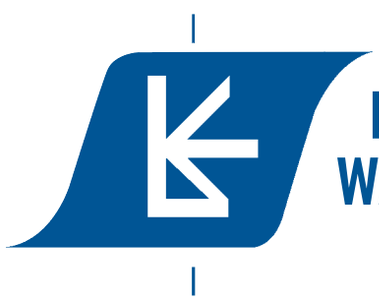

LABORATORIO ELETTROFISICO
WALKER LDJ SCIENTIFIC

YOUR MAGNETIC BUSINESS RESOURCE

MAGNETIZATION
systems and
MEASURING
systems

MAGNETIZATION
systems

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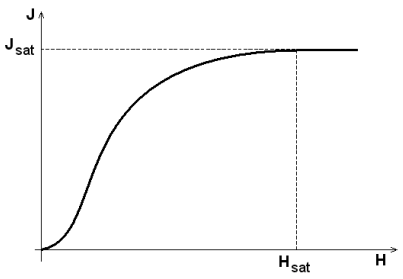
PULSE MAGNETIZERS AND COILS

Introduction

Permanent magnets need to be magnetized prior to being used for their intended application. Early magnet materials, for example Alnicos or Ferrites, saturated with an applied field of less than 1 T (10 kOe). Today's modern rare earth magnet materials, like NdFeB or SmCo, require a higher applied fields to saturate, up to 6 T (60 kOe) for some types of Sm_2Co_{17}.
Listed below is the typical magnetization field necessary to saturate most standard magnet materials on the market today.

Material	Saturation Field Hsat (T)
Alnico	0.5
Ferrite	1
NdFeB	3
$SmCo_5$	2.5
Sm_2Co_{17}	5 ÷ 6
Bonded Nd	3 ÷ 5

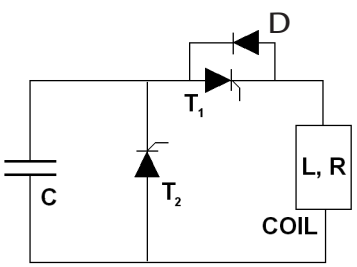


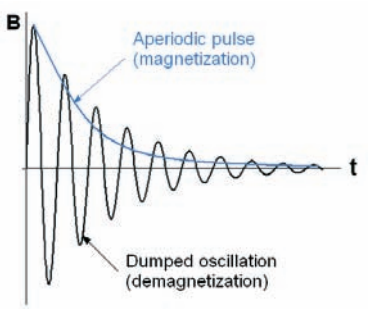
Magnetic fields are produced by electric currents. The large amount of magnetic field required to magnetize permanent magnets requires the current to be in the range of 10 to 30 kiloamperes. To provide a safe and reliable method to avoid overheating and fusing the current carrying conductors during magnetization, an extremely fast current pulse is required. A fast pulse is the preferred method for magnetization. Magnetic materials reacts quickly to the applied field; however, care must be taken to limit eddy currents effects created in conductive materials by the fast rise time of the current pulse, to avoid any shielding effects.
Pulses width duration in the order of 0.5 ÷ 1 milliseconds are considered 'long' enough for the magnetization process to be successful. Ferrite magnets can be magnetized with shorter pulses, with a width duration of a few microseconds.

Due to the extreme operational conditions for the magnetization coils, the coil design must be capable to withstand with the magnetic field strength levels, and also the large amount energy and heating. The coil designs provide a safe and reliable environment for the operator and factory

To generate a pulse magnetizing field, two main components are necessary: a magnetizer and a coil.
A magnetizer is a device that stores electrical energy via a capacitor or a capacitor bank, with a high current switching device to discharge the stored energy into the coil.
The magnetization coil is essentially a set of conductors configured to provide the correct orientation of magnetic field to saturate the magnetic material.

The basic layout of a magnetization system is shown in the picture below.





T1 and D conductive: dumped oscillation (demagnetization)
T1 and T2 conductive: Aperiodic pulse (magnetization)

The capacitors bank is charged with a voltage V_0. The discharge circuit operates via tyristors, to discharge the capacitors into a magnetizing coil (with resistance R and inductance L).
Closing T1, the typical R, L, C values of the circuit creates a current with dumped oscillation shape.
By closing T1 and T2, after the current has reached a maximum value, T2 is used in the circuit to block the recharging of the capacitors to a reverse polarity, causing the current to decrease exponentially to zero.

The fundamental parameter of magnetization systems is based on the energy of the pulse. Since all the energy is stored in the capacitors, the energy E is given by

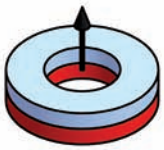
$$E = \frac{1}{2} C V_0^2$$

This energy produces the magnetic field and is dissipated through the magnetizing coil's resistance.
For the same energy, a low capacitance and an high voltage has a bigger efficiency to produce a magnetic field respect to a big capacitance and low voltage condition. A high V and low C magnetizer will also give a shorter magnetizing pulse, reducing the total heating on the coil. Of course, the effect of eddy current on conductive materials has to be considered too, to allow fully penetration of magnetizing field.

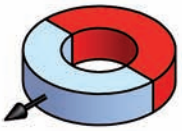
In typical industrial applications, the duty cycles are high and since the magnetizing coil receives large amounts of energy, the coil experiences thermal increases in temperature. If an efficient heat dissipation design has been incorporated into the magnetizing coil, the heating effect will be reduced to an acceptable working temperature for safe operation.

Magnetization coils

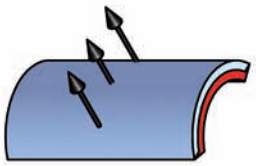
Magnetizing coils are designed to give the necessary field strength in the proper pattern. Listed below are the classical magnetization orientations, from the simple classical axial to the most complicated multi polar.



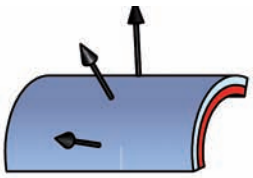
Axial



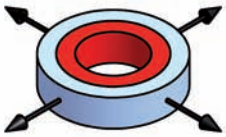
Diametral



Axial



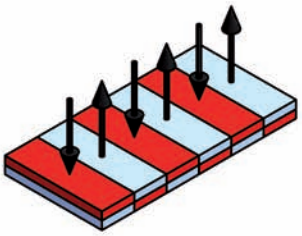
Radial



Pure radial

Multipolar radial

Multipolar axial

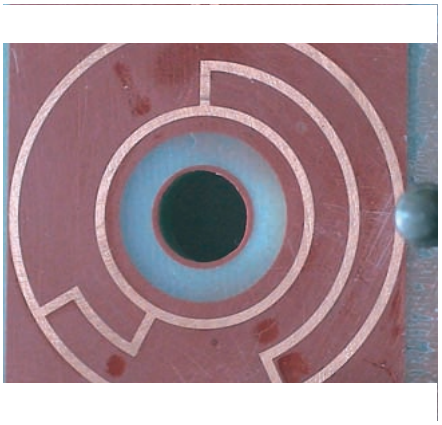


Multipolar axial

Laboratorio Elettrofisico offers a wide range of coils types and configurations

To obtain the most efficient method to saturate magnetic materials, each design is focused on a particular product or device. Our magnetizing coils can meet very simple to ultimately complex applications.

Exceptions to the rule are axial magnetizing coils for general use applications. These coils produce a unidirectional field, directed on the coils axis. The magnetizing field is highest at the center of the coil, and in most cases, the sample to be magnetized is placed in the center.



These types of magnetizing coils can also be used to magnetize a magnet outside the coil, providing the field level is high enough for the application. Typically the axial coils are used for a single magnet application; two poles rotor/motor, relays or for axial assemble like loudspeakers.

Our multi-polar coils designs are so varied from application to application we cannot list them all; however, in the next section we have listed and detailed the most common types with relative application details. One common point most multi-polar magnetizing coils exhibit: the magnetic field lines generated from one pole goes immediately into the adjacent pole. This requires the magnetic material to be placed in close proximity to the magnetizing poles.

Magnetization in the Assemble

In a magnetic assembly, all magnets have to be magnetized. In principle, this can be accomplished either by mounting or inserting single magnets already magnetized in the assembly, or mounting or inserting non-magnetized magnets, and magnetizing then the whole assembly.

Benefits to magnetization in the assembly:

- Simple handling of the magnets
  Automatic assemble lines will not require the use of special non-magnetic materials and no extra forces will be necessary to move the magnets through the process.
- Simple mounting on the device
  The magnet material can be easily glued to a surface for precise location, for critical applications like rotors, stators, and loudspeakers.
- Simple storage of the magnets
  Magnets can be easily stored and won't attract dust or ferrous objects.
- Improved safety
  Rare-earth based magnets can create a danger due to the magnetic strength of the material once magnetized. Handling magnetized materials, special precautions for safe handling by operators and other personnel is require to prevent injury or damage to equipment.
- Lower cost of the raw material
  Magnets ordered not magnetized cost less; lower transportation cost due to hazardous material restrictions and regulations (especially via air)

When production is limited or during the prototyping stages, it might be useful to purchase a development coil. This will provide the best solutions when magnetization services are offered. See also the service chapter.

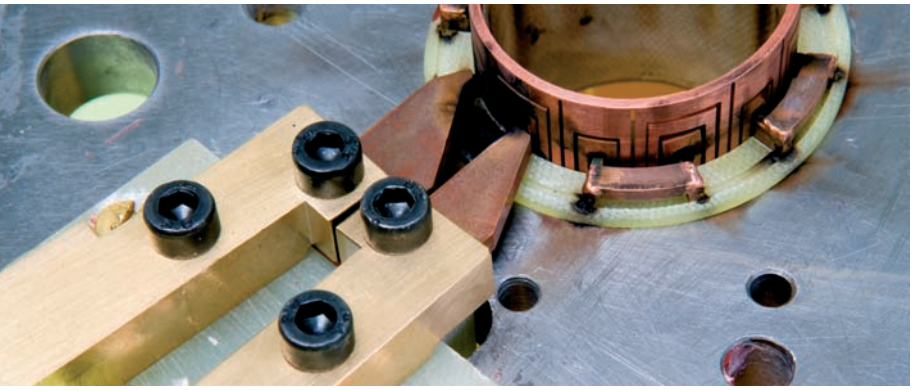
If you have questions please contact Laboratorio Elettrofisico to assist you in providing the best solution for meeting the application.

Magnetic Calibration

The term ‘magnetization’ is often synonymous for ‘saturation’. When the need arises to have a product with a specific magnetization level, or a lower field level other than saturation, then ‘calibration’ is required.

