VACOFLUX 18 HR
High Resistivity and High Saturation Iron-Cobalt-Alloy with improved Strength and Machinability

To meet the demand for fast-switching magnetic valves the soft magnetic actuator material applied needs to have a high electrical resistivity to suppress eddy current effects. The material should also exhibit a high saturation to enable designers to realize high force actuators in small volumes. A high magnetic permeability results in good flux guidance.

The new developed iron-cobalt-alloy VACOFLUX 18 HR provides a combination of high resistivity and high saturation that is unique on the market of soft magnetic materials (see diagram 1).

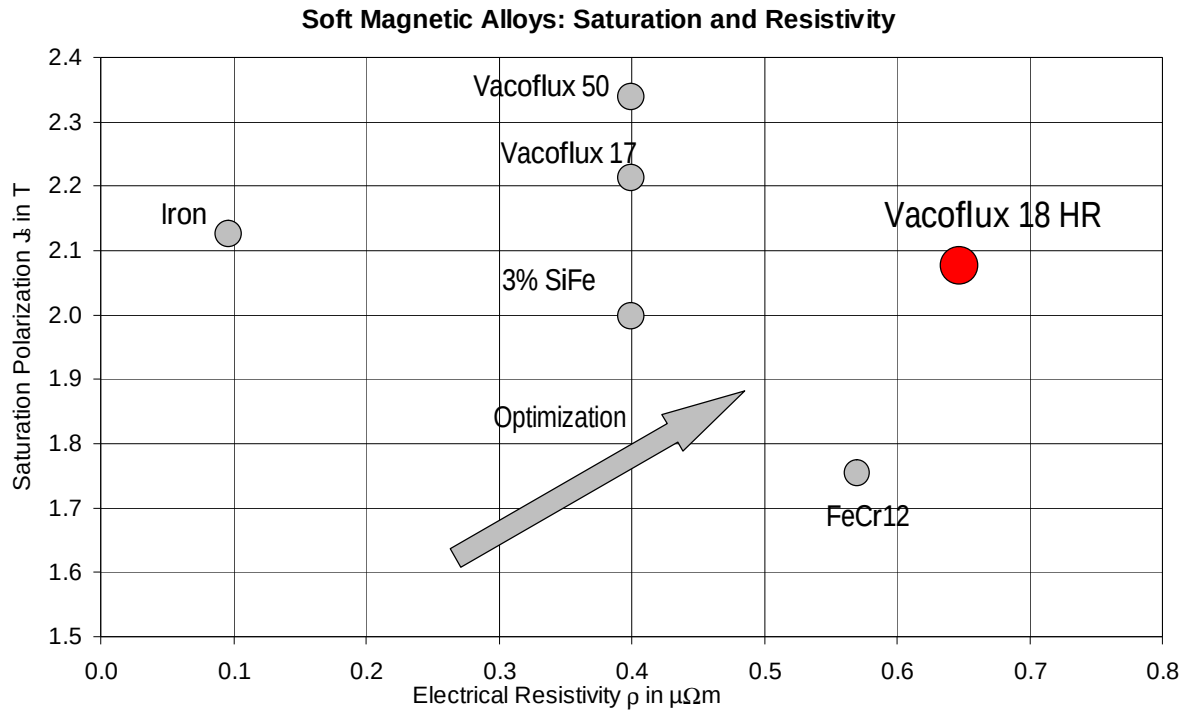

Diagram 1: Saturation Polarization and specific electrical resistivity of typical soft magnetic actuator materials

Iron-cobalt-alloys are well known for their high magnetic saturation, the highest saturation of all soft magnetic materials available. Magnetic valve actuators in fuel injection systems are a typical application.
Optimum soft magnetic properties with the highest saturation are realized in a 49% cobalt and 49% iron alloy. By addition of 2% vanadium processibility and electrical resistivity are improved. The corresponding commercial VACOFLUX 50 and VACODUR 50 alloys today are the best solution for actuators with highest forces.
By reduction of the cobalt content below 30% material ductility can be increased and as a result processibility improves. The lower cobalt content also leads to a considerable cost reduction and makes the material attractive for automotive applications.
The Co-reduced alloy Vacoflux 17 with 17% Co entered the market successfully about a decade ago in large-scale diesel injection applications.

