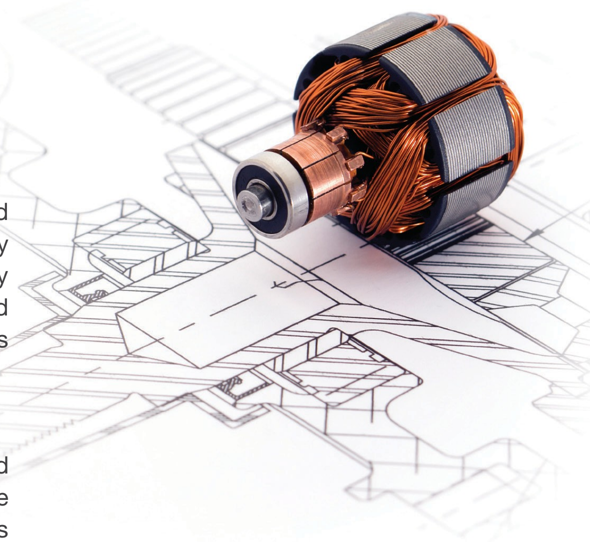
Advancing Motor & Rotor Designs with Thin and Ultra-thin Silicon Iron



Improved Efficiency for Electrical Machinery

With an increased focus on achieving more efficient electrification of devices, engineers and system designers continue to explore new materials and techniques for improving what they design and build. Because Silicon Iron (Si-Fe) or "electrical steel" is the material most widely used as the soft magnetic flux carrier in devices used to generate, transmit, transform, and consume electrical energy, it makes sense to take advantage of the improved efficiencies and performance that Arnold Magnetic Technologies' Silicon Steels offer.

Thin-gauge Advantages

Lamination thickness is one factor that affects the overall efficiency of electrical devices and contributes to energy losses in motor and transformer designs. Thin and ultra-thin gauge Silicon Steels from Arnold's Precision Thin Metals Division (PTM) offer efficiency benefits over conventional lamination materials that far outpace cost considerations. Available in grain-oriented and non-grain-oriented Si-Fe types, both have particular advantages over other materials for a range of applications. When optimally applied to a particular design, each offers more efficient use of electrical steel, resulting in higher power density, reduced losses and heat, and overall energy savings. Efficiency gains also help designers to trim size and weight — without sacrificing performance!

Our thin gauge Si-Fe materials are proven performers in a host of applications, such as transformers and inductors, motors, and other rotating machinery. Measurements of energy efficiency for electrical machinery clearly show the advantages of thin gauge designs over conventional materials and thicknesses, with efficiency improvements up to 35%.

Si-Fe Type	Key Benefits	Best Uses
Grain-Oriented Electrical Steel (GOES)	▪ Directional crystal orientation provides for anisotropic properties of permeability, flux density and core loss. ▪ Enhanced magnetic properties along the rolling direction improve inductive properties. ▪ For higher frequency applications, thinner materials reduce the negative effects of core losses due to eddy currents. Lower core loss means less heat buildup. ▪ Reduced thicknesses support high-power pulse applications with pulse widths as low as 0.25 microseconds.	**Transformers** or **inductors** where the relative angles of the magnetic field and the rolling direction of the alloy strip can be closely aligned. **Power, instrument and current transformers**, as well as **cores** for high-voltage direct current (HVDC) transmission systems.
Non-Grain-Oriented Electrical Steel (NGOES) Arnolds' NGOES Si-Fe is manufactured under the trade name **Arnon**®	▪ Thin gauge Arnon provides efficiency improvements at frequencies above 400 Hz with exponential efficiency gains as the frequency increases. ▪ High permeability for improved saturation and low coercivity coupled with the hysteresis curve shape of thin gauge Arnon provides reduced hysteresis loss in rotating machinery, yielding a more efficient motor or generator with less heat buildup and better performance (e.g. improved torque density) and/or the ability to maintain constant RPM'S under load. ▪ Frees up design constraints by allowing the motor to be fully enclosed without external cooling, for example. ▪ Favorable ductile properties for fabrication and usability. ▪ Up to 50% lower core loss than competitive non-oriented silicon steel when driven by the same field. ▪ Usable at higher frequencies than cobalt-iron and capable to at least 10 kHz –at about 1/3 the cost.	**Rotating machinery** that provides a continuously changing angle of incidence of the applied field relative to the lamination steel rolling direction. Arnon is frequently used for laminations in high speed, high efficiency motors and generators. Best for motors and generators above 400 Hz.

