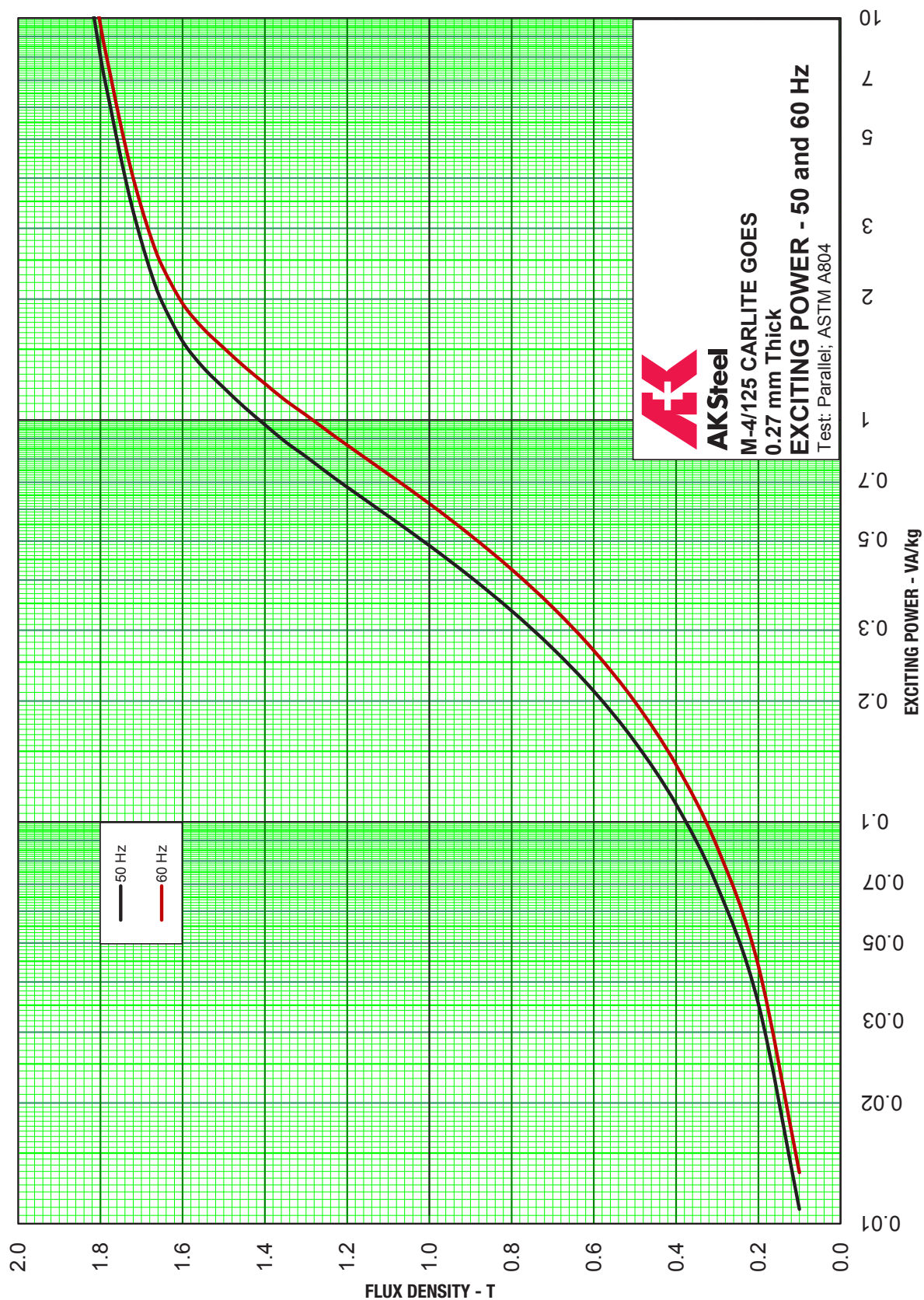
EXCITING POWER CURVE – M-3 CARLITE



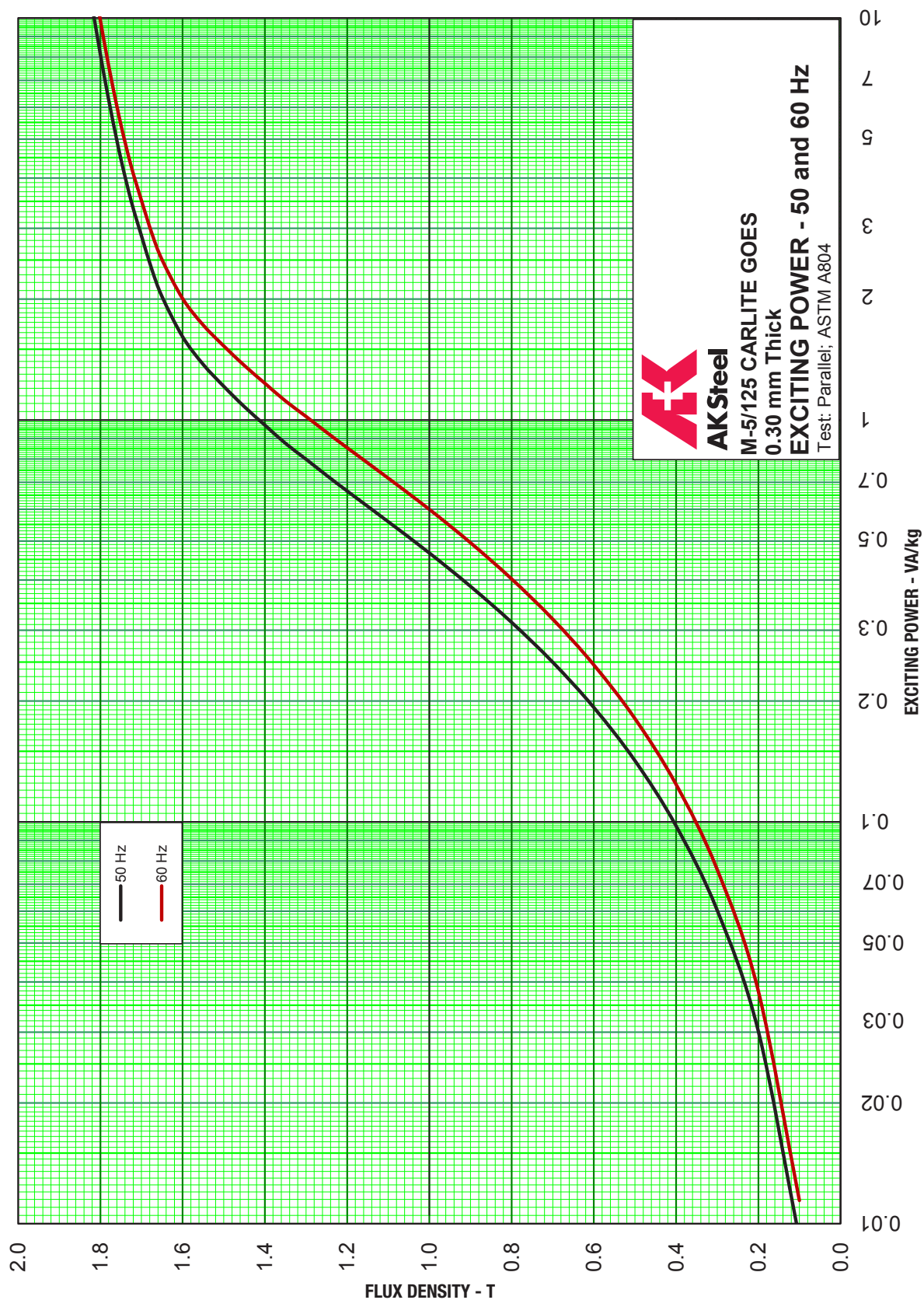
EXCITING POWER CURVE – M-4/120 CARLITE



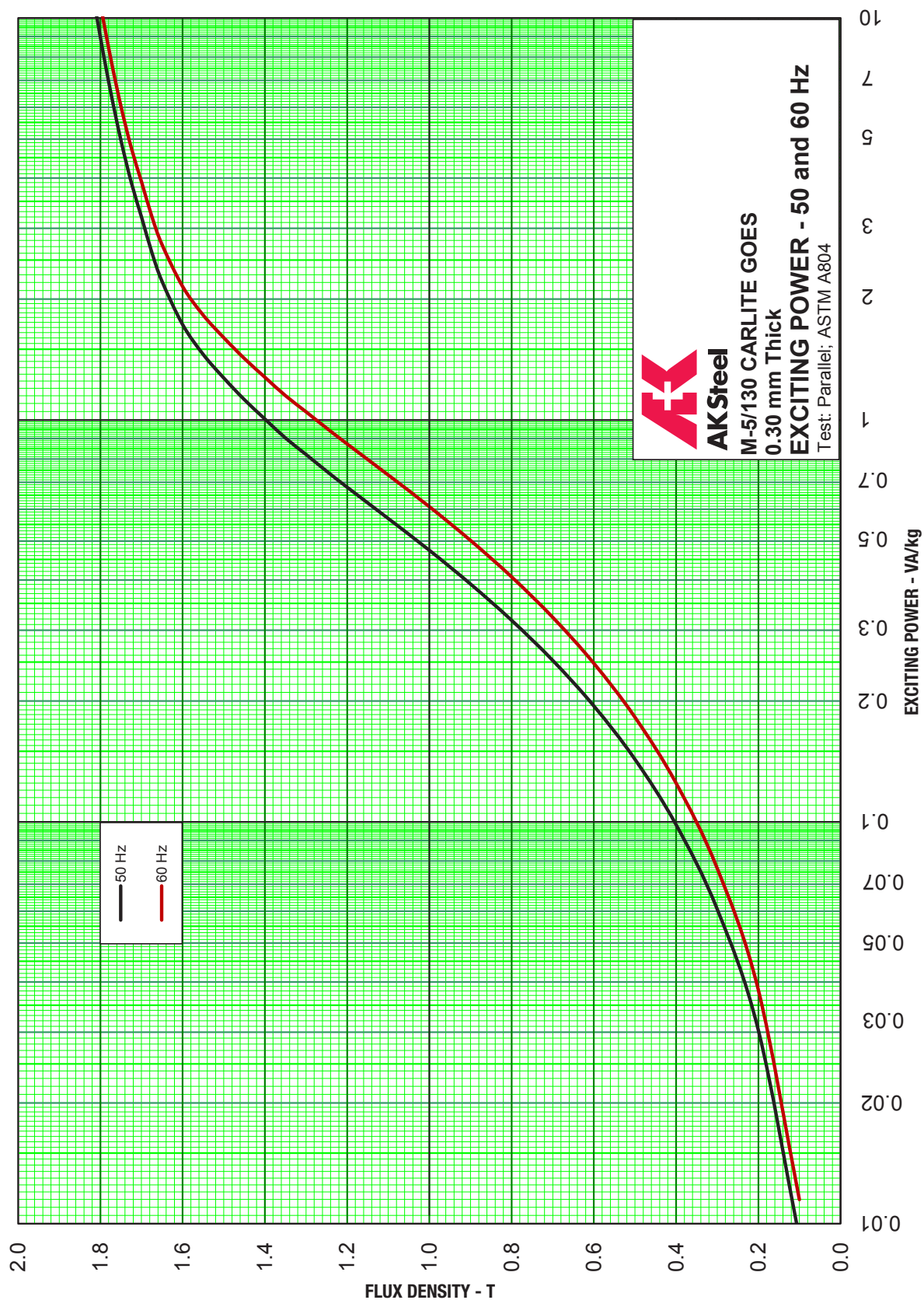
