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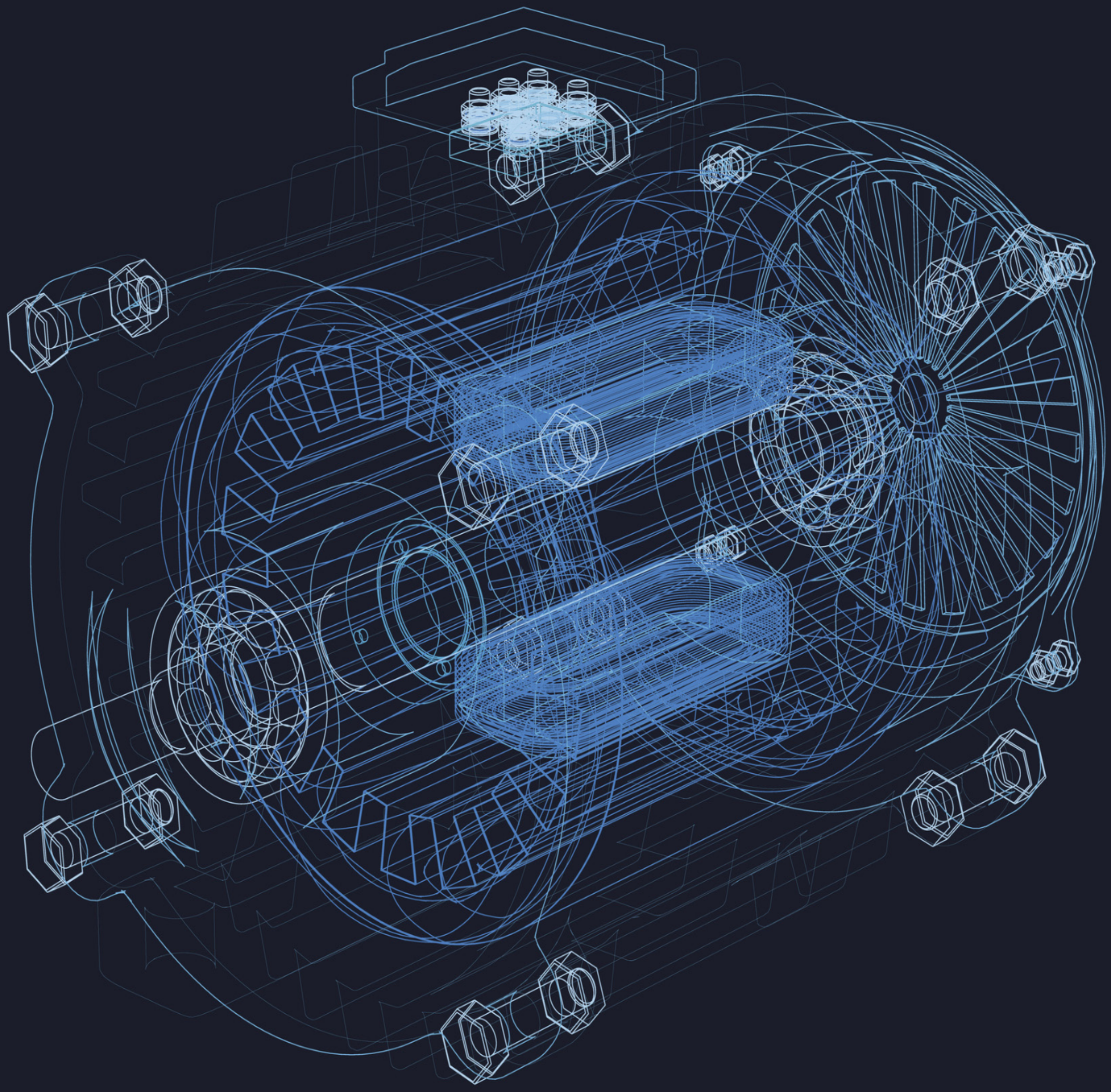