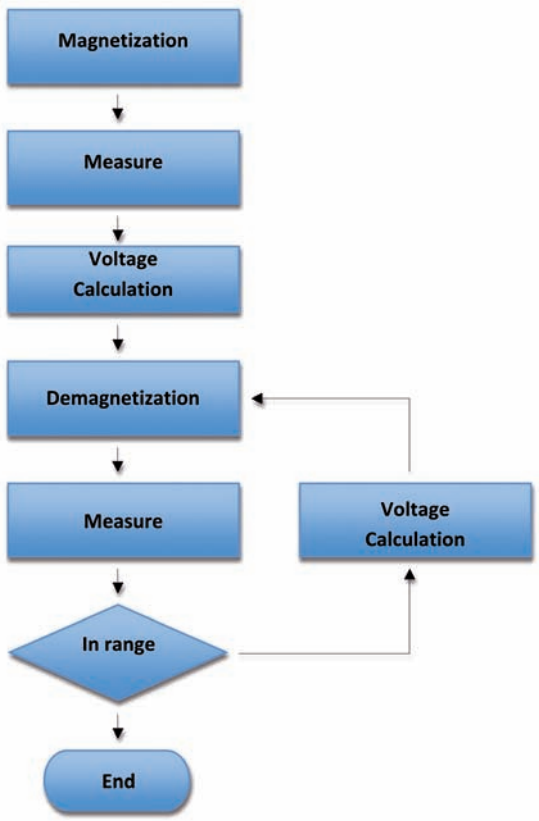
Magnetic calibration is required:

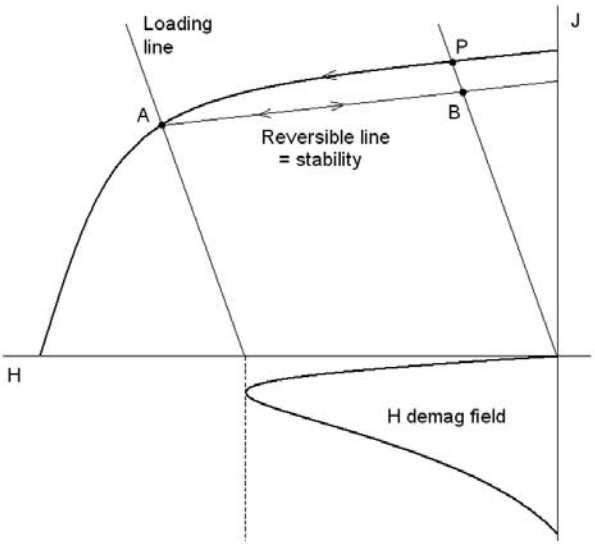
- when a desired field range is necessary for the product to meet optimal performance characteristics (within a certain level of tolerance);
- to compensate magnetically all possible mechanical tolerances;
- to stabilize the behaviour of the magnet to prevent variation during operation (due to external demagnetizing fields or thermal influences).
- to compensate variability from materials or vendors.



Magnetic calibration is achieved by saturating the product first and then demagnetizing it until it reaches the desired level. This is accomplished automatically by using a feedback control that measures the result at each demagnetization step and defines the next voltage as a function of the difference between the target and actual level.
This is repeated until the final target is reached.

Magnetic calibration requires a good charging voltage accuracy.





CALIBRATION PRINCIPLE

A device, such as an electrical motor or sensor, can experience irreversible losses if during its operation is exposed to demagnetizing fields or thermal variations.

Magnetic calibration is basically a light demagnetization process that is made before the normal working. By demagnetizing the magnet or magnet assembly assures stability against external influences.

CALCULATION METHODS

F.E.A. and other Methods

Advanced Electromagnetic Calculation and Simulation

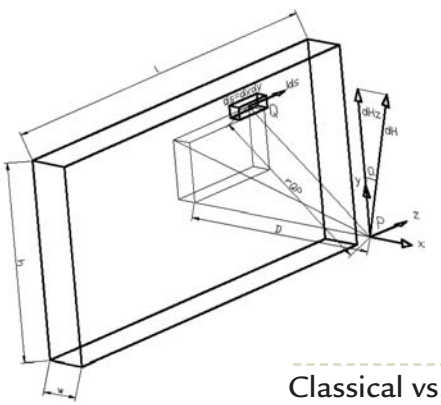
The project of a coil is based on complex studies of magnetic phenomena and makes use of advanced calculations techniques and simulation methods, such as:

- Classical Elementary Laplace Action Law
- Reluctance Net Method
- Finite Element Analysis (F.E.A.),

according to the complexity of the problem (see windows in next pages).
The elementary Laplace action law is used for simple geometries like wound coils, Helmholtz coils, solenoid, or even for more complex coils, i.e. Bitter coils and coils for sensors. In all cases, the relative simplicity of the calculation arises for the absence of ferromagnetic materials in the interested volume of space.

The reluctance method can be used even in presence of ferromagnetic materials; this applies when the geometry is relatively simple or can be divided in simple shape trunks. The reluctance is calculated in each trunk, and with iterative method it is derived the flux in each trunk.

The most general method is the Finite Element Analysis, and will be described in more details.



$$H(D, Xp, Yp, Zp) = \frac{J}{4\pi} \int_{-l/2-Zp}^{l/2-Zp} \int_{-h/2-Yp}^{h/2-Yp} \int_{D-Xp}^{D+w/2-Xp} \frac{\cos\left(\arccos\left(\frac{|(y)|}{\sqrt{(z^2+x^2)}}\right)\right)}{x^2+y^2+z^2} dxdydz$$

Classical vs. numerical methods

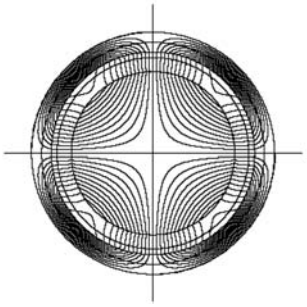
Finite Element Analysis (F.E.A.)

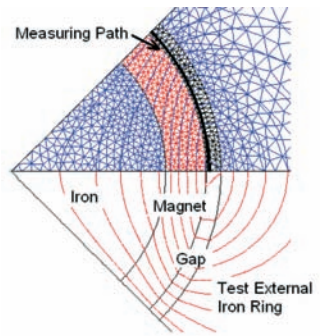
Using the Finite Element Analysis (F.E.A.), the domain is divided into several small cells and nodes and Maxwell equations are numerically solved under certain boundary conditions.
The domain can be considered in 2 or 3 dimensions, depending on the geometry of the system to be evaluated:

- 2D for simple rotors magnetization fixtures, axial coils, cylindrical symmetry, etc.;
- 3D for more complicated geometries, skewed fixtures and sensors.

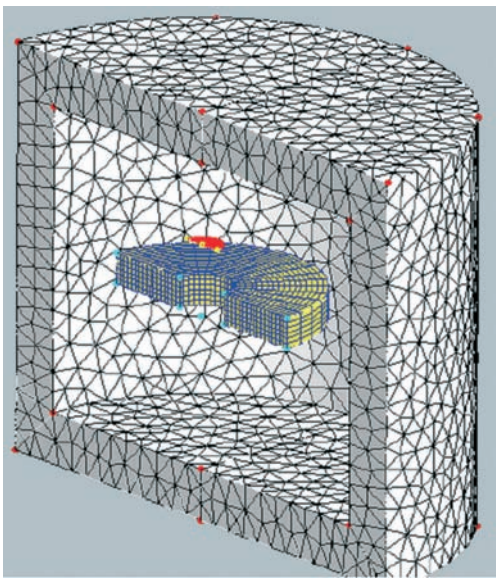
Due to the large and fast current pulses and changing fields that characterize our magnetization device, our projects request a complete analysis of the circuits in all their parts with the study of both electrical and magnetic phenomena.

Most magnetization devices produced by LEE are coupled to a capacitive discharge magnetizer that generates very high and fast current pulse in the coils. For this reason, it's necessary to perform a complete analysis, considering all physical factors that are correlated with fast-changing fields. Electrical circuit analysis cannot be considered separately from the magnetic design, because influences from inductance, resistance, eddy currents, magnetization of materials, etc. affects the final result.
The 'classical' calculation is in general not possible, especially if the final device is a motor, a sensor or an actuator.

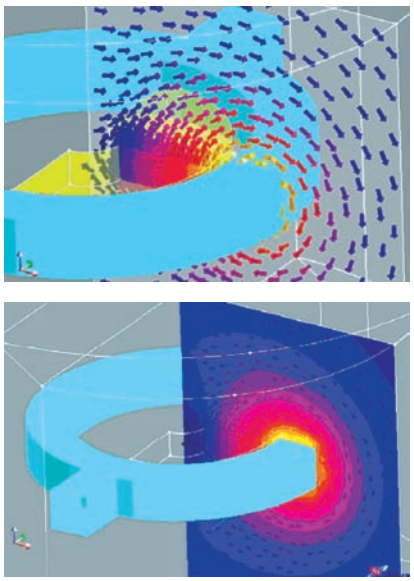




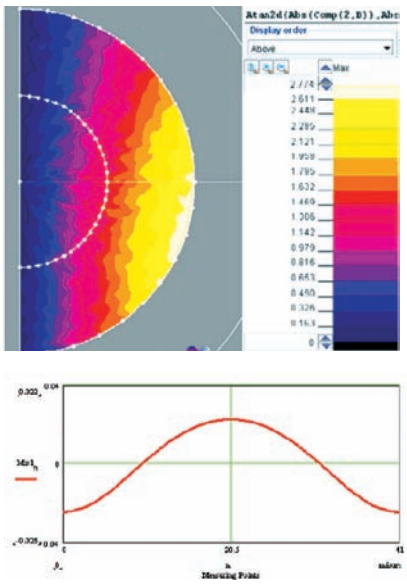
Finite Element Analysis provides the creation of a model of the system which can be either Magnetostatic or Transient. When the current is known, the first model is useful to view the flux path and compute the flux density on a support or at each point of the domain.
A 2D static computation requires a few seconds even for complicate geometries. 3D geometric analyses (transient model) are very time-consuming, and every particular symmetry helps to reduce the amount of modelling and calculations. For example, a 6-poles coil can be modelled only in one 60° sector.



Modelling



Coil analysis



Result on the magnet

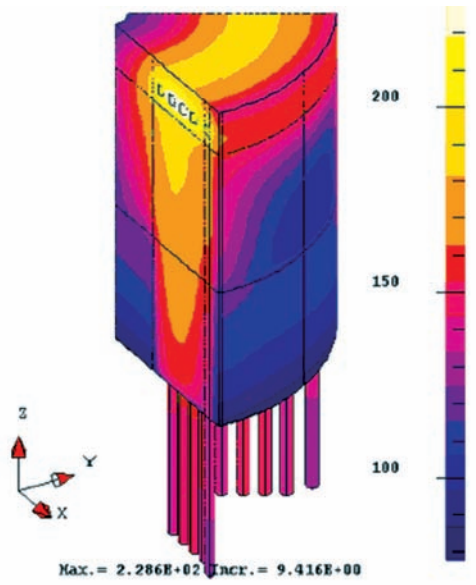
Realistic results are obtained only using proper material characteristics: induction B vs. magnetizing field H curve, permeability, specific losses, electrical conductibility, etc. Laboratorio Elettrofisico offers also a wide variety of measuring equipment and services for this purpose.