EXCITING POWER CURVE – M-4/125 CARLITE



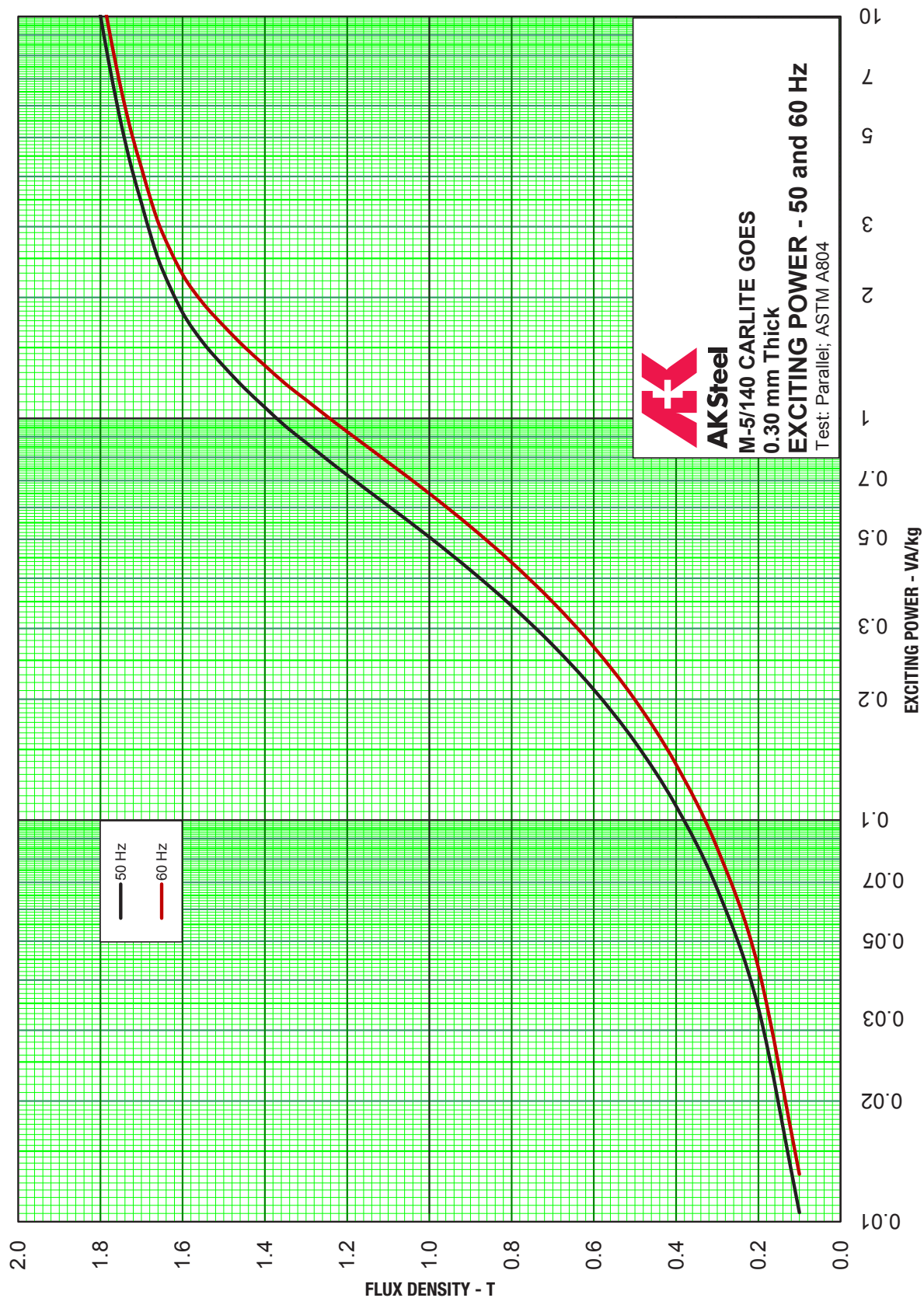
EXCITING POWER CURVE – M-5/125 CARLITE



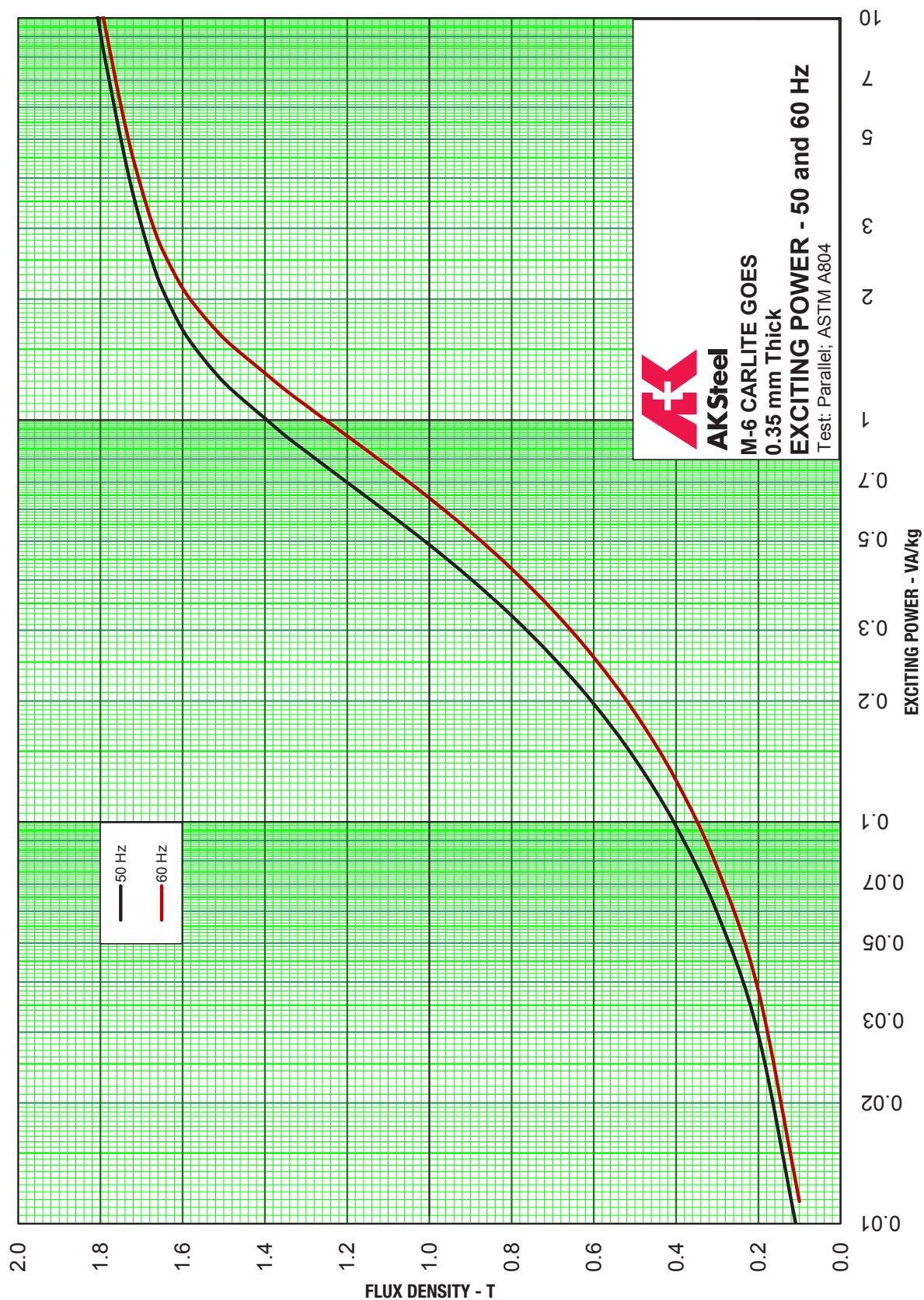
EXCITING POWER CURVE – M-5/130 CARLITE



