

COLD-ROLLED MOTOR LAMINATION

STEEL

USED IN:

- Home Appliances
- Transformers
- Generators
- Electrical Equipment and Components
- Small and Large Electric Motors



Cleveland-Cliffs' **Cold-Rolled Motor Lamination Steel** (CRMLS) products are Semi-Processed non-oriented electrical steels (NOES) designed for use in both small and large motors, generators, transformers, and electrical equipment. Standard grades available are Types 2 – 5 and are available in thicknesses of 0.018" – 0.060" nom (0.46 – 1.52 mm)

Cleveland-Cliffs' CRMLS is low carbon steel that can be made into ultra-low carbon steel after being stamped and annealed by the customer. Cleveland-Cliffs controls the reheat temperature and keeps the coiling temperature hot to prevent the AlN precipitates from dissolving and allows them to coarsen in the final microstructure. This yields the best crystallographic texture for magnetic properties and has a large positive effect on Permeability with a small effect on the Core Loss. The steel is pickled to remove scale, trimmed to improve gamma, and tandem reduced by 70-85%. The full hard coils are put through anneal to recrystallize and grow the grains to 10-20 microns. Small grain size is best for magnetic properties and response in the secondary anneal. Steel is then temper rolled to impart high stored deformation energy, which drives the grain boundary movement and the secondary grain growth during the secondary anneal.

The secondary anneal is performed by the customers in a decarburizing atmosphere. Semi-processed steel can contain carbon up to 500 ppm prior to the secondary anneal. The secondary anneal will reduce the carbon level to less than 50 ppm and most laminations are reduced to less than 30 ppm. This decarburizing secondary anneal causes the carbon to form iron carbides that inhibits secondary grain growth, pins the domain wall, and promotes high core loss and low permeability. The final carbon level should be as low as possible to minimize domain wall pinning by the iron carbides and prevent magnetic aging over time.

COLD-ROLLED MOTOR LAMINATION STEEL

Magnetic Properties Optimized and Controlled

CORE LOSS

The measure of the wasted heat energy in a motor or transformer that is absorbed by the steel laminations. Low Core Loss steel promotes energy efficiency in motors and transformers.

PERMEABILITY

Defined as the ease of magnetization of the steel laminations when exposed to an applied field. Higher permeability promotes energy efficiency and higher motor starting torque.

Alloy Effects on Cold-Rolled Motor Lamination

Silicon, Aluminum, Manganese, and Phosphorus are solid solution alloying elements used to increase resistivity and decrease power loss. Unfortunately, these alloy additions also reduce the saturation magnetization of iron so the permeability decreases. Sulfur and Oxygen are reduced as low as possible to minimize domain wall pinning by the oxides and sulfides. Phosphorus improves the punching performance of the soft grades. Aluminum and Silicon stabilize the ferrite while Manganese stabilizes austenite. Antimony (Sb) is added to minimize the formation of subsurface oxides of silicon and aluminum. To optimize permeability, you must decrease the alloy content. Cleveland-Cliffs selects the needed alloy balance for phase stability and properties.

These specifications shown in the following table have been selected to provide an introduction to Cleveland-Cliffs' CRMLS. This information was produced using standard ASTM A 343 testing. Gauges are available from 0.018 – 0.060" nom (0.46 – 1.52 mm). Please contact your Cleveland-Cliffs representative so we can satisfy your specific needs.

COLD-ROLLED MOTOR LAMINATION STEEL

Magnetic Properties Optimized and Controlled

Typical Properties							
Type	Grade	Gauge in. (mm) Nominal		Typical Core Loss W/lb (W/kg)*		Typical Permeability	HRB**
2	CS Rephos	0.030	(0.76)	4.43	(9.77)	3096	62 as-rolled
3	ML 64 ELC	0.0220	(0.56)	2.74	(6.04)	3054	59 as-rolled 28 post-anneal
		0.0250	(0.64)	3.28	(7.23)	3013	
		0.0285	(0.72)	3.88	(8.56)	3409	
		0.0340	(0.86)	5.15	(11.36)	3036	
4	2.5/2000 ULC	Inquire					
4.5	2.37/2000 ^[1] ELC	0.0245	(0.62)	2.72	(6.00)	2510	No Data
		0.0280	(0.71)	3.13	(6.90)	2473	
		0.0310	(0.79)	3.63	(8.00)	2587	
5	2.25/2000 ULC	Inquire					

* Test conditions -- 15 Kilogauss, 60 Hz

** Converted to Rockwell B

[1] Also available in ULC chemistry upon inquiry

ELC = Carbon .016 max typical, not guaranteed. Customer recommended annealing conditions: 1450°F, 70°F dewpoint, 45 minute soak at temperature, HNX gas.

ULC = Carbon .005 max typical, not guaranteed. Customer recommended annealing conditions: 1550°F, 0°F dewpoint, 45 minute soak at temperature, HNX gas.



COLD-ROLLED MOTOR LAMINATION STEEL

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.



CLEVELAND-CLIFFS INC.

200 Public Square
Suite 3300
Cleveland, OH 44114-2315
844.STEEL99 | 844.783.3599
clevelandcliffs.com

All information in this brochure is for the purpose of information only. Cleveland-Cliffs reserves the right to change its product range at any time without prior notice.