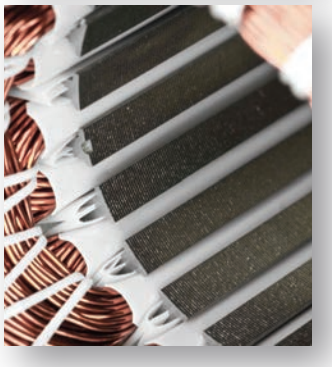
CLIFFS

DI-MAX® HF-12

COLD-ROLLED FULLY PROCESSED NON-ORIENTED ELECTRICAL STEEL



- **Aircraft Generators**
- **High Speed Motors**
- **Traction Motors**

DI-MAX® HF-12 is a fully processed non-oriented electrical steel designed for use in high-speed motors, traction motors, aircraft generators, and other rotating equipment operating at frequencies above 60 Hz. DI-MAX HF-12 electrical steel is supplied in a nominal thickness of 0.30 mm.

DI-MAX® HF-12

Product Description

COMPOSITION (TYPICAL)		(WT %)
Silicon	(Si)	3.1
Aluminum	(Al)	0.8

MAGNETIC PROPERTIES

Release grading is based on as-sheared Epstein test and based on core loss at 1.0 T and 400 Hz in accordance with ASTM A343 (reference data at frequencies above 400 Hz were developed in conformance with ASTM A348). Representative properties using stress relief annealing are shown for reference.

CORE LOSS

	TYPICAL	MAXIMUM
As-Sheared	13.8 W/kg	16.0 W/kg
After 830 °C SRA	12.5 W/kg	15.0 W/kg

OTHER MAGNETIC PROPERTIES

Magnetic Induction at 2500 A/m (B25)	1.55 T
Magnetic Induction at 5000 A/m (B50)	1.64 T
Volume Resistivity	56 $\mu\Omega$•cm
Saturation Induction	1.98 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	97.0% @ 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	≤ 7.65 gm/cm3
Yield Strength	400 MPa
Tensile Strength	500 MPa
Elongation, % in 2 in.	20%
Rockwell Hardness	B90
Vickers Hardness	193
Thickness Aim	0.30 mm
Tolerance	±0.02 mm
Strip Crown	0.005 – 0.006 mm

All values typical unless otherwise noted.

Core Loss And Exciting Power Tables As-Sheared

B (T)	H (A/m)	CORE LOSS (W/kg) @ Frequency (Hz)											
		50	60	100	200	300	400	800	1000	2000	2500	5000	10000
0.2	27.0	0.0508	0.0626	0.116	0.282	0.491	0.741	2.10	2.97	8.91	12.7	38.3	117
0.3	32.2	0.108	0.134	0.248	0.606	1.050	1.580	4.43	6.22	18.4	26.0	76.7	239
0.4	36.8	0.179	0.222	0.414	1.020	1.780	2.67	7.51	10.5	30.6	43.4	129	–
0.5	41.4	0.261	0.324	0.607	1.510	2.64	3.98	11.2	15.7	45.8	65.0	196	–
0.6	46.5	0.352	0.438	0.826	2.06	3.63	5.51	15.5	21.8	64.1	91.7	–	–
0.7	52.3	0.453	0.565	1.070	2.69	4.77	7.23	20.5	28.9	–	–	–	–
0.8	59.2	0.565	0.705	1.340	3.40	6.03	9.18	26.3	37.2	–	–	–	–
0.9	68.1	0.690	0.860	1.640	4.17	7.44	11.4	32.9	46.7	–	–	–	–
1.0	79.9	0.828	1.030	1.970	5.03	9.00	13.8	40.4	57.6	–	–	–	–
1.1	97.9	0.986	1.230	2.35	6.00	10.8	16.5	49.0	70.5	–	–	–	–
1.2	131	1.170	1.470	2.79	7.12	12.8	19.7	–	–	–	–	–	–
1.3	213	1.420	1.770	3.35	8.52	15.3	23.5	–	–	–	–	–	–
1.4	518	1.750	2.17	4.03	10.2	18.2	27.9	–	–	–	–	–	–
1.5	1580	2.14	2.66	5.01	12.6	22.4	34.4	–	–	–	–	–	–
1.6	3710	2.57	3.20	6.02	15.0	26.7	41.1	–	–	–	–	–	–
1.7	7040	3.12	3.90	–	–	–	–	–	–	–	–	–	–