Thermal Analysis

To optimize the thermal exchange and determine the temperature level reached inside the coil during its working level, it is necessary to perform a thermal analysis using F.E.A. 3D.

The thermal results obtained with F.E.A. are unique, because it is often impossible to monitor the real temperature of some internal components of the coil, especially on coils with small dimensions. Even the rapidity of the transient makes it difficult to measure overheating conditions.

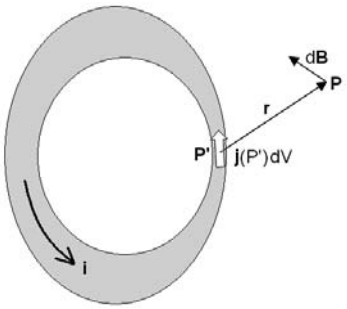
In general, 3D thermal analysis is long and difficult, due to the number of calculations and because the unknown or poor precision of thermal exchange coefficients.



Temperature map

Type of Magnetic Analysis

ELEMENTARY LAPLACE ACTION LAW



Used mainly in air or in presence of non magnetic materials. This method consists in the pure application of the Laplace's law upon elementary parts of the circuit, summing the resulting vectors for each part. The general equation is

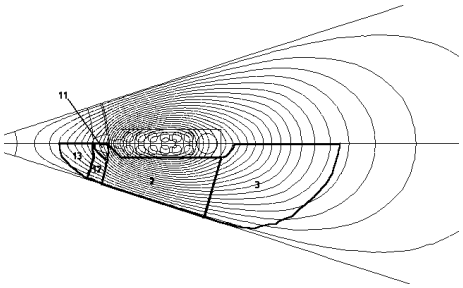
$$\boldsymbol{B}(P) = \frac{\mu_0}{4\pi} \oint_V \frac{\boldsymbol{j}(P') \wedge \boldsymbol{r}}{r^3} dV$$

where B in the point P is obtained integrating the current density j in the volume V where it is different from zero. If the volume is so thin that it can be considered a line l, then the formula becomes simply

$$\boldsymbol{B}(P) = \frac{\mu_0}{4\pi} i \oint_\ell \frac{d\ell \wedge \boldsymbol{r}}{r^3}$$

RELUCTANCES NET: CONCENTRATED PARAMETERS

The magnetic circuit (generally the ferromagnetic core of the coil) is divided in elementary trunks for which the calculation of reluctance R is simple. The basic principle consists of calculating the single reluctances R_i of all the single trunks. The inductance contribution L_i of the single trunk is inversely proportional to its reluctance. Then, from single reluctances it is possible to evaluate the total inductance L of the circuit, hence the calculation of max peak current i_p. The flux of the circuit will be simply $\Phi = L \cdot i_p$, and from Φ it comes the B in all the parts of the circuit.



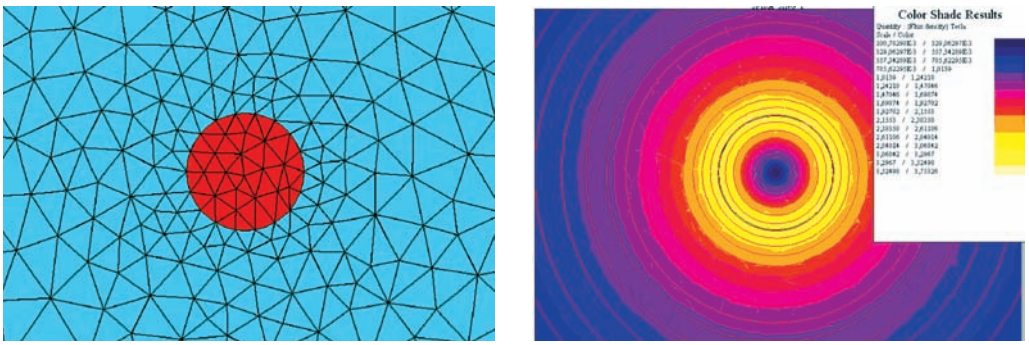
This method can be used in 2-D geometries and when the calculation of Ri is not complicated.

FINITE ELEMENT ANALYSIS

The finite element analysis (F.E.A.) is a numerical technique for finding solutions of systems described by partial differential equations, such as magnetic circuits that are described by the Maxwell's equations. The method is based on simplifying the partial differential equations to permit a numerical evaluation through standard mathematical techniques. This is done by dividing the domain under test into several small cells and nodes, and fixing certain boundary conditions on the borders.

The domain can be considered in 2 or 3 dimensions, depending on the geometry of the system to be evaluated:

- 2D for simple rotors magnetization fixtures, axial coils, cylindrical symmetry, etc.;
- 3D for more complicated geometries, skewed fixtures and sensors.



Example of calculation on a conductor carrying a current

MAGNETIZATION COILS

Overview

Exemple of an epoxy vacuum process

The first chapters of this catalogue introduced the magnetizing methods and coil calculations for complex magnetizing solutions required by the modern magnetics industry. Only an experienced well-established manufacturer can meet the demanding applications for quality and reliability.

With over 50 years of experience designing, manufacturing and providing solutions to top International Companies, Laboratorio Elettrofisico offers the widest range of high tech magnetizers and magnetizing coils designs, as well as integrated handling solutions.

The magnetizing coil is the most important part of a magnetization system. This overview provides a brief description for all the available models, as well as common characteristics of the magnetizing coils.

A list of the coils vs. main applications will guide you to the desired section. The magnetizers are described just after the coils sections.

There are standard categories for magnetizing coils, but not standard models with one exception: circular axial coils. Each magnetic device or application has particular dimensional characteristics, for example: the number of poles, the length, and type of material.

Magnetization coils models

The magnetizing coil design is based on matching the magnetizing coil and magnet (or assembly) to provide the best energy transfer.

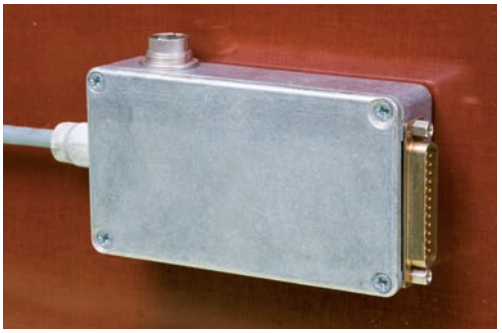
- CAB or CA (circular axial) and RAB (rectangular axial) coils can be used to magnetize 2-poles devices.
- HE models are designed mainly for multi polar assemblies, such as rotors (internal coil) or stators (external coil). If the magnetizing field requirement is radial, the field is directed from one pole toward the center of the coil, and turns are located in close proximity in the adjacent poles.
- SAT coils are a unique type of coil that optimizes the use of energy. SAT coils have a particular complex pattern, to achieve the appropriate results to minimize energy and cooling.
- MTC coils work together with a Pulse Transformer (PT): the PT replaces a high-voltage pulse and reduces it to a low-voltage pulse with extremely high amounts of current (up to 100 kA). The field generated is radial, and the typical application for MTC coils are stators.
- CAF coils are made with an Fe-Si core to enhance the field. This is extremely effective due to the slow pulse that fully penetrates through closed motors assemblies, allowing the magnetization at the final stage of production.
- NT Multi Pole coils are designed for small multi polar sensors, like encoders or ABS magnets, etc. The Micro Mag magnetizer is the suggested model due to the small amount energy required.
- Multi Pole Flat MP coils permit magnetization of flat magnets, like holders or refrigerators magnets.

TYPE	FIELD DIRECTION	NUMBER OF POLES	APPLICATIONS
CAB, RAB CA	Axial	2	Single magnets 2-poles motors Loudspeakers Relays
HE, SAT	Radial (internal or external)	2 and multi polar	Rotors Stators Sensors
NT	Radial	2 and multi polar	Sensors Encoders
MTC	Radial external	2 and multi polar	Stators
CAF	Axial	2	Complete 2-poles motors
Flat MP	Axial	Multi polar	Holders Refrigerators magnets

Common characteristics

CODE BOX

To prevent improper or dangerous operation, each coil is provided with a safety circuit named Code Box.
The Code Box is an electronic circuit that stores the coil's characteristics, such as the maximum voltage or maximum working temperature.
All Laboratorio Elettrofisico coils design requires connection to a Code Box to operate the magnetizer. If the Code Box is not connected or is by-passed, the magnetizer will not operate.



When connected to the magnetizer, the Code Box permits the magnetizer to:

- Limit a preset max voltage
- Limit the minimum cycle time
- Stop the magnetizer operation if the temperature exceeds the max limit (typically between 80 and 120 °C)
- Read the total flux of the magnetic device (HE, SAT, MTC models only)
- Read the actual temperature of the coil (when connected to Midi Mag and Maxi Mag only).

FAST CONNECTORS

The power connection of the magnetizing coil is a crucial point. The contact between the coil's cable terminals and the magnetizer's power terminals must be properly connected: these connections conduct high currents up to 20-30 kA, and it is necessary to remove the potential of hazardous and dangerous electrical arcs and shock.
Moreover, the high current pulse exerts electrodynamics forces on the cables, and over a period of time will cause the cables to loosen.

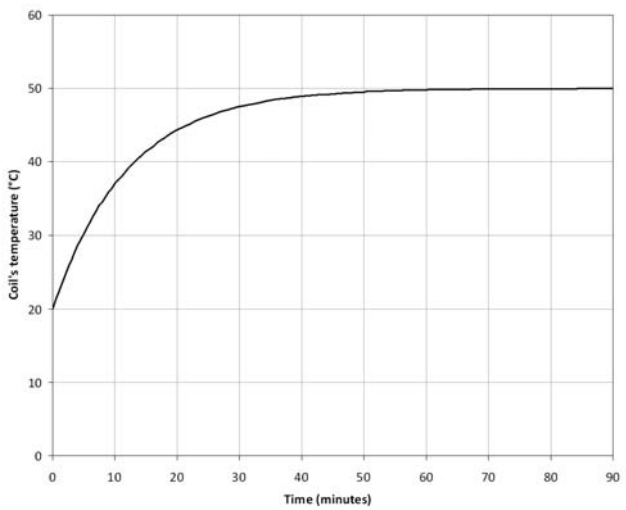
To avoid dangerous and hazardous conditions, Laboratorio Elettrofisico uses fast power connectors for its coils and magnetizers. This connector is bayonet style coupling that's guaranteed for very high currents and strong forces.
If for any reason the connector fails or if contact resistances change, the safety interlock will detect it and stop the operation of the magnetizer.

To eliminate any possible incorrect connections to the magnetizer and coil, connectors are specific for positive and negative polarity.
This will ensure the proper magnetizing polarity is adhered to.
We also offer the option to provide the same connectors for both polarities, to easily change the final magnetizing polarity on the coil.
The fast connectors can be easily mounted on old coils and magnetizers design. If you have any concerns regarding the connection to your magnetizer and coils please contact us today. Our technical application engineers will be glad to assist you.