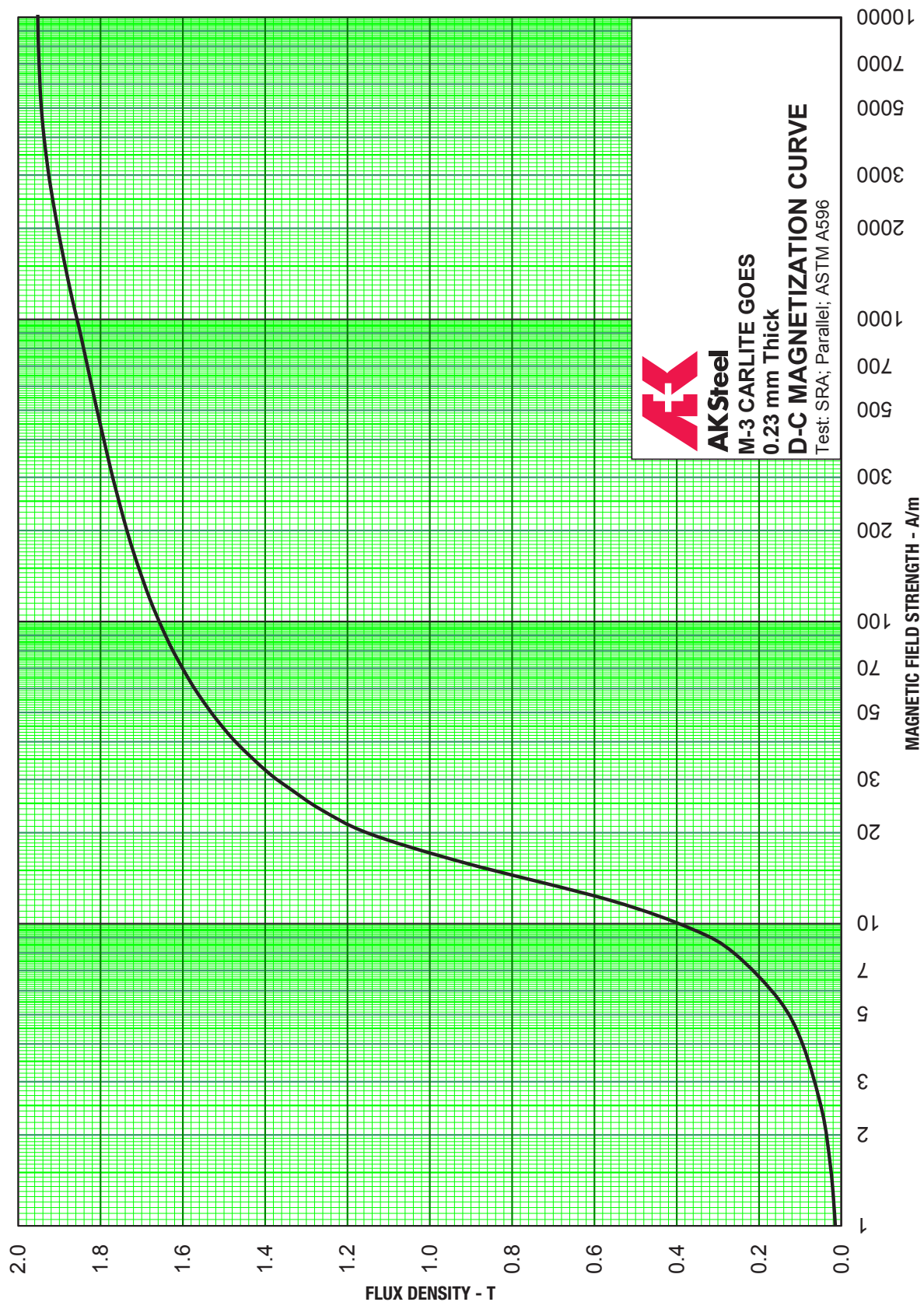
EXCITING POWER CURVE – M-5/140 CARLITE



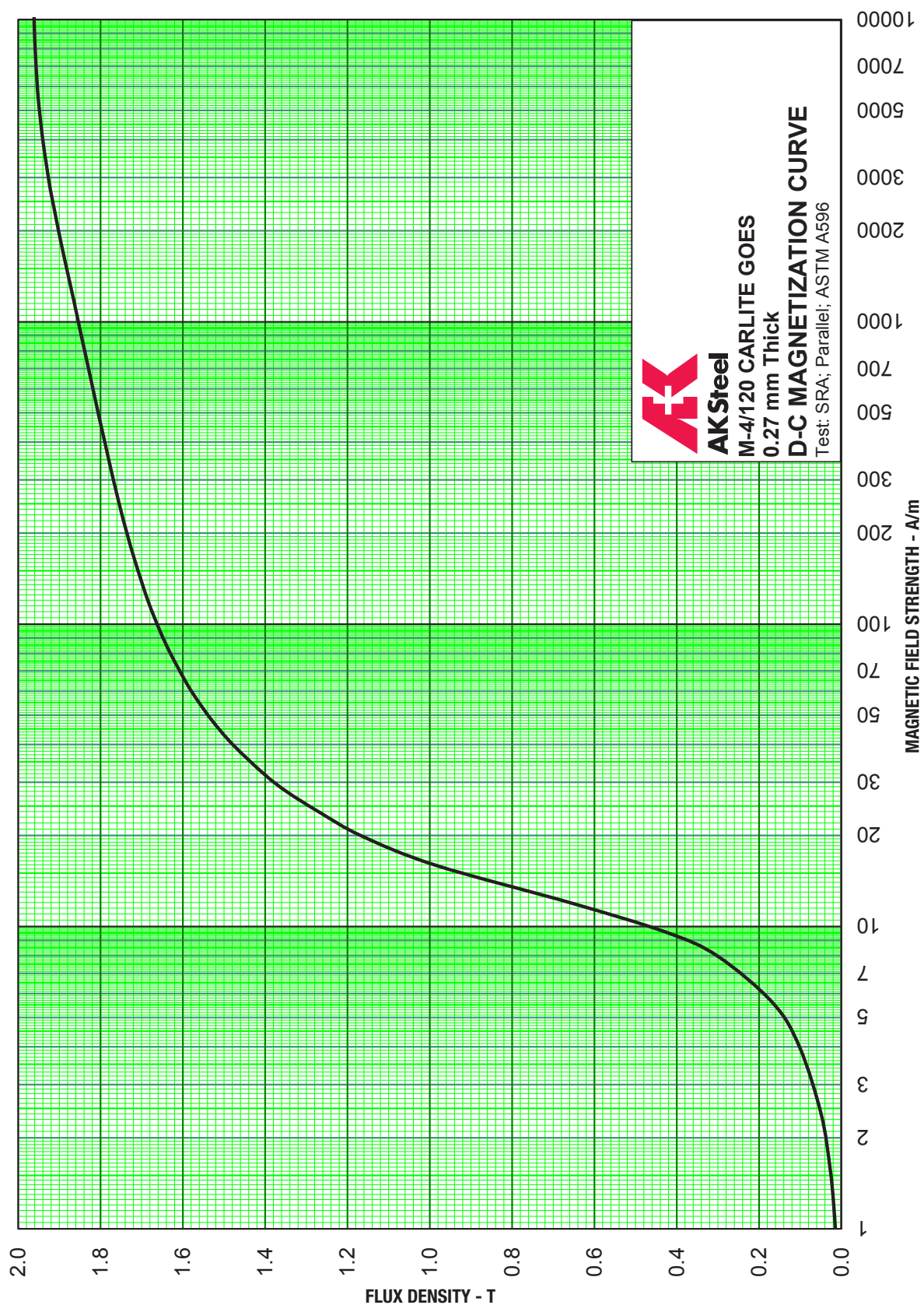
EXCITING POWER CURVE – M-6 CARLITE



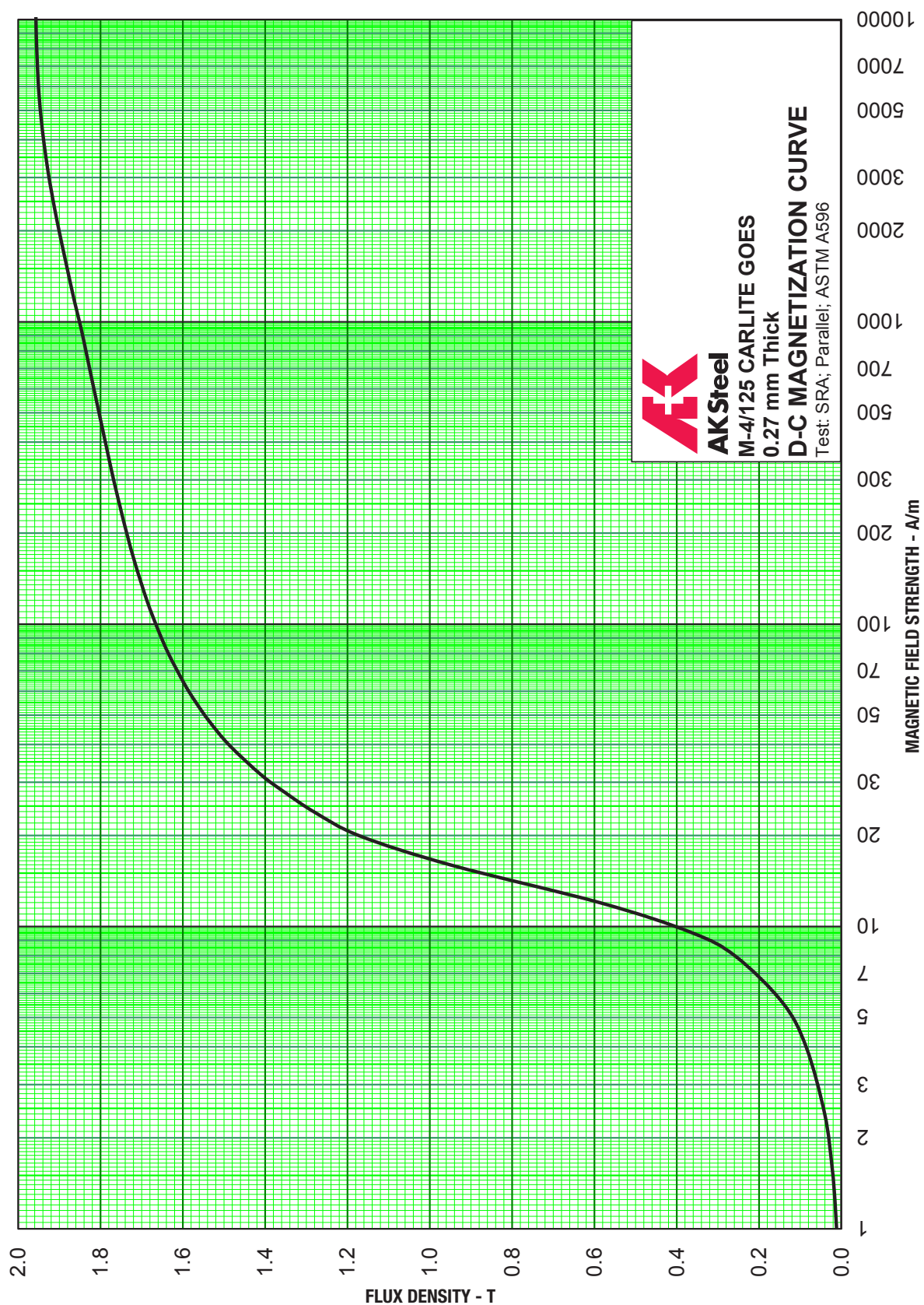
