

MOTOR-MAX[®]

**NON-ORIENTED ELECTRICAL STEEL FOR
HIGH FREQUENCY MOTORS AND GENERATORS**



Automotive Traction Motors
Aircraft Generators
High Speed Motors

Cleveland-Cliffs is the only North American steel producer currently producing automotive quality High Frequency Non-Oriented Electrical Steel (HF NOES) grades. As demand for electrical steel increases, we are positioned to meet a broad range of customer requirements.

Cleveland-Cliffs' line of **MOTOR-MAX[®]** HF NOES grades have low core loss and are energy efficient at high operating frequencies. **MOTOR-MAX** steel is produced in a wide-range of fully processed HF NOES including 25HF1550, 25HF1300, 27HF1500 and 30HF1600.

MOTOR-MAX HF NOES is designed for and desirable in high speed motors (operating at frequencies above 60 Hz), EV traction motors, aircraft motors, aircraft generators and other rotating equipment. Cleveland-Cliffs' line of **MOTOR-MAX** steel offers a variety of electrical properties with three different distinctive insulative coatings, to meet your design needs.

MOTOR-MAX is made from recycled content, making it among the most sustainable steel products in the world.

MOTOR-MAX® HF NOES FOR MOTORS & GENERATORS

GUARANTEED MAXIMUM AND TYPICAL MAGNETIC PROPERTIES

Release grading is based on as-sheared Epstein test core loss at 1.0 T and 400 Hz in accordance with ASTM A343.



TYPICAL PROPERTIES

Common Grade	Grade	Nominal Thickness mm (in)	Density gm/cm ³	Core Loss W/kg (W/lb)	Magnetic Induction at 5000 A/m, T	Electrical Resistivity μΩ•cm	Saturation Induction T	Yield Strength MPa (ksi)	Tensile Strength MPa (ksi)
25HF1550	HF-10	0.25 (0.010)	7.65	14.5 (6.60)	1.65	54-56	1.99	350 (50.8)	450 (65.3)
25HF1300	HF-10X	0.25 (0.010)	7.60	11.9 (5.40)		60	1.97	440 (63.8)	570 (82.7)
27HF1500	HF-11	0.27 (0.011)	7.60	12.5 (5.67)		60	1.97	440 (63.8)	570 (82.7)
30HF1600	HF-12	0.30 (0.012)	7.60	13.8 (6.30)		60	1.97	440 (63.8)	570 (82.7)

Additional property information can be found under electrical steel at www.clevelandcliffs.com/products for these grades and all electrical steel products.

MOTOR-MAX® HF NOES FOR MOTORS & GENERATORS

INSULATIVE COATING OPTIONS

Type	C-5-R Chromium Free ASTM A976 C-5	C-5 Phosphate Chromium Free ASTM A976 C-5	CARLITE® 3 ANTI-STICK™ ASTM A976 C-5-A
Components	Inorganic	Inorganic with some organic material	Inorganic
Thickness (μm)	0.5 – 1.3 μm	2.3 – 2.8 μm	0.25 – 0.76 μm
Space Factor	97.2% @ 1.0 MPa	96.6% @ 1.0 MPa 96.4% @ 0.345 MPa	97.0% @ 1.0 MPa 97.4% @ 0.345 MPa
Typical Franklin Current (A)	0.3	0.02	0.6
Typical Surface Resistivity (Ω-cm ² /sheet)	15	300	5
Weldability	Excellent (no porosity)	Good (minimal porosity)	Excellent (no porosity)

APPLICATION RESEARCH ASSISTANCE

Cleveland-Cliffs provides customers with valuable research assistance. We provide guidance on the most cost effective and efficient use of our electrical steels. Our engineers use a comprehensive collection of magnetic testing equipment to evaluate the application of electrical steel in a particular product, along with factors that may influence its final performance.

Cleveland-Cliffs offers material, design and production assistance in such areas as:

- Analyzing the sensitivity of equipment performance to small but normal variations in materials properties.
- Helping assure efficient use of electrical steels in present and future product design changes.
- Determining the most critical design and manufacturing factors affecting proper equipment performance.
- Assisting in isolating and solving design or manufacturing problems.
- Determining the standard test method best suited for a particular application.
- Providing assistance in defining or performing nonstandard testing.

Cleveland-Cliffs' vast knowledge of electrical steel products, processes, and applications, in addition to our commitment to quality and customer support, are unparalleled in the industry.



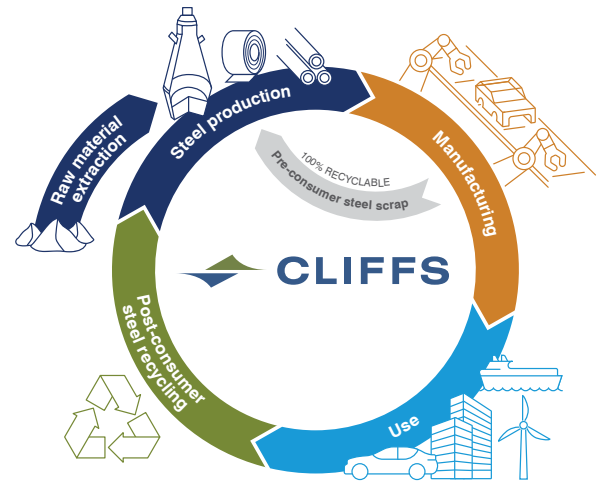


MOTOR-MAX® HF NOES FOR MOTORS & GENERATORS

SUSTAINABLE PRODUCTION

Cleveland-Cliffs maintains control over the entire production cycle, using U.S.-sourced materials and incorporating recycling and other environmentally friendly sustainable practices. Through our extensive experience developing specialty steel grades including **MOTOR-MAX** HF NOES, we are able to make our electrical steel products in our electric arc furnaces (EAFs) in the United States, utilizing a cleaner mix of our high-quality direct reduced iron and recycled steel scrap. Cleveland-Cliffs' technique to produce electrical steels, like **MOTOR-MAX** HF NOES, results in lower greenhouse gas emissions than steel mills utilizing carbon-intensive energy sources and production methods.

CLOSED-LOOP STEEL RECYCLING



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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