COOLING SYSTEMS

The energy discharged into the coil produces heat, that must be dissipated to avoid thermal runaway.
Our coils are designed and optimized for efficient heat dissipation through the specific internal placement of conductors and laminated core materials.
When static air is not enough, we offer options to properly cool the magnetizing fixture.

A fan removes warm air from the coil. The air flow is guided through a specific path inside the coil across hot surfaces of the conductors. For some particular applications, it's more efficient to circulate cold air in the coil or on the surface.



Typical heating curve of a coil

Forced air cooling can create noise; however the noise can be limited and reduced to zero with suitable sound-absorbent materials. Some types of magnetizer models are equipped so the fan will switch on when the temperature of the coil is over a preset safety level.

Water cooling is used when the coil is particularly small or when the geometry doesn't allow air cooling. The water cooling method is a closed circuit cooling system, pumped by an external chiller.

Plumbing for the water, the cooled fixture is embedded within the fixture itself. Should a leak occur, the magnetizing fixture has built in sensors to detect a leak to ensure there is no cooling loss.

MAGNETIC FIELD MAPPING AND PROTECTION FROM MAGNETIC FIELDS

Are magnetic fields dangerous for the health? There are many studies on this topic, and the results are not always conclusive. Each country adopts their own safety policies, indicating limitations on magnetic field exposure produced by electrical machines. Generally, magnetic field limits depend on the frequency: the higher the frequency of the magnetic field, the lower is the limit.

Laboratorio Elettrofisico considers personal safety first and monitors and maps the (pulsed) magnetic field produced by our magnetizers and coils. We evaluate and determine safe distances according to the most recent regulations and will provide appropriate shielding when necessary.

Our line magnetic instrumentation products provides complete and precise mapping of magnetic fields. Should you need or want to have your magnetizer and fixture tested to determine safe exposure levels, Laboratorio Elettrofisico offers this service and would be pleased to answer your questions.

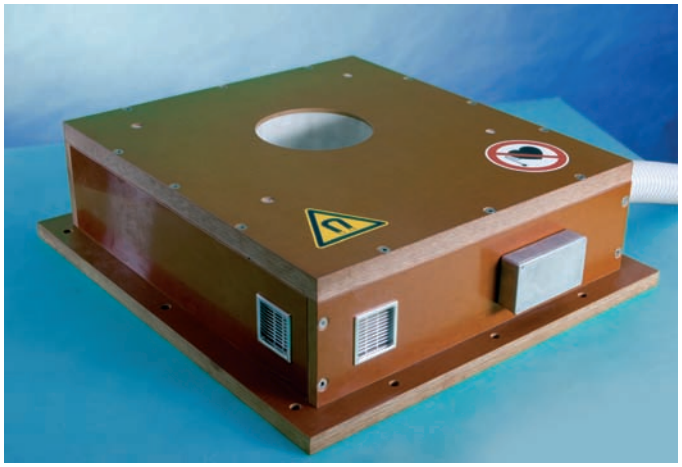
Warning signs applied on magnetizing coils:

- General warning for presence of magnetic field;
- Warning to keep distances for pace-makers holders

AXIAL MAGNETIZING COILS

Models: CA - CAB and RAB

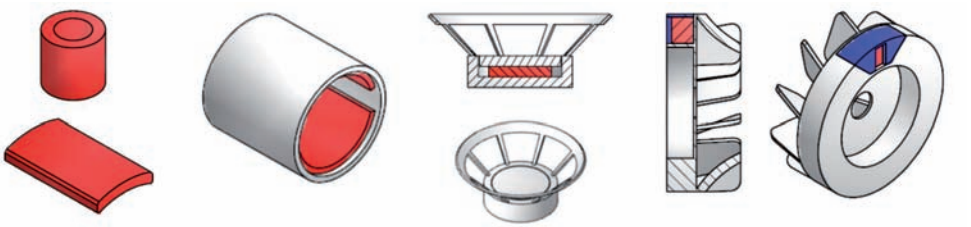
Axial magnetizing coils generate a magnetic field directed on the axes of the coil. The basic principle is the same of the classical solenoid: the currents flows in the coil following a helicoidally path, producing a field that is more or less axial in the winding volume.



The Axial Coil:
the most versatile
Robust and
reliable

Axial coils are produced in two main configurations:

- Winding conductive turns in a spiral path on a suitable support (circular or rectangular)
- Staking different conductive disks, insulated except a connection area, where the current flows spiraling like in a solenoid. This type of coil design is known as a Bitter Coil.

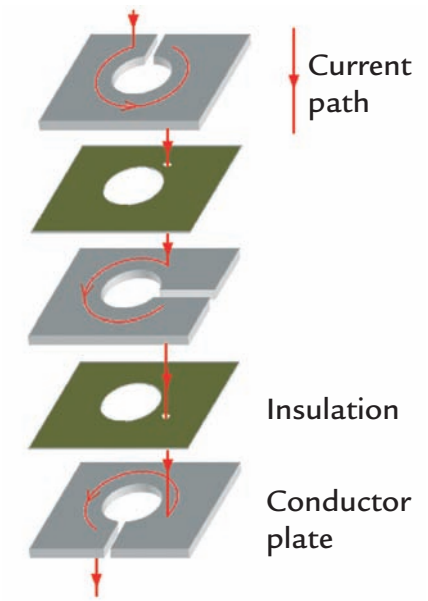


Magnets, arcs | 2-poles rotor | Loundspeaker | Flywheels

Laboratorio Elettrofisico indicates the first wound type with the CA prefix, while the Bitter coil type has the prefix CAB (circular coil) or RAB (rectangular coil). The numbers after the prefix indicate the hole dimensions and the last the height (in mm).

For example:

- CA50/60 is a circular wound coil having useful diameter of 50 mm and a height of 60 mm.
- CAB80/100 is a circular Bitter coil having useful diameter of 80 mm and a height of 100 mm.
- RAB50-80/100 is a rectangular coil having 50x80 mm hole dimensions and 100 mm height



Working principle of Bitter coils

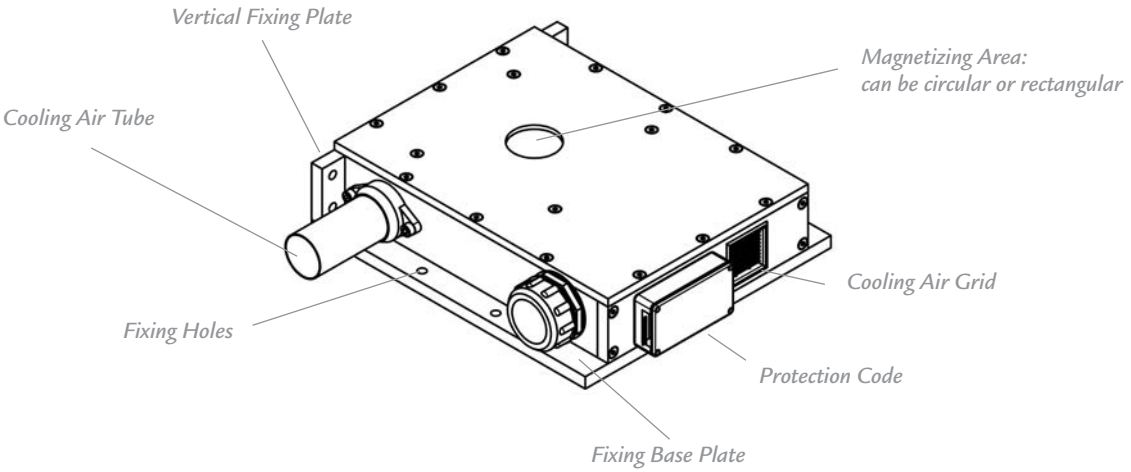
The table below shows the main advantages of the two types of coils:

WOUND COIL (CA)
Lower peak current to reach the same field respect a CAB
Higher peak time with same energy configuration
Simple construction
Can be used in a dirty environment

BITTER COIL (CAB OR RAB)
Lower energy to reach the same field respect a CA
Excellent heat dissipation
More robust, better strength resistance
No resin necessary
Lower current density
Easy to maintain

Due to superior characteristics of the Bitter Coil design, it is the preferred type of magnetizing fixture for today's demanding environment and applications

Axial coil are also very versatile: they are used to magnetize, demagnetize, calibrate all 2-poles magnets and magnetic devices that can be placed in the central bore of the fixture. The maximum magnetic field is axially oriented.

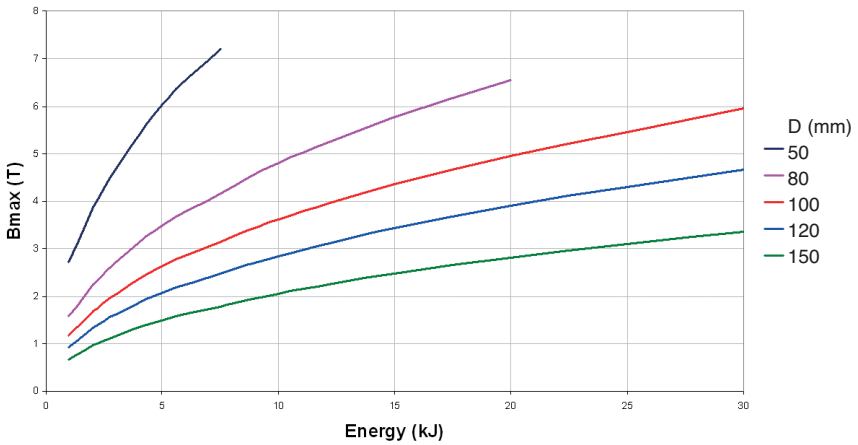


USE

- Single magnets
- Loudspeakers
- 2-poles motors
- Diametrical magnetization of cylinder
- Magnetic clamps
- Flywheels

GENERAL FEATURES

- Can be used for many products (not required to fit the product size)
- Robust and reliable
- Good power dissipation and cooling
- Many standard models available
- Fast connectors and box code included



B_{max} vs. energy for CAB axial coils having equal diameter and height (D/L = 1).
B_{max} is the field in the centre of the coil.