B (T)	EXCITING POWER (VA/kg) @ Frequency (Hz)											
	50	60	100	200	300	400	800	1000	2000	2500	5000	10000
0.2	0.114	0.139	0.239	0.516	0.829	1.180	2.88	3.91	10.7	14.9	42.8	140
0.3	0.207	0.251	0.438	0.964	1.570	2.25	5.68	7.75	21.3	29.8	85.1	273
0.4	0.315	0.383	0.672	1.500	2.47	3.57	9.15	12.5	34.7	48.7	141	–
0.5	0.440	0.535	0.943	2.12	3.52	5.12	13.3	18.3	51.2	72.2	213	–
0.6	0.583	0.710	1.250	2.84	4.73	6.90	18.1	25.0	71.2	101	–	–
0.7	0.749	0.912	1.610	3.66	6.12	8.96	23.8	33.0	–	–	–	–
0.8	0.944	1.150	2.03	4.61	7.72	11.3	30.3	42.2	–	–	–	–
0.9	1.180	1.43	2.52	5.71	9.56	14.0	37.9	53.1	–	–	–	–
1.0	1.470	1.78	3.13	7.05	11.7	17.2	46.8	65.8	–	–	–	–
1.1	1.850	2.25	3.92	8.74	14.5	21.2	57.4	80.8	–	–	–	–
1.2	2.44	2.96	5.12	11.2	18.3	26.6	–	–	–	–	–	–
1.3	3.68	4.45	7.61	16.2	25.8	36.6	–	–	–	–	–	–
1.4	8.13	9.85	15.4	31.7	48.8	67.2	–	–	–	–	–	–
1.5	26.6	32.3	54.7	111	169	229	–	–	–	–	–	–
1.6	73.2	88.7	150	303	460	622	–	–	–	–	–	–
1.7	157	191	–	–	–	–	–	–	–	–	–	–

7.60 gm/cm3 test density
ASTM A343, ASTM A348; 50/50
B = Magnetic induction
H = Applied field

Core Loss And Exciting Power Tables Stress Relief Annealed

B (T)	H (A/m)	CORE LOSS (W/kg) @ Frequency (Hz)											
		50	60	100	200	300	400	800	1000	2000	2500	5000	10000
0.2	23.2	0.0424	0.0521	0.0958	0.234	0.409	0.620	1.790	2.55	7.73	11.3	34.1	108
0.3	27.2	0.0894	0.110	0.204	0.499	0.874	1.330	3.79	5.37	16.1	23.3	69.8	220
0.4	30.4	0.150	0.186	0.345	0.854	1.500	2.27	6.45	9.18	27.0	39.0	117	–
0.5	33.3	0.222	0.276	0.517	1.280	2.26	3.43	9.78	13.8	40.5	58.7	180	–
0.6	36.4	0.305	0.379	0.714	1.79	3.16	4.79	13.7	19.3	57.0	82.9	–	–
0.7	40.0	0.398	0.496	0.938	2.36	4.18	6.36	18.2	25.8	–	–	–	–
0.8	44.7	0.502	0.626	1.190	3.01	5.35	8.19	23.6	33.4	–	–	–	–
0.9	51.1	0.619	0.771	1.470	3.73	6.68	10.2	29.7	42.4	–	–	–	–
1.0	60.4	0.751	0.936	1.780	4.56	8.17	12.5	36.9	52.8	–	–	–	–
1.1	75.2	0.905	1.130	2.14	5.48	9.86	15.2	45.3	65.2	–	–	–	–
1.2	102	1.090	1.360	2.57	6.55	11.8	18.2	–	–	–	–	–	–
1.3	164	1.330	1.650	3.11	7.88	14.1	21.8	–	–	–	–	–	–
1.4	388	1.660	2.07	3.87	9.68	17.3	26.6	–	–	–	–	–	–
1.5	1370	2.06	2.56	4.78	11.9	21.0	32.3	–	–	–	–	–	–
1.6	3570	2.42	3.01	5.63	13.9	24.7	38.1	–	–	–	–	–	–
1.7	6980	2.85	3.58	–	–	–	–	–	–	–	–	–	–

B (T)	EXCITING POWER (VA/kg) @ Frequency (Hz)											
	50	60	100	200	300	400	800	1000	2000	2500	5000	10000
0.2	0.0964	0.117	0.200	0.429	0.685	0.970	2.40	3.28	9.04	12.9	38.1	126
0.3	0.174	0.210	0.365	0.800	1.300	1.870	4.78	6.58	18.3	26.2	76.4	254
0.4	0.261	0.317	0.555	1.240	2.05	2.98	7.76	10.7	30.1	43.1	127	–
0.5	0.359	0.438	0.775	1.760	2.93	4.29	11.4	15.7	44.5	64.1	193	–
0.6	0.470	0.574	1.020	2.34	3.94	5.80	15.6	21.7	62.1	90.1	–	–
0.7	0.596	0.729	1.300	3.01	5.10	7.54	20.5	28.7	–	–	–	–
0.8	0.743	0.909	1.630	3.78	6.43	9.55	26.2	36.9	–	–	–	–
0.9	0.919	1.120	2.01	4.68	7.97	11.9	33.0	46.6	–	–	–	–
1.0	1.140	1.390	2.49	5.76	9.80	14.6	40.9	58.2	–	–	–	–
1.1	1.440	1.760	3.12	7.14	12.1	17.9	50.5	72.2	–	–	–	–
1.2	1.90	2.32	4.07	9.12	15.2	22.4	–	–	–	–	–	–
1.3	2.83	3.44	5.94	12.8	20.8	30.1	–	–	–	–	–	–
1.4	5.97	7.27	12.3	25.5	39.5	55.0	–	–	–	–	–	–
1.5	22.2	27.3	45.7	92.9	142	193	–	–	–	–	–	–
1.6	69.2	84.1	141	286	435	588	–	–	–	–	–	–
1.7	155	188	–	–	–	–	–	–	–	–	–	–

7.60 gm/cm3 test density
ASTM A343, ASTM A348; 50/50
B = Magnetic induction
H = Applied field

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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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