Iron Cobalt Alloys - IMPHY AFK
The electrical revolution

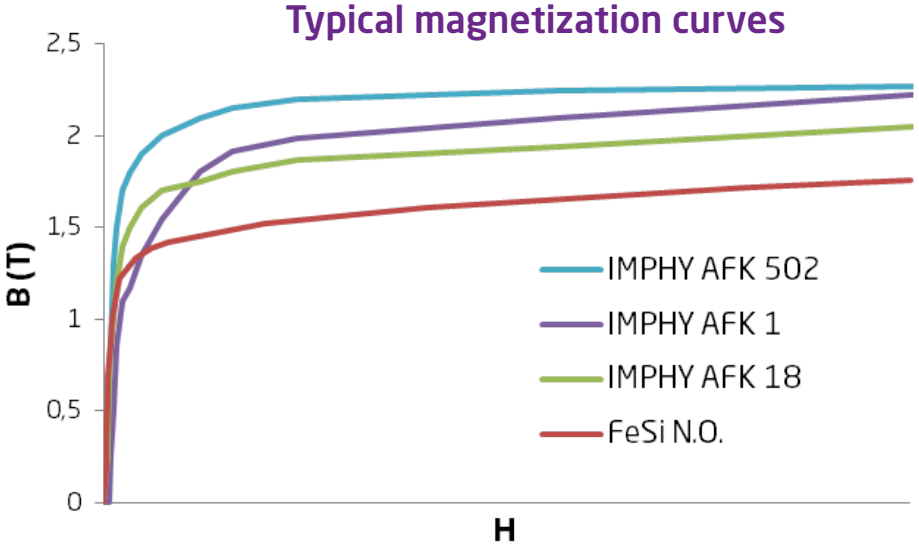
About us

Aperam is a global player in the production of stainless, specialty, and electrical steels and a world leading producer of cobalt and nickel based alloys.
From our patenting of the groundbreaking nickel-iron alloy INVAR to developing the field of precision metallurgy, Aperam Alloys Imphy has been providing innovative, high-performing, quality alloys for over a century. Today, we offer a portfolio of over 200 grades and numerous patents, meaning Aperam Alloys Imphy has an alloy for every need.

Today's electric vehicles demand a better performing engine.

To optimize power density, electric vehicle engines must decrease in weight and volume. Thanks to their high permeability, our magnetic materials excel at doing both. However, engine designers must figure out how to manage the magnetic losses that occur when the electric motor converts electrical power into mechanical power.
Not only do electric motors need a material that can minimize loss while maximizing performance, they also need a material that can help reduce engine noise. Our IMPHY AFK range has the solution.
These innovative iron cobalt magnetic alloys offer a very high saturation induction, high resistivity, low losses, and low coercive field. In fact, depending on the level of cobalt content, the materials in our IMPHY AFK range can reach a saturation induction level of over 2.35 T – resulting in either a significant increase in power density, higher power for the injector, higher torque by the generator, or a more powerful transformer.

Typical magnetization curves



Finding the right solution for your application

Your need...	Application type...	Our solution...
High torque	Motor	IMPHY AFK 502 R, IMPHY AFK 1, IMPHY AFK 18
High yield strength & stability	High speed rotating electrical machines	IMPHY AFK 502 FP
Harsh environment	Actuator	IMPHY AFK 502 R, IMPHY AFK 1
Low magnetic losses	Onboard machines	IMPHY AFK 502 R, IMPHY AFK 1
High working dynamism	Actuator	IMPHY AFK18 L, E, R

Grade	Chemistry
IMPHY AFK 18	18Co-Bal.Fr
IMPHY AFK18 R	18Co-0,5Si-Bal.Fe
IMPHY AFK 18 E	18Co-3,7Cr-Bal.Fe
IMPHY AFK 18 L	18Co-2Cr-1,9Si-1,9V-Bal.Fe
IMPHY AFK 1	27Co-0,5Cr-0,3Mn-Bal.Fe
IMPHY 502 R	49Co-49Fe-2V
IMPHY 502 FP	49Co-49Fe-2V

Good choice of formats:

Cold rolled strip | Part | Wire rod | Forged bar

Standard dimensions and tolerances are available. Contact us for specific requests.