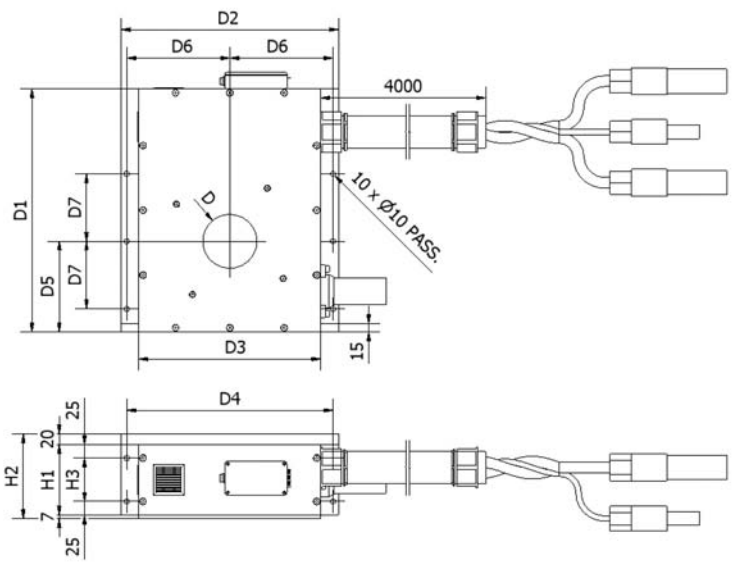
TECHNICAL SPECIFICATIONS

Max voltage	3500 V
Max current	20 000 A (1)
Max power without cooling	100 W
Max power with cooling	3000 W
Max temperature	80 ÷ 100 °C
Temperature sensor	Included
Thermal switch	Included
Box code	Included
Cooling connection	Included
Cable length	4 m (2)
Power connectors	Fast connections

(1) the current limit can be increased by providing special modifications on the coil
(2) Cable length can be increased up to 10 m

D [mm]	H1	H2	H3
H[mm]	H+11	H+36	Depend on the model

D [mm]	D1	D2	D3	D4	D5	D6	D7
30<D<50	320	280	215	250	107,5	125	75
50<D<100	390	350	285	320	142,5	160	105
100<D<150	460	420	355	390	177,5	195	140



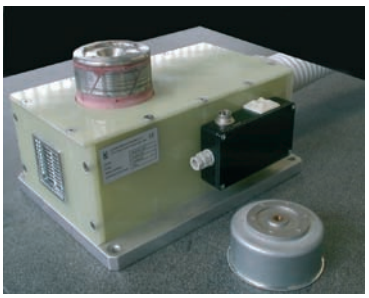
A rectangular axial coil (RAB) used to magnetize a small 2-poles motor

HE COILS

Multi Polar Coils

High Energy (HE) coils are multi polar magnetizing fixtures.
They are provided in two configurations:
External HE coils are designed to magnetize magnetic assemblies such as rotors,
Internal HE coils are designed for stators or flywheels.

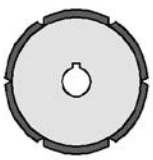
External HE - Rotors, sensors



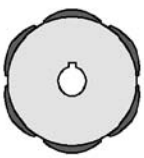
Internal HE - Stators, flywheels

The design of the N-poles in HE coils consists mainly of, a laminated steel core configured with N slots wound with copper wires. The conductors can be positioned to generate a magnetic field with the desired pattern on the magnetic device, for example; radial, diametric, trapezoidal, sinusoidal, Halbach, etc.
The HE coils can be used with all types of magnetic materials such as NdFeB, SmCo, Ferrite, Alnico, bonded magnet or sintered, isotropic or anisotropic.
All main configurations of rotors and stators can be properly magnetized with HE Coils.

Ring



Segments

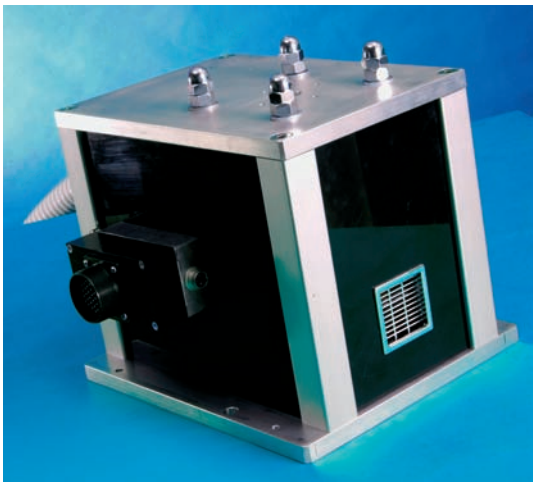


Shaped segments

Shielded magnets

Internal magnets

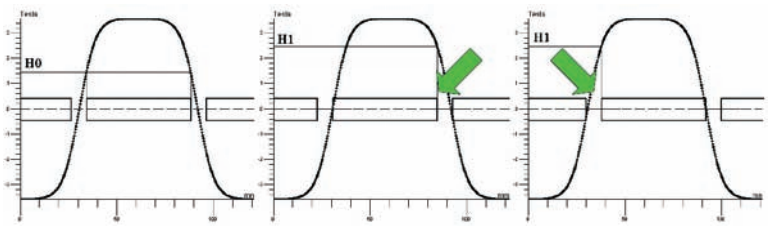
V-shaped internal magnets



HE COILS
High Energy
Multi polar coils
Rotors
Stators
Flywheels
Sensors

BENEFITS OF USING HE COILS:

- Reduces cogging torque, through a skewed magnetization technique.
- If spacing is required between magnets, the edges can be accurately magnetized.
- For applications that require little or no spacing between magnets, a three shots technique will guarantee the proper magnetization, moving the edge toward the center of the pole, where the field is higher.



Three-shots technique:
the first central magnetization shot prevents demagnetization on the edges. The second and third shot magnetize the right and then the left edges of the magnet.

- A sinusoidal magnetization pattern can be achieved through proper design using iterative software procedures in conjunction with Finite Element Analysis (F.E.A.). The internal material will be completely saturated in a configuration called Halbach magnetization. Very low THD can be obtained.

SINUSOIDAL MAGNETIZATION

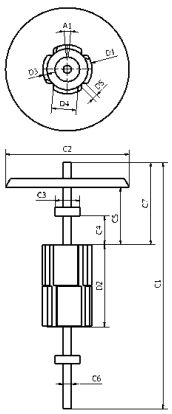
Sinusoidal magnetization is required to:

- Reduce torque oscillations and noise level
- Reduction of losses

The benefits of sinousoidal magnetization will overcome a reduction of the total flux, that means a reduction of the torque. It's only possible for isotropic magnets.
The Halbach magnetization allows the sinusoidal condition, giving a magnet internally fully saturated, reducing the influences from external demagnetization fields.
Sinusoidal condition is often required, but not only, for AC brushless motors having concentrated windings.

Radial Type
$B_\rho = Br$
$B_\theta = 0$

Halbach Type
$B_\rho = Br \bullet \cos(\rho\theta)$
$B_\theta = Br \bullet \cos(\rho\theta)$



LISTED BELOW ARE THE MAIN PARAMETERS REQUIRED TO MAGNETIZE AN ASSEMBLY OR DEVICE.

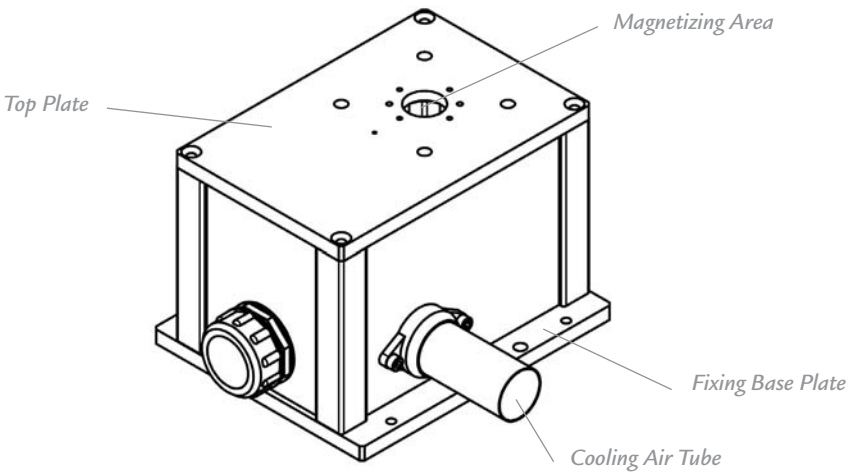
- Geometry: number of pole pairs, max. diameter, stack height, distance between magnets, skewing
- Magnet material: isotropic, anisotropic, sintered, bonded, segments ring, etc.
- Magnetic shape: sine wave, square wave, max flux density, THD, pole pitches accuracy
- Specific features: presence of bearing assemblies, an impeller, sensors to be protected or to magnetize, and shafts, etc.
- Type of desired process: automatic, manual, and the number of pieces per hour.

TECHNICAL SPECIFICATIONS

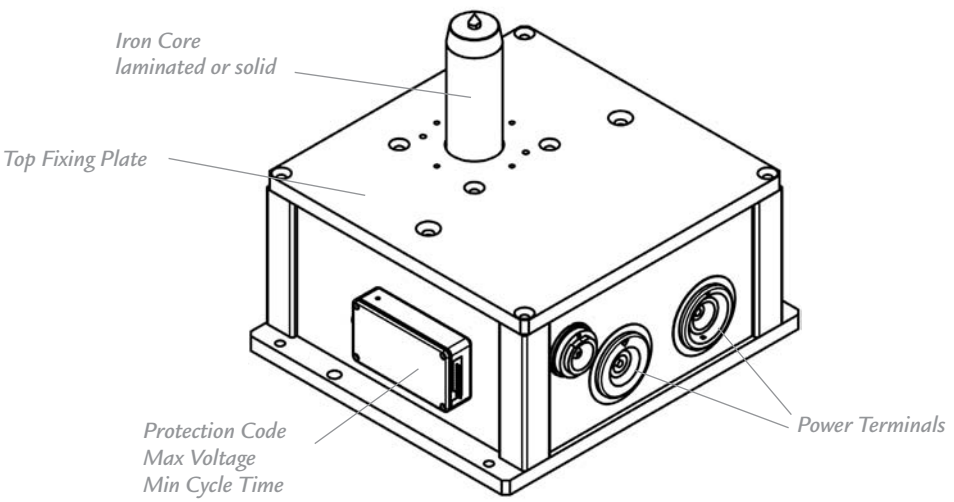
Max voltage	3500 V
Max current	20 000 A (1)
Max temperature	80 ÷ 100 °C
Temperature sensor	Included
Thermal switch	Included
Box code	Included
Cooling connection	Included
Cable length	4 m (2)
Power connectors	Fast connections
Size	3 ranges of diameter: Ø < 50; 50 < Ø < 100; Ø > 100

(1) the current limit can be increased by providing special modifications to the coil
(2) Cable length can be increased up to 10 m

EXTERNAL HE COIL



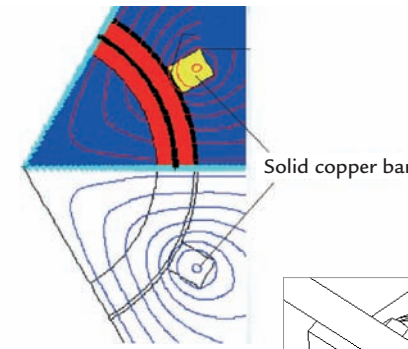
INTERNAL HE COIL

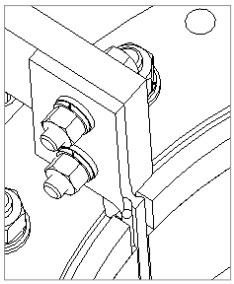


SAT COILS

Multi Polar Coils

Laboratorio Elettrofisico SAT coil is a high performance multi polar magnetizing fixture for rotors using NdFeB or SmCo materials.
Due the unique technology that's incorporated in the design, this product is used to magnetize, demagnetize and calibrate large and small rotors assemblies, even for designs that require a very narrow space between poles.