D-C MAGNETIZATION CURVE – M-3 CARLITE



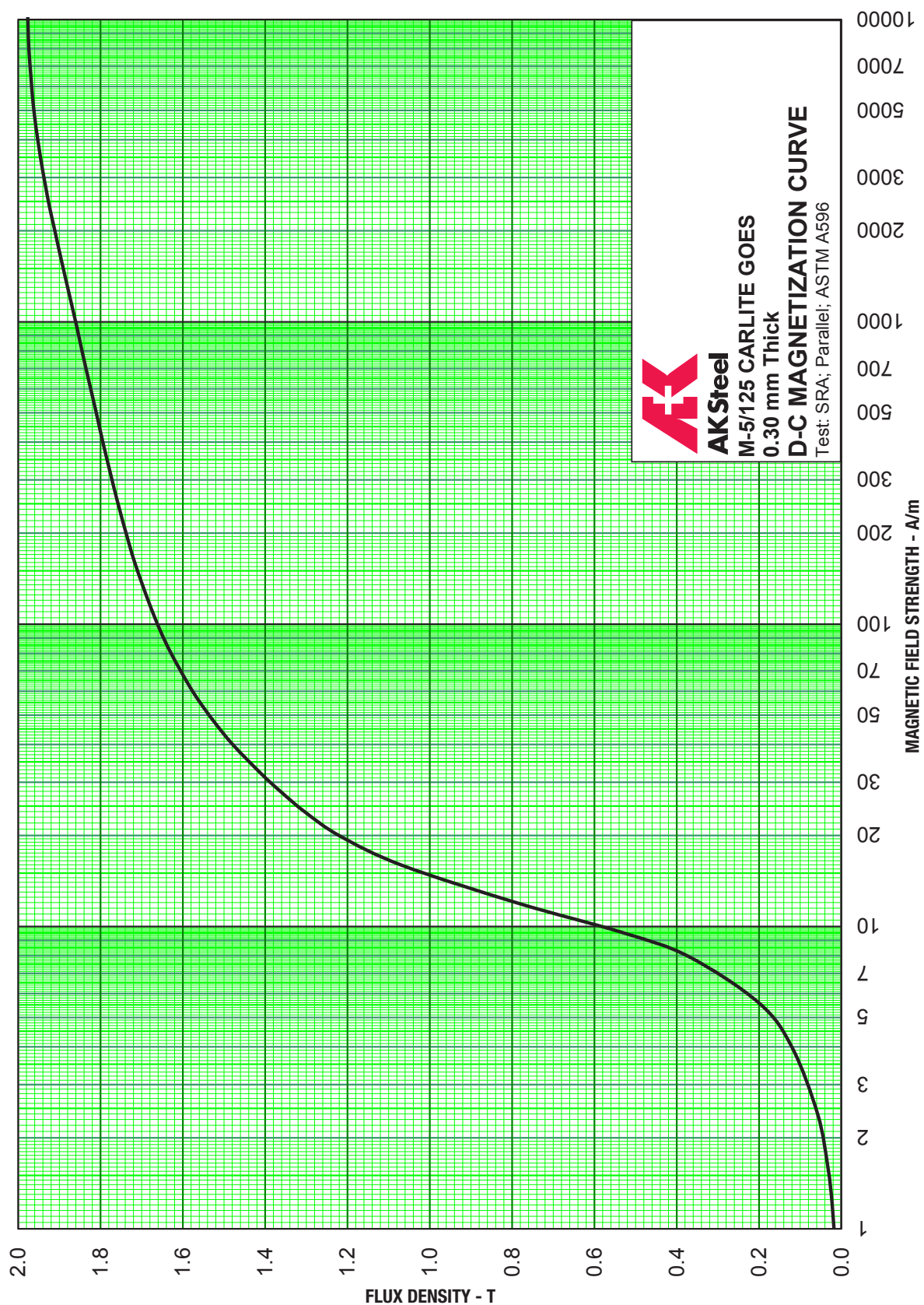
D-C MAGNETIZATION CURVE – M-4/120 CARLITE



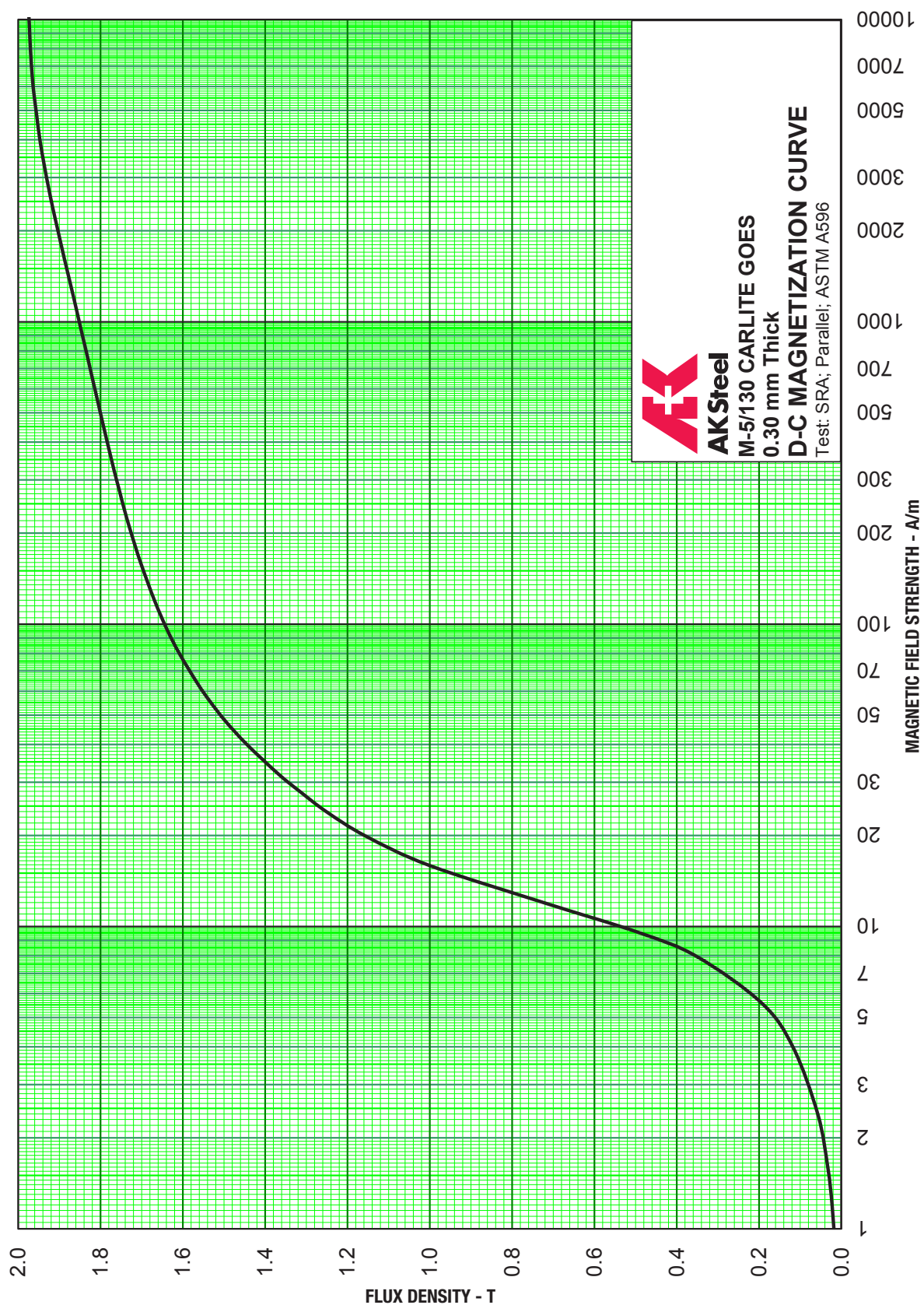
D-C MAGNETIZATION CURVE – M-4/125 CARLITE