1. A high torque motor

As only a small amount of energy can be distributed across a given plane, drone or car, the best way to achieve higher efficiency is to increase the electrical machine's performance. After all, higher power density invariably requires higher magnetic and mechanical properties.

By coupling induction - using IMPHY AFK 502, which can reach 2.35 T - with a low coercive field, one can optimize the transmission chain.

Material such as IMPHY AFK 18, which has a lower cobalt content, can be used to optimize both performance and costs. IMPHY AFK 1, which has the highest saturation level, is ideal for applications needing a very high induction.

Grade	Thick. (mm)	$R_{0,2}$ (MPa)	μ_r^{max}	Hc (A/m)	B_{2500c} (T)	$B_{10\,000}$ (T)	J_{sat} (T)	$W^{1,5T}{}_{1000Hz}$ (W/kg)	$W^{2T}{}_{400Hz}$ (W/kg)	$W^{2T}{}_{1000Hz}$ (W/kg)
IMPHY AFK 18	0,35	210	6000	60	1,85	2,05	2,30	360	135	730
	0,20	210	6000	60	1,85	2,05	2,30	150	70	310
IMPHY AFK 1	0,35	300	2600	140	1,87	2,10	2,38	350	170	630
	0,20	300	2500	140	1,85	2,05	2,38	245	120	430
IMPHY AFK 502 R	0,35	300	11000	50	2,25	2,32	2,35	170	70	320
	0,20	300	10000	60	2,25	2,32	2,35	80	45	140
	0,10	300	8000	60	2,25	2,32	2,35	55	32	100

2. High yield strength and stability for high-speed rotating electrical machines

Increasing the rotating speed of spinning machines requires a material that has the mechanical properties to withstand significant constraints. Furthermore, material that undergoes strong centrifugal forces must be able to limit magnetic losses to both maintain motor yield and minimize machine size.

The ready-to-use IMPHY AFK 502 Fully Process (FP) alloy enables this balance between high mechanical properties (between 600 – 1 000 MPa) and low magnetic loss. Thanks to its high temperature, good fatigue resistance and excellent ageing, IMPHY AFK 502 FP offers the market's best mechanical capabilities. By easing the production process, it also provides attractive cost savings.

IMPHY AFK 1, which has a higher saturation level, is the ideal material for components used at a very high induction rate.

Grade	Thick. (mm)	$B_{10\,000}$ (T)	W^{2T}_{1000Hz} (W/kg)	$R_{0,2}$ (MPa)	R_{max} (MPa)
IMPHY AFK 502 R	0,35	2,32	320	300-420*	480-720*
IMPHY AFK 502 FP *.6*	0,35	2,13	710	600	900
IMPHY AFK 502 FP *.8*	0,35	2,13	880	800	1250
IMPHY AFK 502 FP *.9*	0,35	2,13	1100	950	1380
IMPHY AFK 502 FP *.9.5*	0,20	2,10	760	950	1380

* Note that different heat treatments give different specifications for the same material.

3. Severe environments

Whether it be high temperatures or a corrosive atmosphere, electrical machines must be able withstand the severest of environments.

Thanks to our diverse portfolio, Aperam Alloys has a solution ready to perform in every condition.

Grade	Working (T° C)	B_{2500} (A/m)	B_{1000} (A/m)
IMPHY AFK 1	500	1,88	2,17
IMPHY AFK 502 R	500	2,16	2,30

4. Low magnetic losses – Onboard machines at mid and high frequencies

As rotating frequency increases so too does the electrical current frequency, which impacts magnetic losses. Thanks to its resistivity and low thickness, IMPHY AFK alloys help reduce losses, making it the material of choice for electromagnetic systems used at high frequencies.