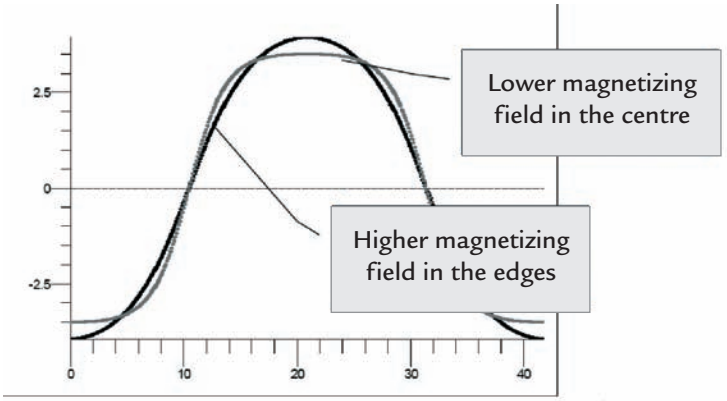


THE SAT COIL DESIGN PROVIDES ADVANTAGES OVER THE TRADITIONAL STYLE FIXTURES:

- Lower energy requirement
- Improved efficiency, especially in the area of pole borders
- Very low heating, that provides higher production rates (no cooling necessary!)
- Low maintenance costs with no core coil rebuild

The core of a SAT coil consists of a laminated steel magnetic circuit that operates as an efficient flux amplifier. The magnetizing area consists of a single solid copper bar that provides very high currents and very high magnetic fields to all pole surfaces. This design improves the efficiency of magnetization both in the center and at the edges of the poles.

High current concentrated in one single conductive bar increases the magnetic field strength in the edges of the pole

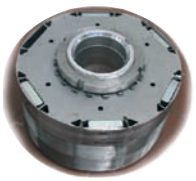


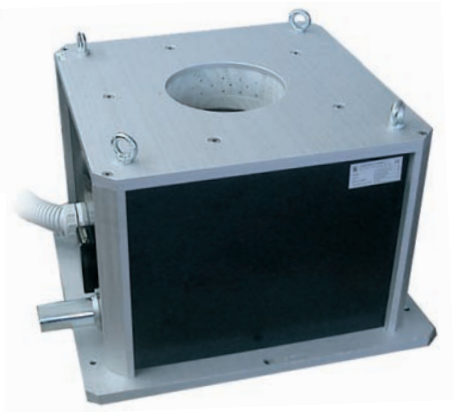
High Energy Multi polar coils
Rotors
Stators
Flywheels
Sensors

TECHNICAL SPECIFICATIONS

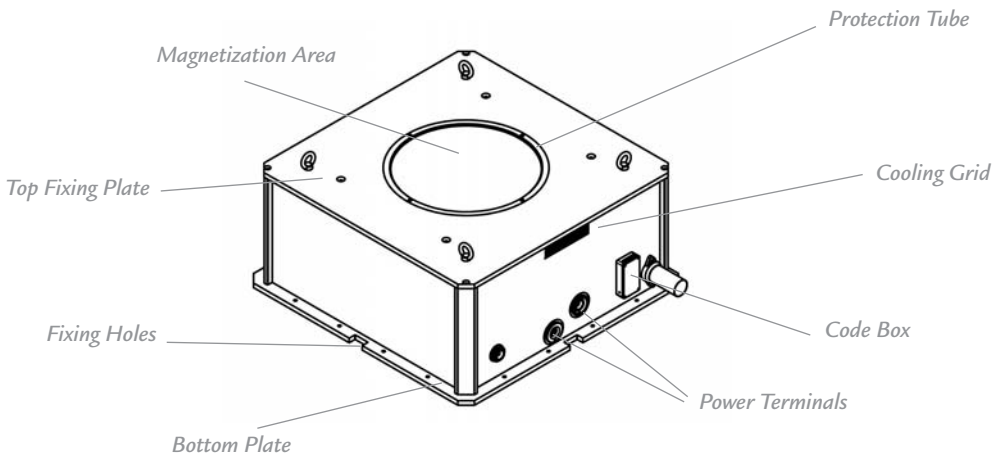
Max voltage	3500 V
Max current	100 000 A (1)
Max temperature	80 ÷ 100 °C
Temperature sensor	Included
Thermal switch	Included
Box code	Included
Cooling connection	Included
Cable length	4 m (2)
Power connectors	Fast connections

(1) the current limit can be increased by providing special modifications to the coil
(2) Cable length can be increased up to 10 m





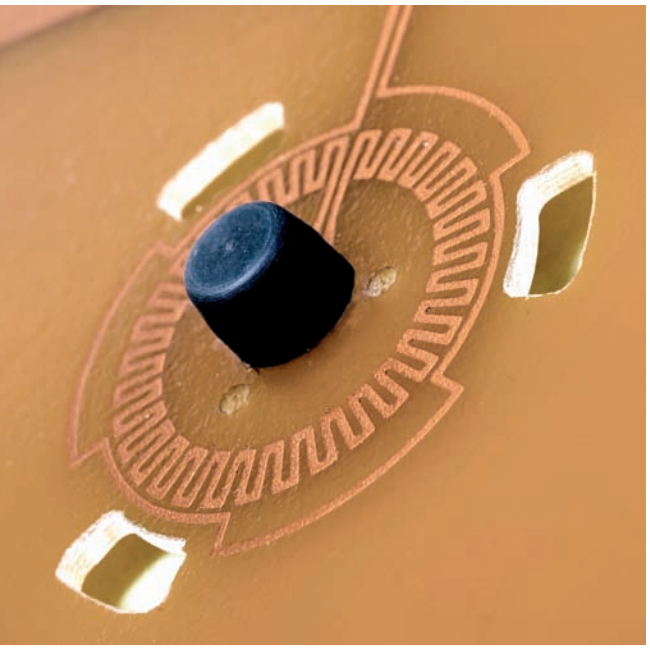
This new state of the art technology has experienced proven results and wide acceptance around the world.
The results obtained with this type of coils are excellent.



COILS FOR SENSORS

Iron-Less Multipolar Coils

NT Multi Polar coils differ from other magnetizing coils by the precise imprint of the magnetization on the part. Typical applications are magnetic sensors and encoders.



Magnetic encoders incorporate a magnetic sensor that detects variations of magnetic field intensity produced by a multi polar magnetized material. The multipolar magnet is fixed to a rotating device, so that the field reading provides an indication on the angular displacement or angular speed of the device.

The magnetic material is generally a layer of bonded ferrite or NdFeB, that is often mounted to a rigid ferromagnetic plate or ring.

These multipolar coils don't use iron, so that it is avoided any coupling situation between magnets and coil.

Multipolar Coils for Sensors

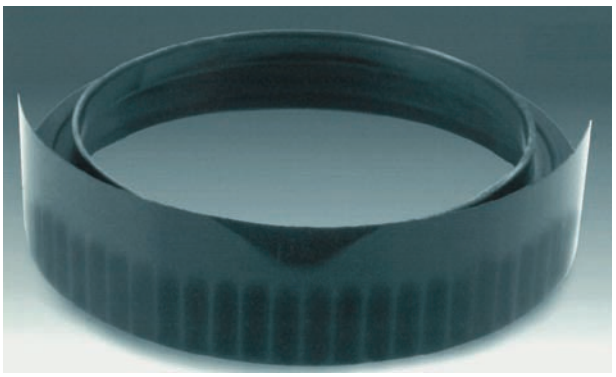
Precise magnetic pattern

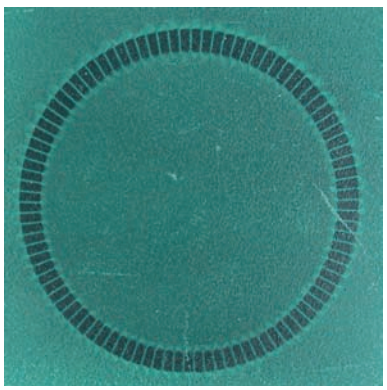
ABS – Encoders – Sensors – Small motors

To achieve the required magnetic precision, it is necessary to control mechanical precision on the coil itself. Laboratorio Elettrofisico employs state of the art technology that ensures the desired accuracy is achieved in each and every step of the coil's production:

- Accuracy on the coil's substrate
- Accuracy on the conductor
- Accuracy on the assembling

The assembled coil is inspected using a computer controlled optical microscope that guarantees all mechanical tolerances are met.
Once all these mechanical tolerances are verified, a final magnetic test is conducted to ensure the results on the magnet meet the application requirement. This final test verification is completed using the Laboratorio Elettrofisico precision Magneto Scan.





Precise multipolar coil magnetization

MAIN FEATURES

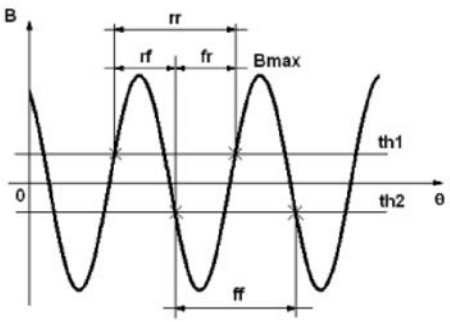
- Precise magnetization results
- Precise mechanical technology
- Low energy requirements
- Fast production rate
- No iron = No magnetic forces after the magnetization

TYPICAL REQUIREMENTS FOR SENSORS

Magnetic encoders are widely used in the automotive industry, so there are particular strictly specifications that must be satisfied.