For the improved alloy VACOFLUX 18 HR an increase in resistivity of 60% was achieved with only minor changes in soft magnetic properties and saturation.
In a 2D-simulation of a simple actuator system use of VACOFLUX 18 HR yields the steepest rise of force. Within the first 0.1ms the force is even higher than for the 50%CoFe Vacoflux 50 (diagram 2).

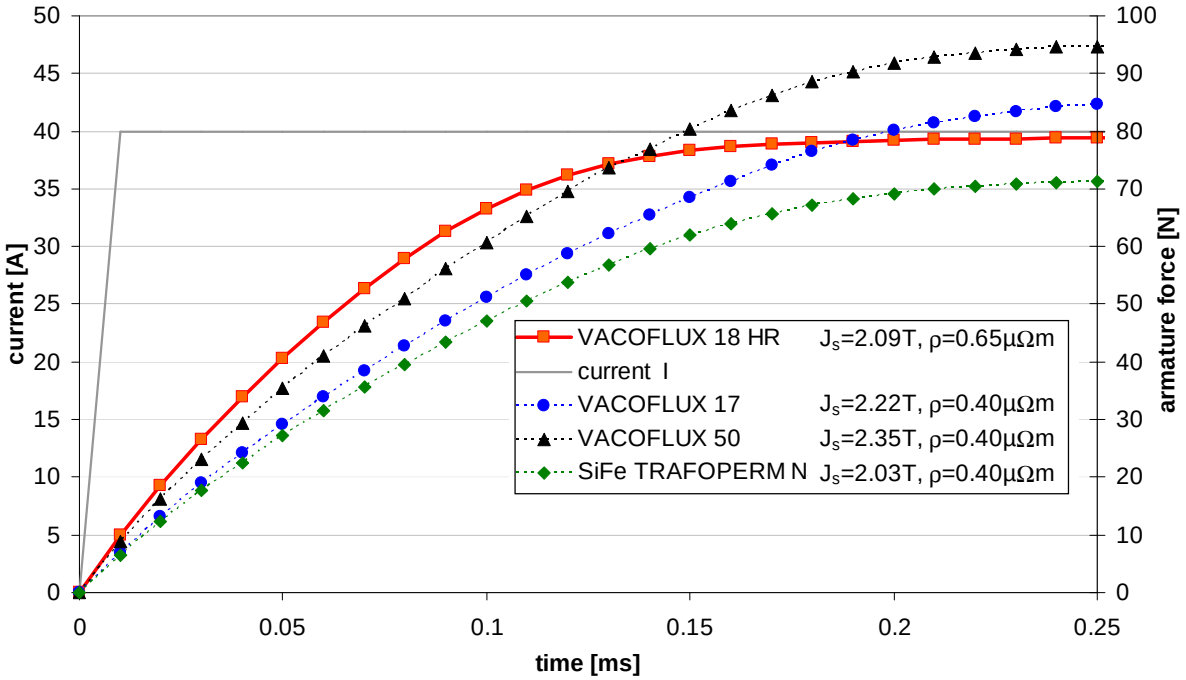

*Diagram 2: Simulation of switching times for various soft magnetic materials in a simple armature-core-actuator-system: **50%CoFe**: VACOFLUX 50, **17%CoFe**: VACOFLUX 17, VACOFLUX 18 HR and **3%SiFe**: Trafoperm N3 (typical properties, not part of specification)*

Further elements were added to the alloy to improve the machinability. This allows cost-optimized processing.
The material must be final annealed after processing to get optimum magnetic properties. Annealing parameters for VACOFLUX 18 HR are 10h at 800°C in hydrogen atmosphere.

Material	B(200A/cm) in T	B(400A/cm) in T	H_c in A/cm	resistivity r in µW m	yield strength in MPa
VACOFLUX 17	2.11	2.24	1.35	0.41	250
VACOFLUX 18 HR	2.03	2.11	1.7	0.65	400

Properties of VACOFLUX 17 and VACOFLUX 18 HR in the final annealed state (typical properties, not part of specification)

In many valve applications a high strength of the armature material is required. For the VACOFLUX 18 HR grade yield strength is about 400 MPa with excellent soft magnetic properties at the same time.