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Available in a Range of Widths and Thicknesses

Thin rolled materials help maintain high efficiency over the frequency range. Arnold's GOES materials are commonly produced in 0.006" (0.15mm) and 0.004" (0.10mm) thicknesses for frequencies below 1 kHz. At increased frequencies in the range of up to 2 kHz, 0.002" (0.05mm) is recommended. For frequencies up to about 5 kHz, GOES thickness in the range of about 0.001" (0.025mm) works best.

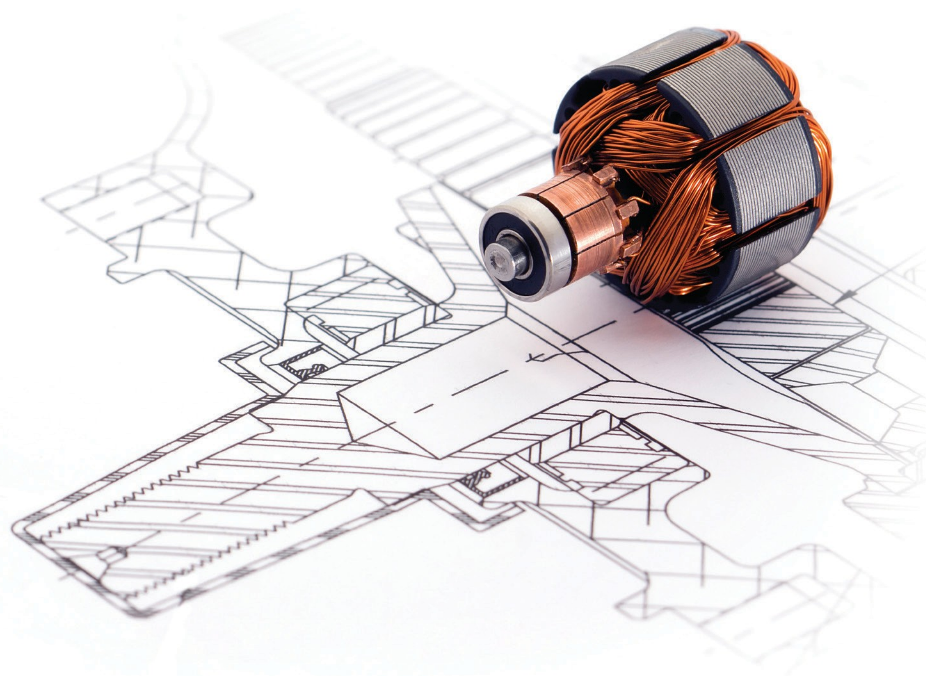
NGOES common laminations use 0.014" to 0.032" (0.356mm to 0.813mm) thicknesses, whereas our Arnon NGOES materials are thinner at 0.005" and 0.007" (0.127mm and 0.178mm). For motors and rotors operating at frequencies above 400 Hz, thin-gauge Arnon provides significant efficiency improvements.

Arnold's Precision Thin Metals (PTM) Si-Fe strip and coil can be shipped bare or with an inorganic coating, capable of surviving 920°C annealing temperature (C-5 IEEE Class).

	Thickness	Minimum slit width	Max width as rolled	Max width, with slit edge
GOES	0.006" (0.15mm)	0.20" (5.08mm)	17.5" (444.5mm)	17.0" (431.8mm)
	0.004" (0.10mm)	0.20" (5.08mm)	17.0" (431.8mm)	16.5" (419.1mm)
	0.002" (0.05mm)			
	0.001" (0.025mm)			
NGOES Arnon®	0.007" (0.178mm)	0.20" (5.08mm)	17.5" (444.5mm)	17.0" (431.8mm)
	0.005" (0.127mm)	0.20" (5.08mm)	17.0" (431.8mm)	16.5" (419.1mm)

Getting the Most From Silicon Steel

As part of our ongoing commitment to service and support, we help domestic and international customers specify the thin-rolled Silicon Steel that best serves their needs in a broad range of applications. The Arnold Precision Thin Metals team assists customers in sorting through the oriented and non-oriented options best for their requirements and application. We help work through the options for thickness, coating chemistries, performance tradeoffs, and losses, costs, and supply needs. Then, using our extensive in-house testing capabilities, we validate performance so that customers better understand important aspects of material behavior under different ambient and power conditions and at different frequencies.



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