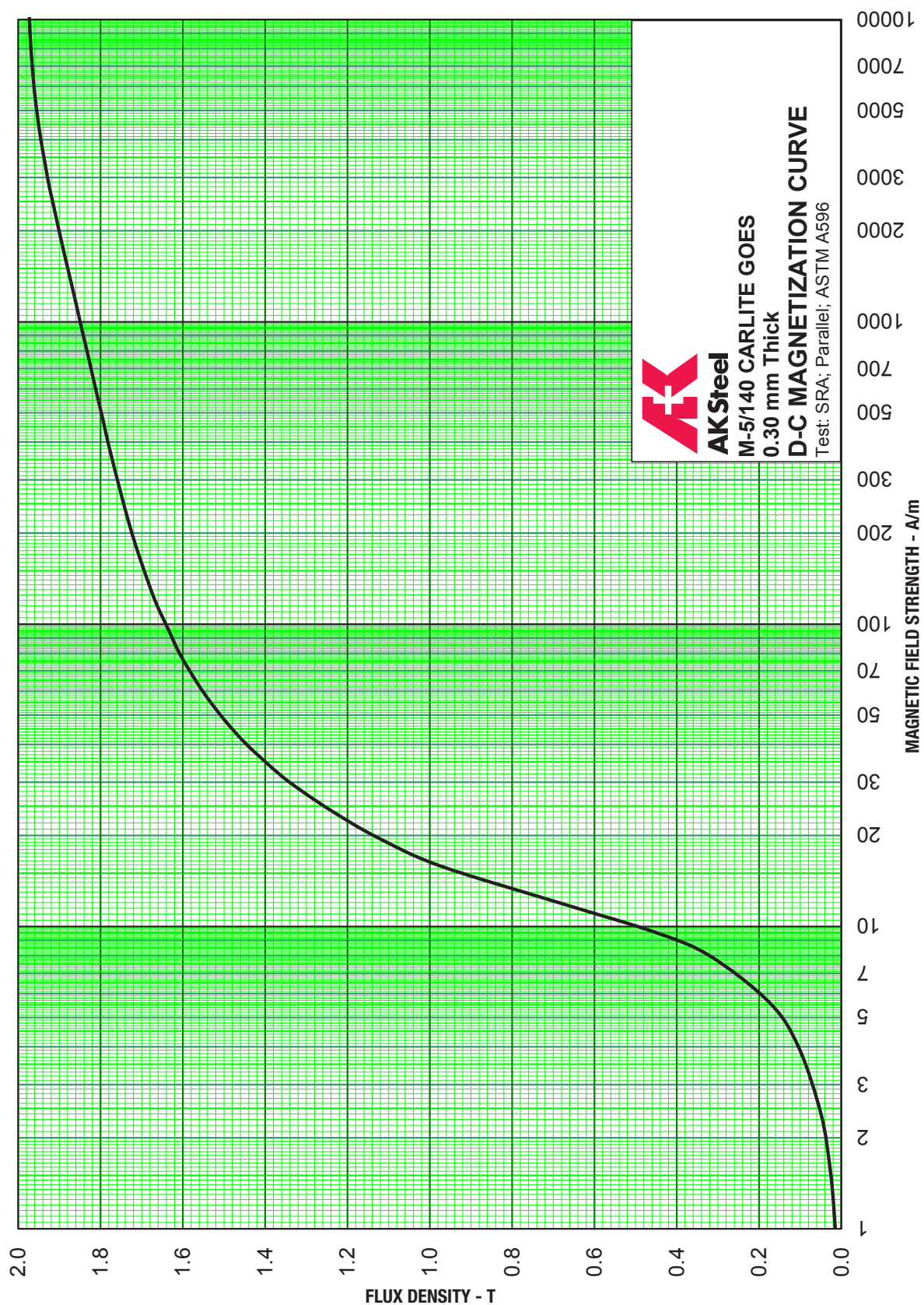
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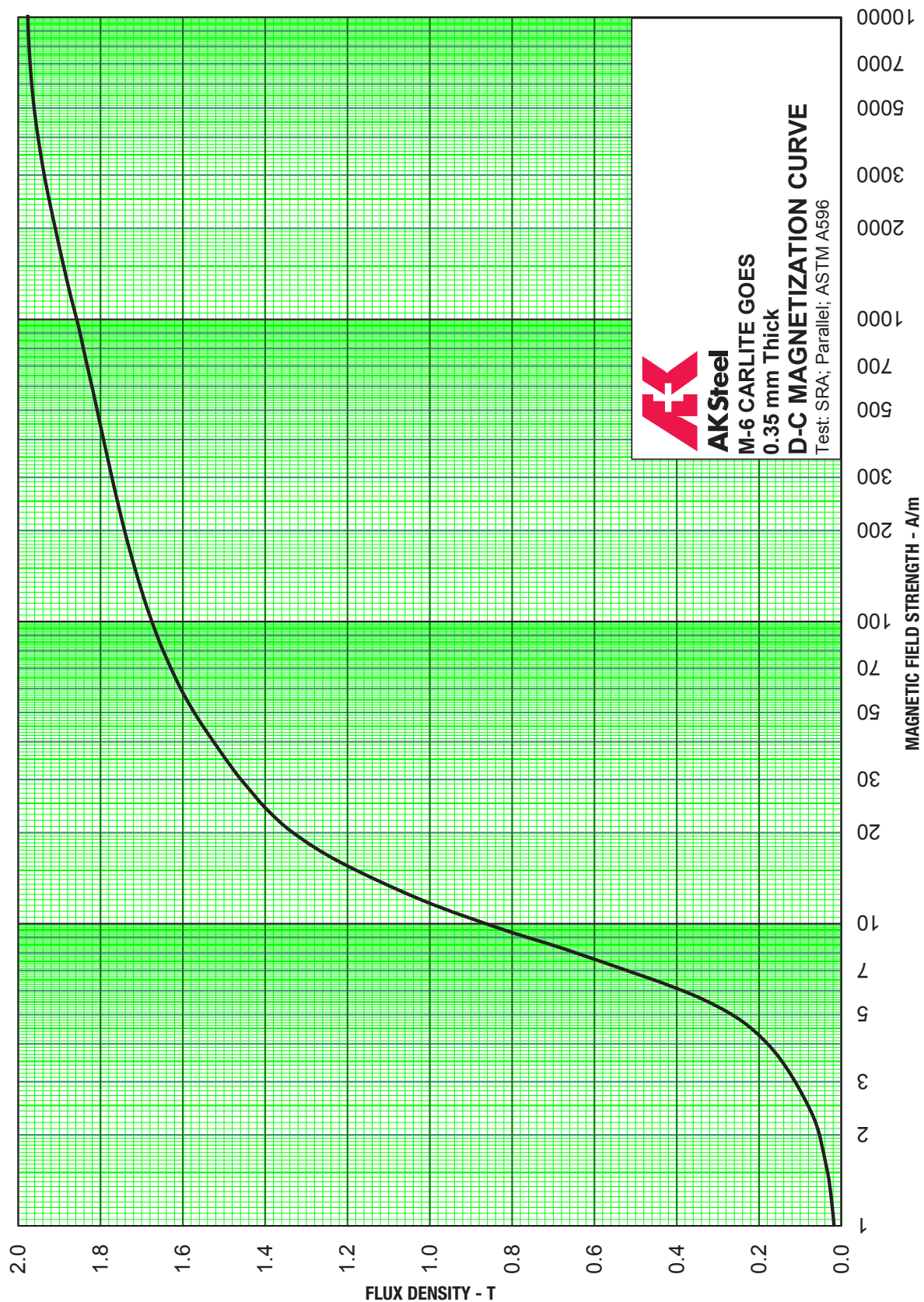
D-C MAGNETIZATION CURVE – M-5/130 CARLITE