Grade	Thick. (mm)	Resistivity (µΩ.cm)	Hc (A/m)	B_{1000} (T)	$W^{1,5T}_{50Hz}$ (W/kg)	$W^{1,5T}_{400Hz}$ (W/kg)	W^{2T}_{400Hz} (W/kg)	$W^{1,5T}_{1000Hz}$ (W/kg)	W^{2T}_{1000Hz} (W/kg)
IMPHY AFK 502 R	0,20	40	60	2,32	2,0	27	45	80	140
	0,10	40	60	2,32	0,6	18	32	55	100
	0,05	40	53	2,32	0,2	12	21	44	79
IMPHY AFK 1	0,20	30	140	2,10	1,4	65	120	245	430

5. High working dynamics - Electric actuator with massive magnetic core

How well an electromagnetic machine performs depends on the quality of the material used. One way to lower a machine's kinetic effect, and thus increase performance, is to increase the mass of such components as the electric actuator.

Our alloys, including IMPHY AFK 18, offer the magnetic properties needed to optimize the electric actuator's performance. For massive components, only the electrical property can improve dynamism and lower magnetic losses. That is why we recommend using IMPHY AFK 1 or IMPHY AFK 502, both of which will enhance magnetic flux density within a closed area.

Grade	J_{sat} (T)	B_{800} (T)	B_{2500} (T)	B_{10000} (T)	ρ_{el} (µW.cm)	μ_r^{max}	Hc (A/m)	λ_{app} (ppm)	T° Curie (°C)	$R_{0,2}$ (MPa)
IMPHY AFK 1	2,40	1,52	1,87	2,10	20	2500	200	35	980	300
IMPHY AFK 502 R	2,35	2,127	2,32	2,32	40	(10000)	160	65	900	200
IMPHY AFK 18 E	2,14	1,42	1,69	1,93	44	4000	165	25	950	260
IMPHY AFK 18 L	2,00	1,42	1,60	1,82	68	4500	155	25	950	260
IMPHY AFK 18 R	2,30	1,64	1,80	2,06	30	2500	150	25	940	355
	0,20	300	10000	60	2,25	2,32	2,35	80	45	140
	0,10	300	8000	60	2,25	2,32	2,35	55	32	100

Technical data

Handling

All finished parts must undergo heat treatment. Not only will this eliminate internal stresses caused by cold work, it will also give the metal the necessary balance between magnetic and mechanical properties.

Although special care must be taken prior to any operation, this is especially pertinent for material with low thickness. Always remove all grease before heat treatment. Use a film to protect each layer from glued components.

Made by Imphy

IMPHY AFK alloys are the result of Aperam Imphy's unique know-how and unparalleled experience. By perfecting every vital step – from the steel mill to cold rolling operations – we are able to produce the very best material. More so, our Code of Conduct is guided by the strictest ethics and all our internal processes are based on the latest best practices.

Have a question? A specific request? An idea for a new solution? Our R&D, Marketing and Development, and Sales teams are standing by and ready to help!

Heat treatment

All finished pieces must undergo heat treatment. This will relieve any stress caused by forming and ensure the component achieves optimal magnetic characteristics.

- **Preparation**

  To avoid the risk of surface contamination, we recommend degreasing all parts, especially small items. Furthermore, to prevent parts from sticking during treatment, we suggest covering them with a film made of inert anhydrous material, such as talc, magnesia, or alumina. To prevent heavy parts from deforming during treatment, use supports suited to the weight and shape of the part.

- **Atmosphere**

  Heat treatment should only be done in a reducing atmosphere, pure dry hydrogen, or vacuum. A cracked ammonia atmosphere is only acceptable for IMPHY AFK 1. Using such an atmosphere with IMPHY AFK502 could cause nitriding to occur, which will seriously affect the material's magnetic characteristics.

- **Recommended cycles**

  CAUTION: the below temperatures should not be exceeded. Reaching the allotropic transformation $\alpha \leftarrow \rightarrow \mu$ temperature, which occurs at about 900°C, will irreversibly reduce the material's characteristics.

We strongly recommend to contact our technical service for the most appropriate heat treatment

Grade	Time (h)	T° (C)	Cooling speed (°C/h)	Environment
IMPHY AFK 502 R	2 to 3	850	250	Pure dry hydrogen or vacuum
IMPHY AFK 1	2 to 3	850	250	Pure dry hydrogen or cracked ammonia
IMPHY AFK 18 (L, R, E, CH)	2	920	250	Pure dry hydrogen, vacuum or in an inert atmosphere (rare gas)

Contact us

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