Here is a summary of the main definitions and requirements for magnetic encoders:

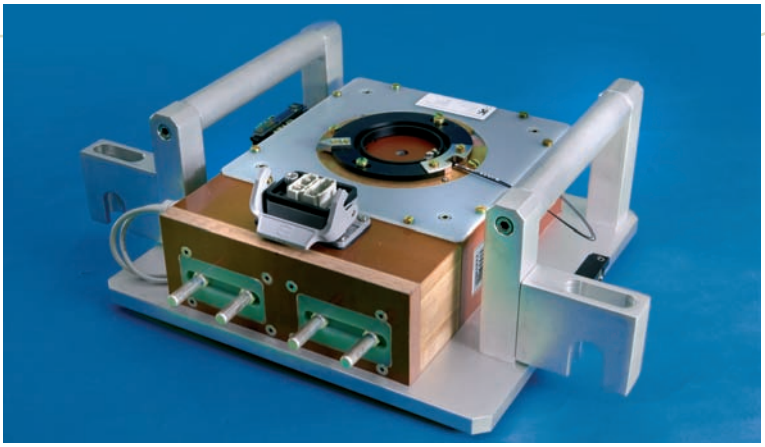
pitch	angular distance between poles pairs
th1, th2	thresholds for the magnetic sensor
rr	raise to rise pitch
ff	fall to fall pitch



The poles accuracy is defined with:

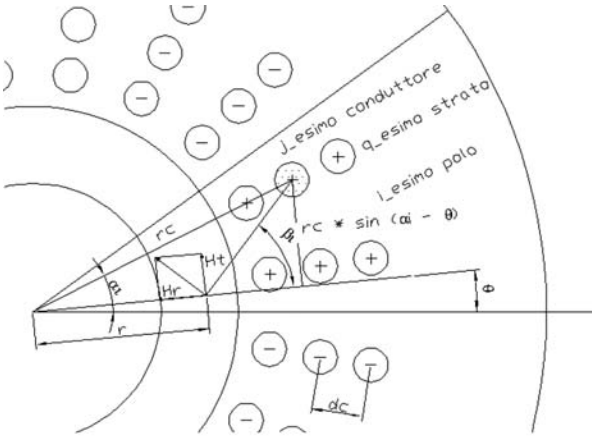
rrs	raise to raise single pitch deviation: difference between maximum positive and negative raise to raise pitch deviation (rr) from average or nominal value
ffs	fall to fall single pitch deviation: difference between maximum positive and negative fall to fall pitch deviation from average or nominal value
rffrs	raise to fall - fall to rise single pitch deviation: difference between maximum positive and negative rise to fall - fall to rise pitch deviation from average or nominal value
rrt	raise to raise total pitch deviation: difference between maximum positive and negative of the algebraic summation of all the rrs
fft	fall to fall total pitch deviation: difference between maximum positive and negative of the algebraic summation of all the ffs
rffrt	raise to fall fall to raise total pitch deviation: difference between maximum positive and negative of the algebraic summation of all the rffrs

In most practical cases, the poles width must be almost perfect to satisfy the hard requirements of automotive industry, and this can be achieved only with an excellent command of this technology and a great experience.

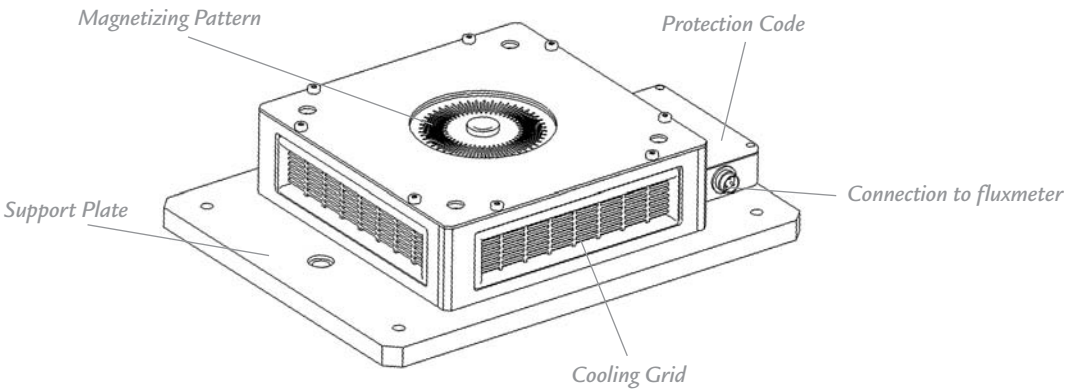


TECHNICAL SPECIFICATIONS

Max voltage	3000 V
Max current	30 000 A
Max temperature	50 ÷ 80 °C
Temperature sensor	Included
Thermal switch	Included
Box code	Included
Power connectors	Fast connections



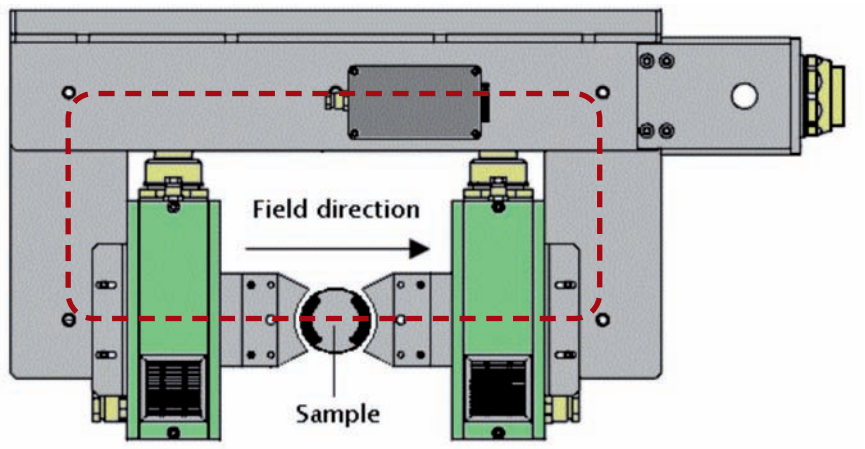
Accurate Calculations
Accurate Design
Accurate Mechanics
Accurate Assembling
Accurate Controls
= Accurate Results



CAF COILS

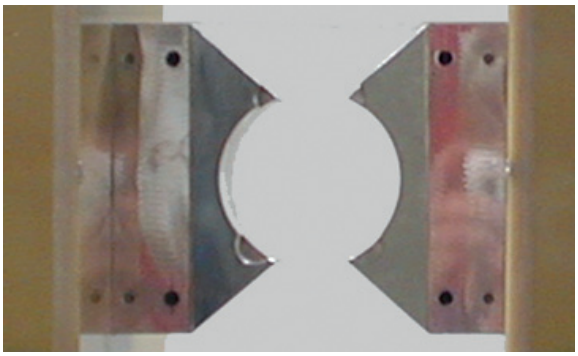
C-core Pulse Coils

CAF coils consist of two pulse coils mounted in a C-shape steel yoke. The laminated steel yoke enhances the field produced by the coils and drives the flux across a fixed air gap, where the sample is placed.
The poles are shaped to match the sample configuration to minimize the air gap. (shown below)



CAF coils are designed to magnetize completed 2-poles motors assemblies, with sintered or bonded ferrite magnets. The electrical characteristics of the CAF coil produce a slow magnetizing pulse, to fully penetrate the motor, without any damage to the motor assembly circuitry (DC motor brushes) from the induced voltage.

Specific applications are rotors and housings.



Long pulse for finished motor magnetization

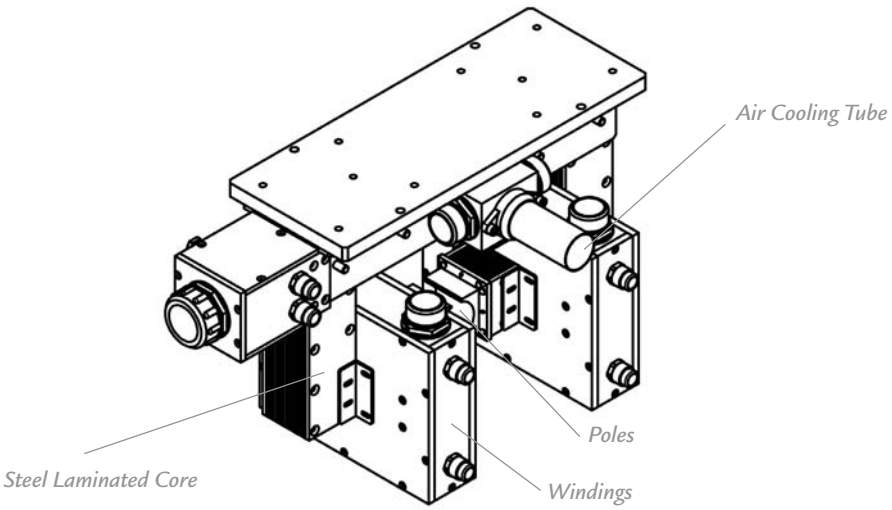
TECHNICAL SPECIFICATIONS

Max voltage	3000 V
Typical current	< 2000 A
Typical peak time	1÷10 ms
Max temperature	80 ÷ 100 °C
Temperature sensor	Included
Thermal switch	Included
Box code	Included
Cooling connection	Included
Cable length	4 m
Power connectors	Fast connections
Pole section	50 x 50 mm (1)
Pole gap	100 mm (1)

(1) can be customized under request

GENERAL FEATURES

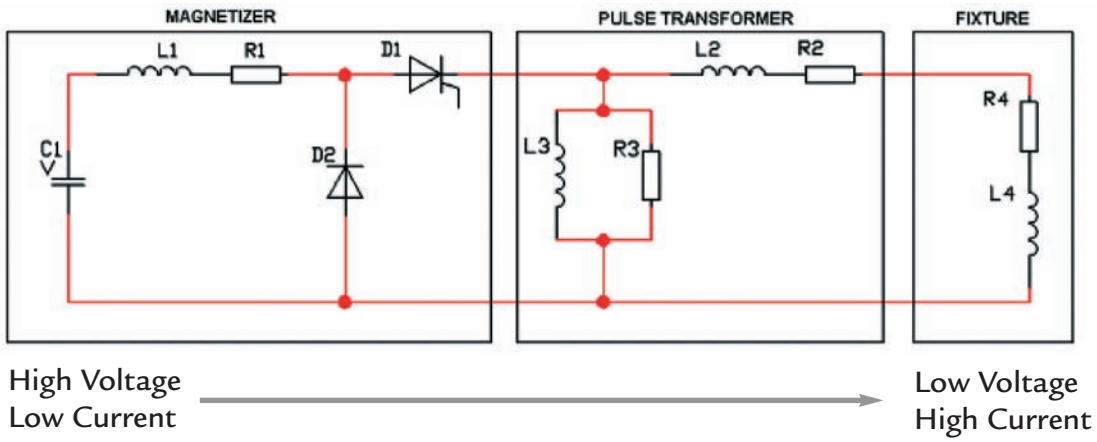
- Slow magnetizing pulse
- Robust and reliable
- Excellent power dissipation and cooling
- Provides complete closed motor magnetization
- Fast connectors and box code included

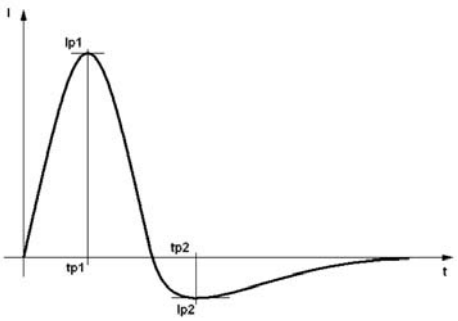


MTC COILS

Solid Copper Coils

MTC coils are made by a single copper conductor having large cross section. They are used when a single conductor carrying a high current is convenient respect a conventional coil with multiple turns carrying lower current.
Peak current can reach up to 100 kA, due to the very low resistance of the coil design. Proper operation of the MTC coil requires that a pulse transformer is connected between the magnetizer and MTC coil, as shown below.