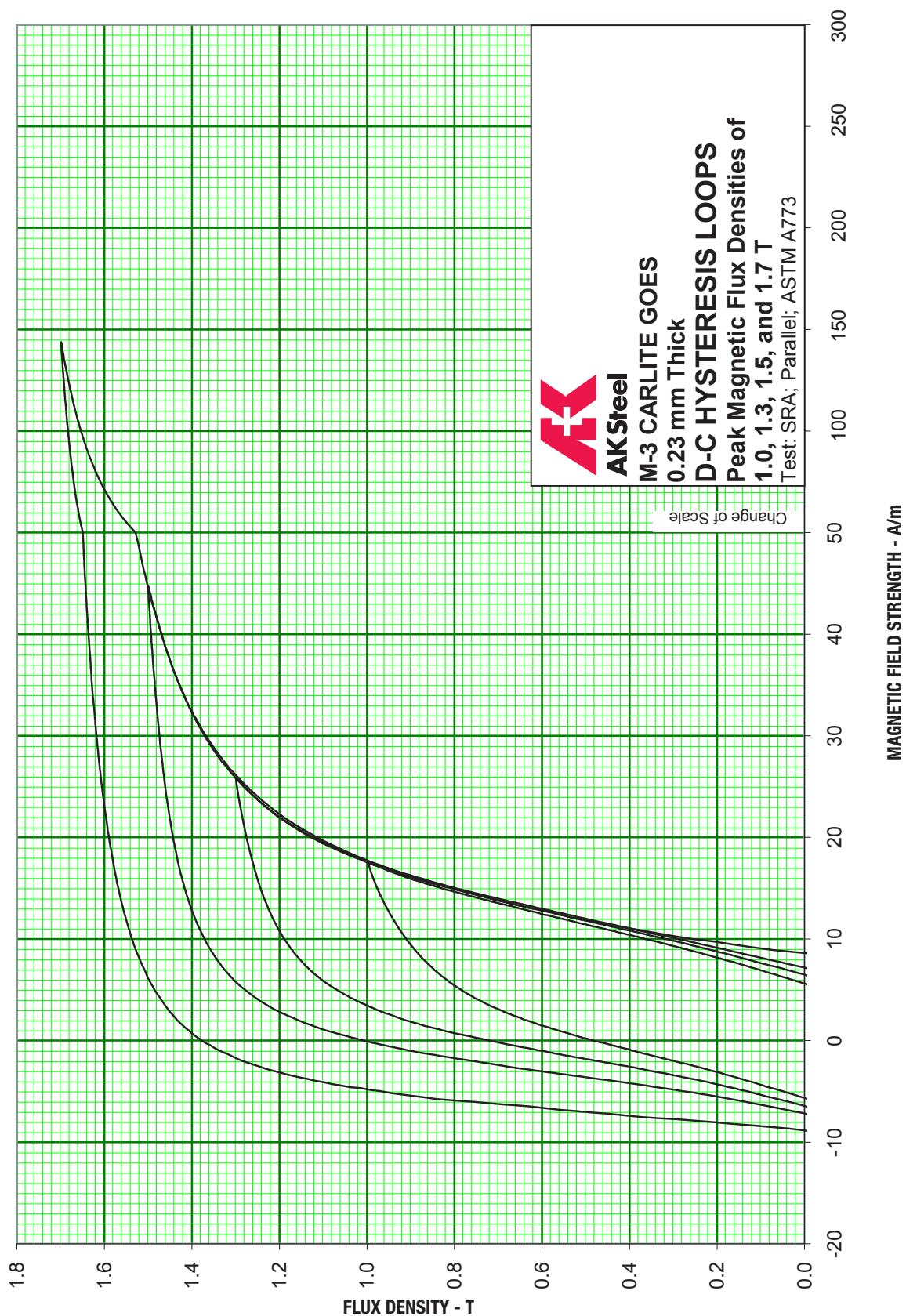
D-C MAGNETIZATION CURVE – M-5/140 CARLITE



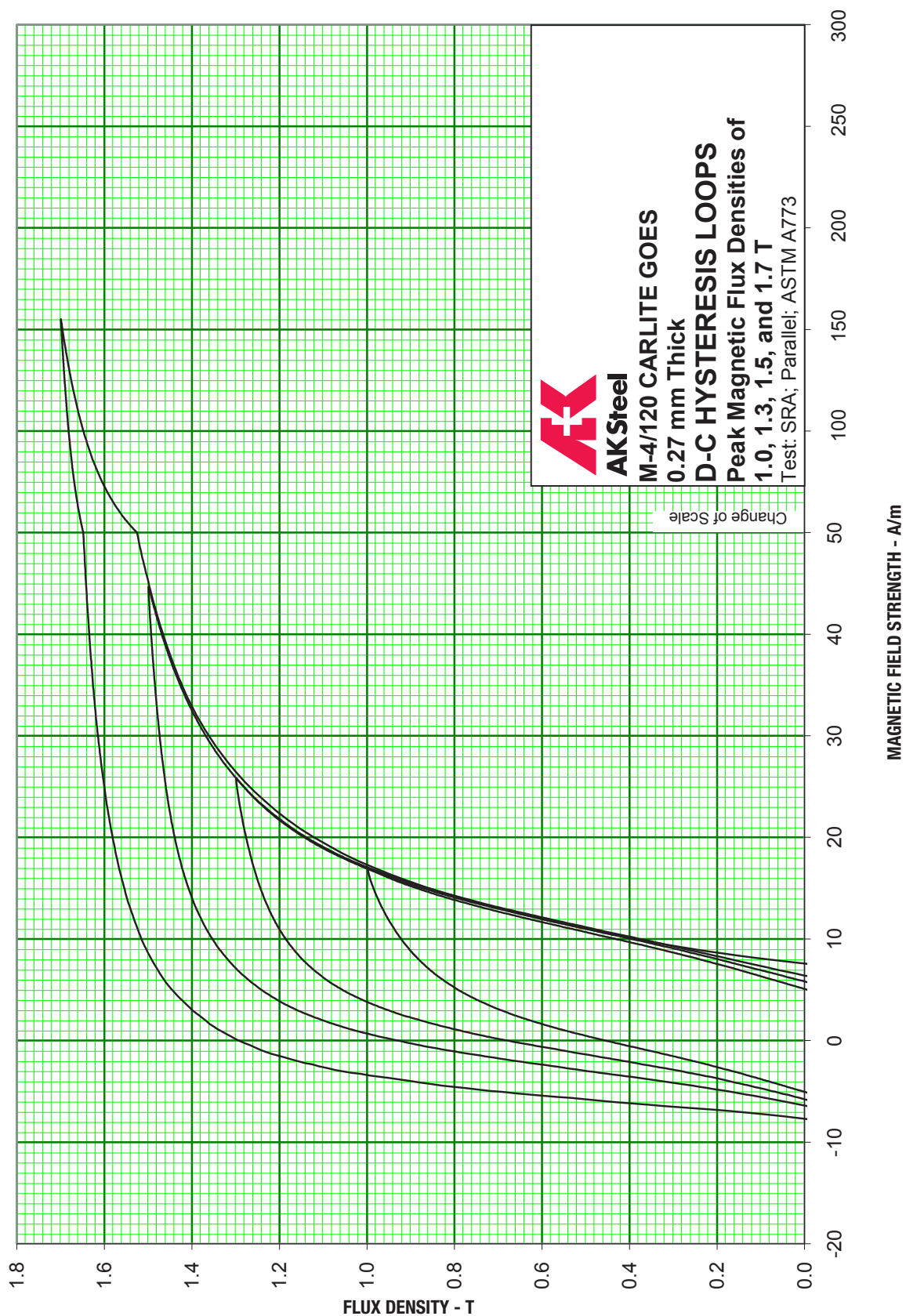
D-C MAGNETIZATION CURVE – M-6 CARLITE



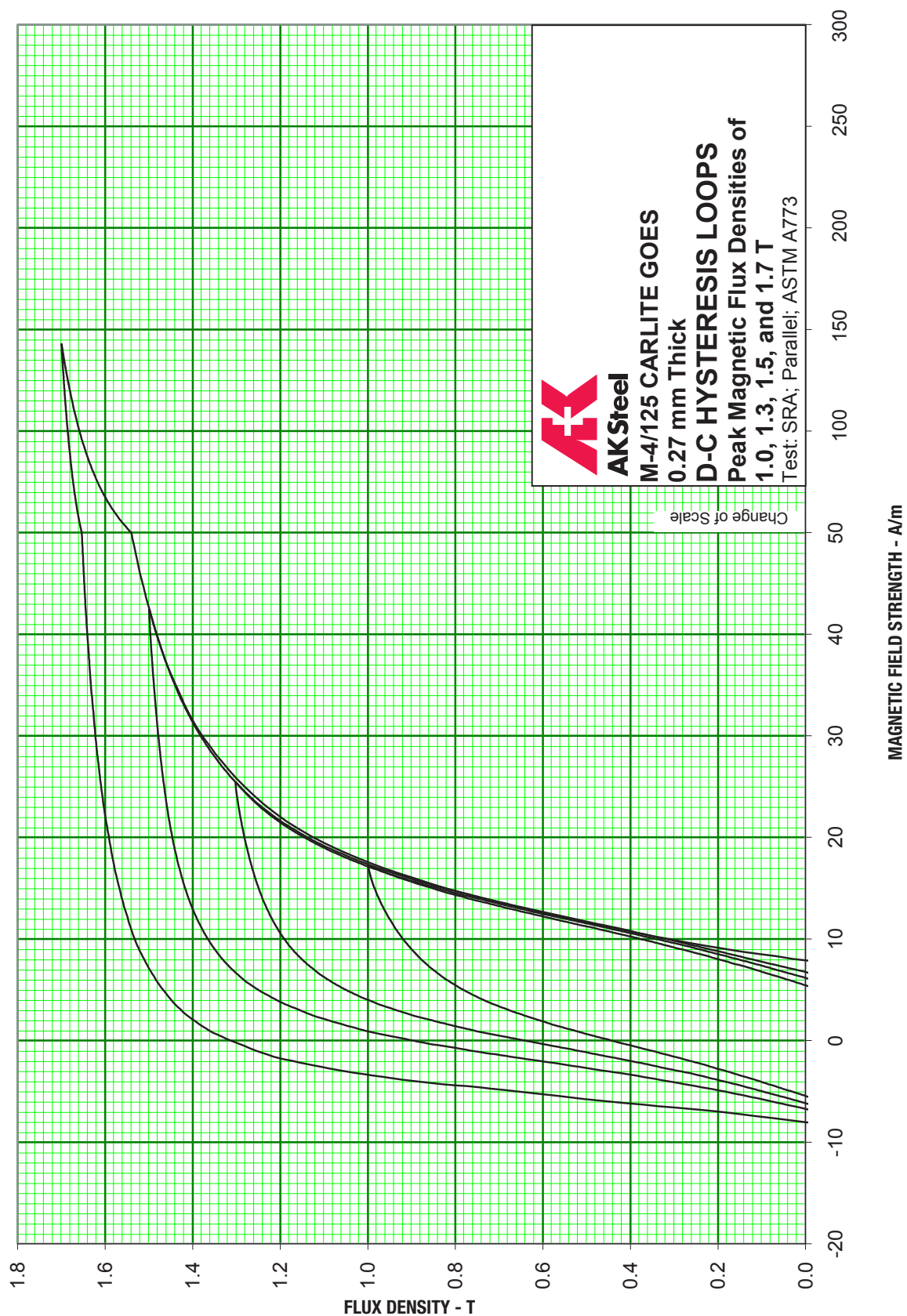
D-C HYSTERESIS LOOPS – M-3 CARLITE



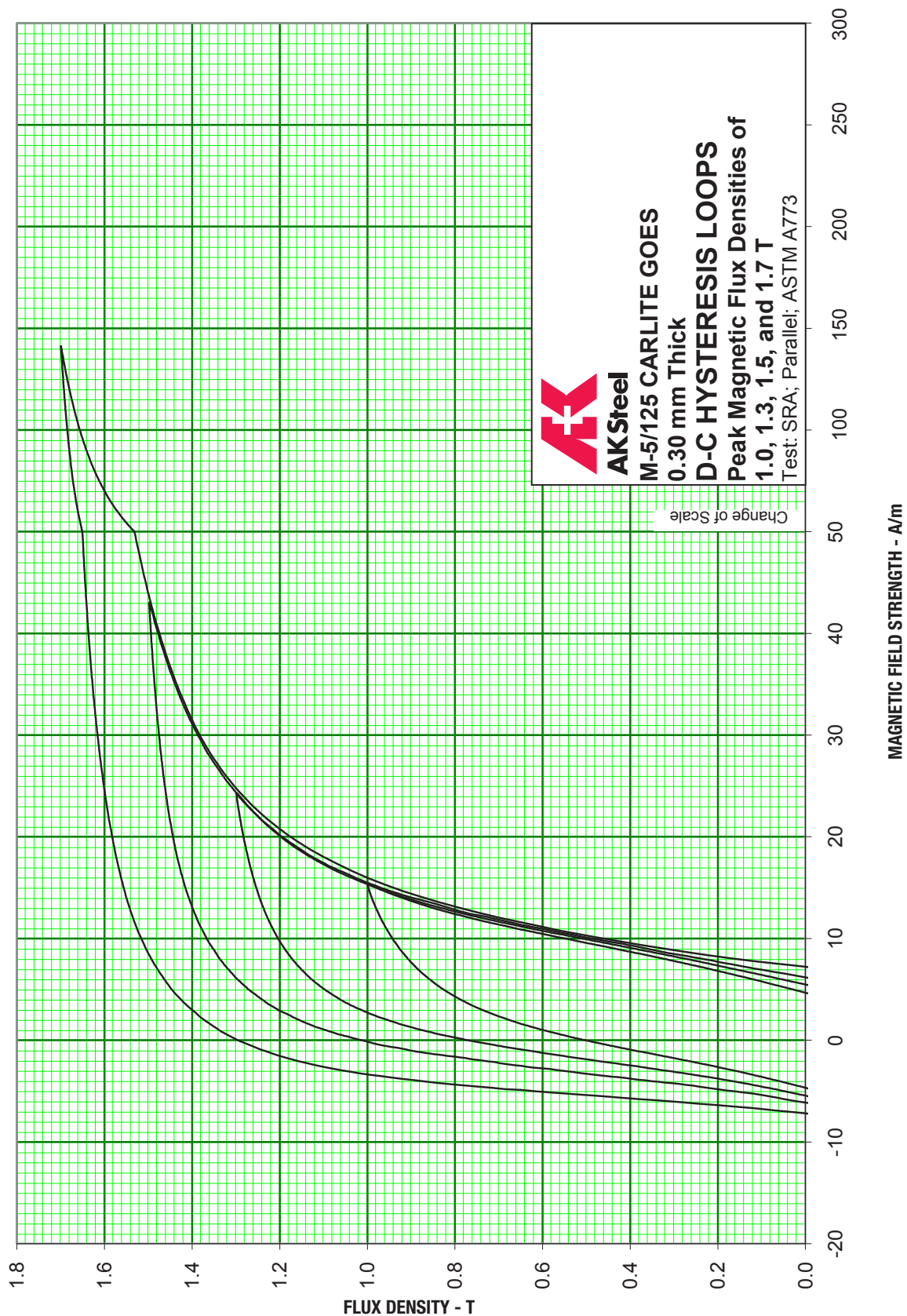
D-C HYSTERESIS LOOPS – M-4/120 CARLITE



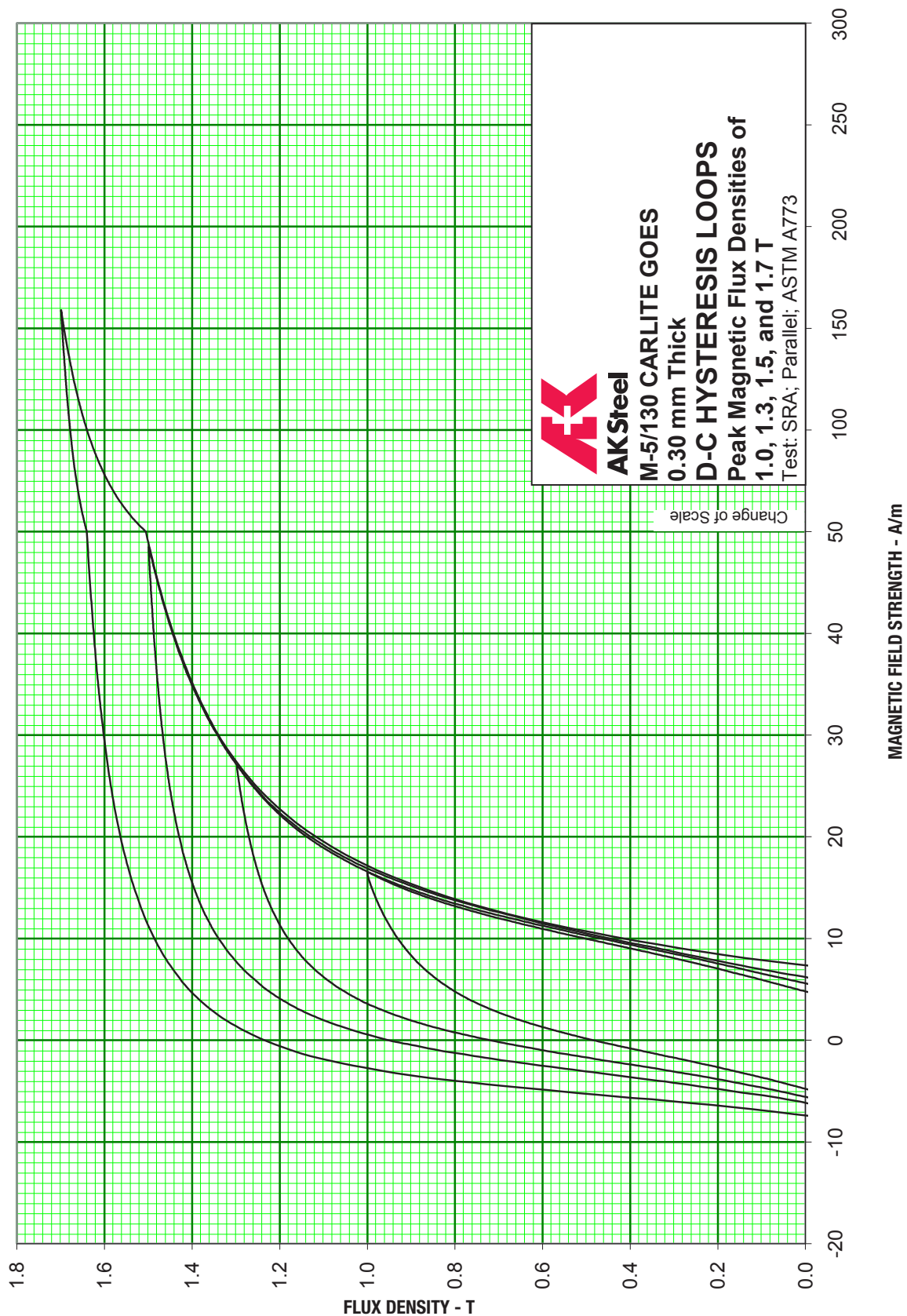
D-C HYSTERESIS LOOPS – M-4/125 CARLITE



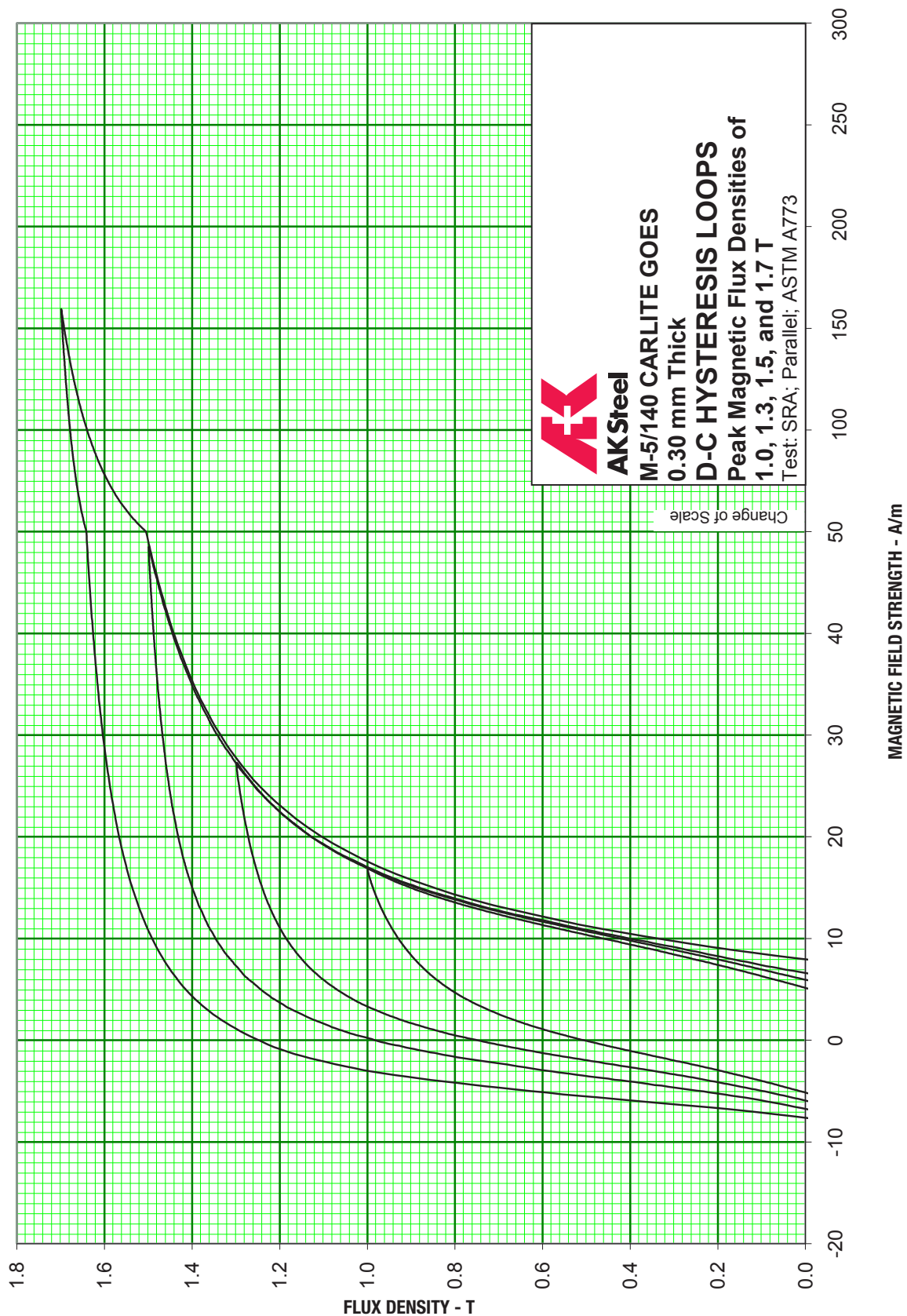
D-C HYSTERESIS LOOPS – M-5/125 CARLITE



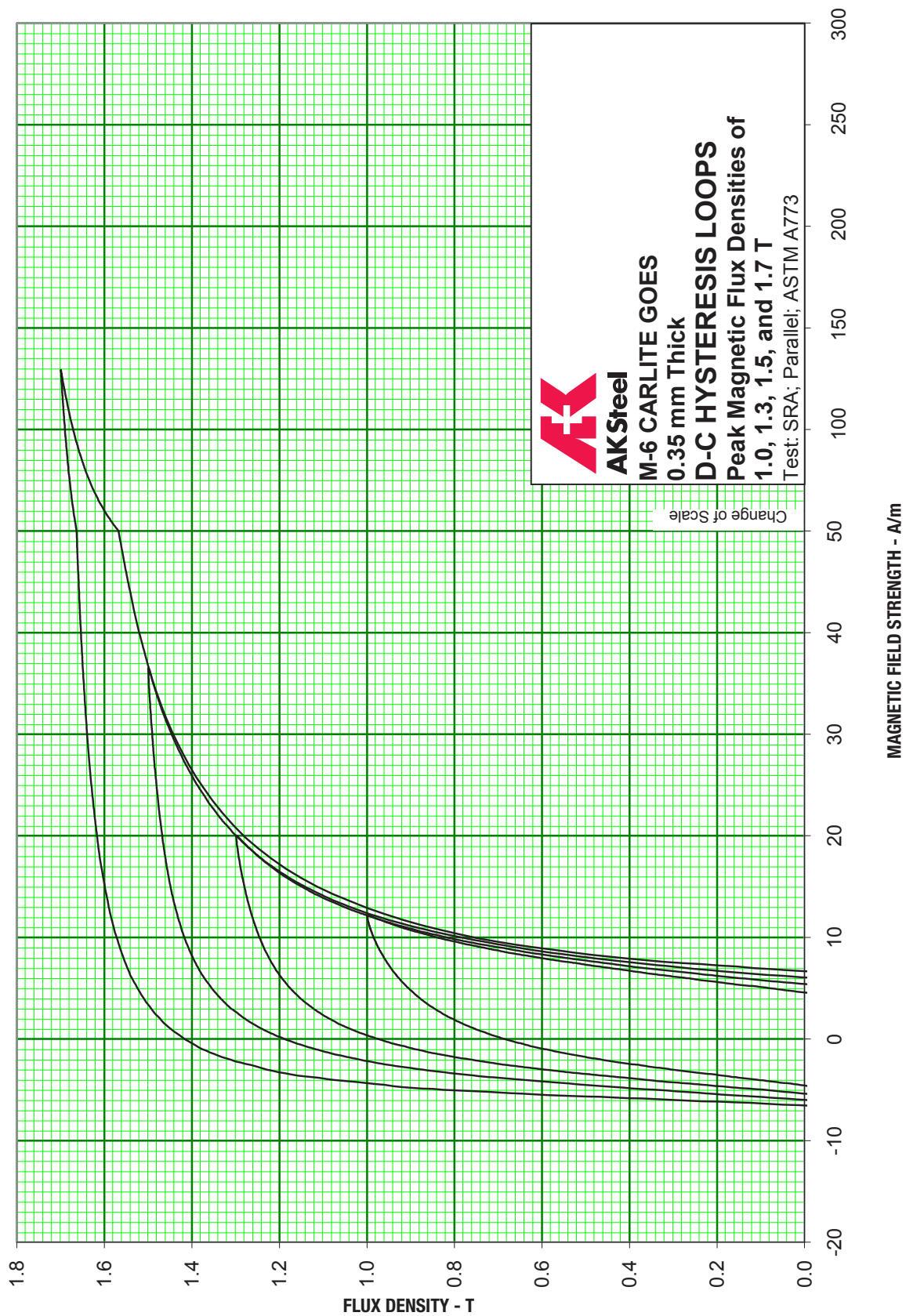
D-C HYSTERESIS LOOPS – M-5/130 CARLITE



D-C HYSTERESIS LOOPS – M-5/140 CARLITE



D-C HYSTERESIS LOOPS – M-6 CARLITE





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Headquartered in West Chester, Ohio, AK Steel is a world leader in the production of flat rolled carbon, stainless and electrical steel products, primarily for automotive, appliance, construction and electrical power generation and distribution markets. The company operates seven steel plants and two tube manufacturing plants across four states – Indiana, Kentucky, Ohio and Pennsylvania. All of the company's steel plants are ISO/TS 16949, ISO 9001 and ISO 14001 certified for their quality and environmental management systems. AK Steel is a publicly held company traded over the New York Stock Exchange under the symbol AKS – aligning the company with many of the most prominent corporations in America.

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