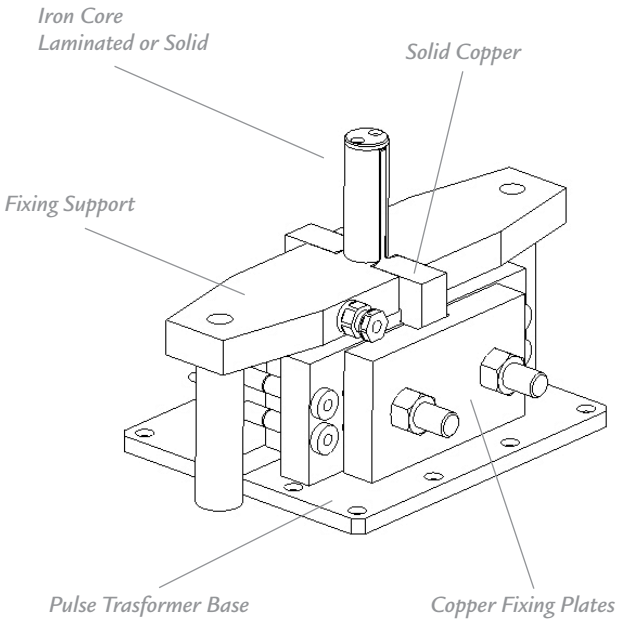




The magnetizer is connected to the primary side of the transformer, while the coil itself is the secondary circuit.

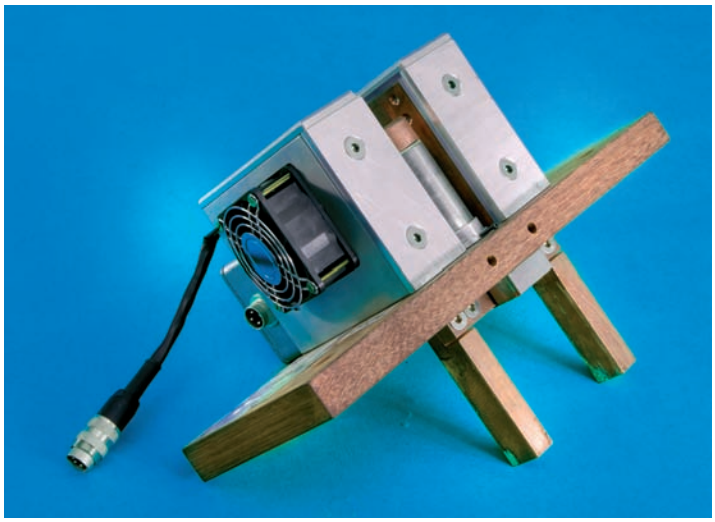
Most of the high-voltage power from the magnetizer is transferred to the coil at low voltage, resulting in a large current pulse.

The mean value of the current in the secondary circuit is zero. This implies that, other than the first magnetizing peak, there is a secondary negative peak that must be kept with lower amplitude and wider time duration. The secondary peak can be minimized by a proper design.



As indicated, the MTC coil is made basically using a single copper conductor wounded in a iron core (laminated or solid), mounted to a non-magnetic base. The MTC coil is connected to the pulse transformer by two robust copper blocks. These blocks are precisely positioned to the mounting plates in the transformer, minimizing the electrical resistance.

Typical applications: Stators, Flywheels, Housings, Axial flux monitors and skewing.
When possible, a cooling system is provided directly in the coil's basement, as shown in the picture.



MTC Coils: the highest current pulse (up to 100 kA)

MTC coils can be used with a variety of magnetic products, generally stators with alnico or ferrite magnets, isotropic, anisotropic or bonded.

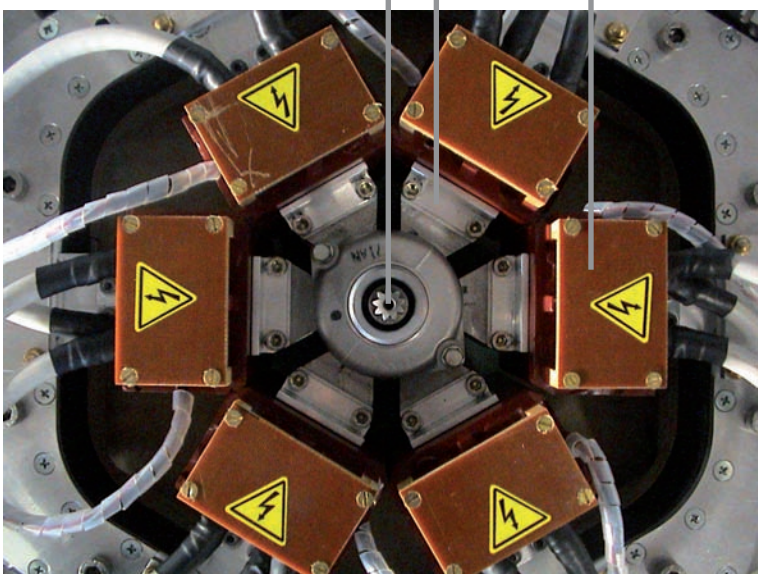
Magnetization, demagnetization and calibration are also possible.

SPECIAL COILS

Custom-Made Solutions with Classic Examples

Demanding technology and the necessity for high quality requires specific coils solutions and designs.
The modern calculus instruments (F.E.A.), combined together with the wide experience of our staff, allows Laboratorio Elettrofisico to consider an infinite number of special magnetizing requests.

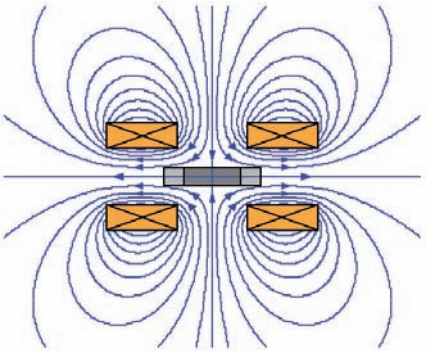
Below exemplifies some of the examples of 'unconventional' magnetizing coils we have product to meet the customers application.

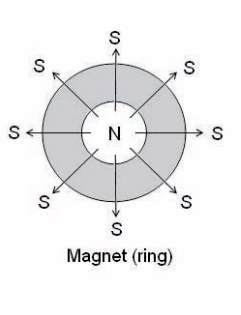


6-poles coil with mobile expansions

MULTI POLAR COIL WITH MOBILE EXPANSIONS

This 6-pole coil design was developed for 6-pole motors having different diameters utilizing one assembly coil. This design was to match the various rotor diameters and it was necessary to design the fixture to accommodate the polar expansion and curvature of motor design. Precise contact with the motor surface was required to ensure efficient magnetization due to the mobility of the poles that move back and forth for processing. Like most CAF type coils, the field pulse is slow enough to fully penetrate inside the motor case, where the magnets are positioned.





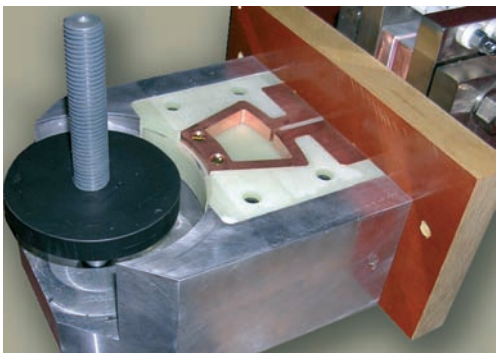
PURE RADIAL COIL

A pure radial magnetization means that in a magnetic sample, having ring shape, the magnetization inside is always radial and the verse is from inside to outside (or vice versa), so that the external surface has one polarity and the internal surface the opposite polarity. This condition is generally achieved using two axial coils having its axis in common but connected in opposite phase, to produce a repulsive magnetic field between the two coils. This is explained in the schematic on the left.

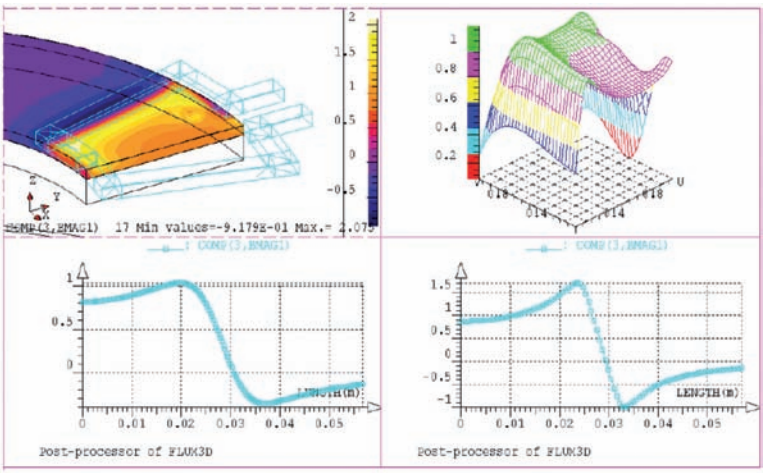
Generally, the coils are closed in a unique rigid structure, since the repulsive magnetic field exerts a very strong force on the coils.
Access of the sample is limited to a suitable aperture size.
To facilitate the insertion and to better 'drive' the field lines, special handling tools are developed, which is specific to the design of the sample's dimension, material, anisotropy, etc.
On the right, one insertion tool is shown for a radial sample.

BIG MULTI POLAR AXIAL COIL

When axial applications require large currents and many poles, it's customary to use an axial single-pole coil. This coil is similar to a MTC coil, with an appropriate rotating mechanism to position in sequence all the poles to magnetize over the coil.



Suitable for big axial motors.
Ironless core, fast pulses permitted.
Automatic rotational system



MAGNETIZERS

Overview

A magnetizer is a power source that provides energy to produce the desired current pulse in a coil. The fundamental operation of a magnetizer is that it charges and stores energy until the magnetizing process starts: at that point, the power circuit is closed on the coil and the energy is then discharged into the coil.
The same magnetizer can be used with any coil, assuming the magnetizer has a sufficient amount of energy.
Basic functions of magnetizers can have many different characteristics, for example: energy, voltage accuracy and regulation, mag/demag capability, internal logic, expansibility.

MODEL	XLE	MICRO MAG	MICRO CAL
Max energy	1000 J	1400 J	5000 J
Max voltage	800 V	2500 V	800 or 3000 V
Voltage accuracy	± 5 %	± 5 %	± 1 %
Voltage display	No	Yes	Yes
Demag option	No	No [1]	Yes
Max number of outputs	1	1	1
Direct coil's T measurement	No	No	Yes
Optimized cooling control	No	No	Yes
Remote control via pc	No	No	via MPI or RS232

1. Micro Mag and Compact models cannot be provided with both magnetization and demagnetization capability, but they can be supplied to have magnetization only or demagnetization only.

MAGNETIZER OVERVIEW

Laboratorio Elettrofisico magnetizers can be divided in 6 main categories, depending on the energy requirements and features.
When choosing a magnetizer, consideration should be made not only for the energy required and options, but even for the ability to upgrade the basic model with additional features to accommodate future changes in processes for new applications and new coil designs.

MAIN OPTIONS:

max energy, upgradeable base unit, demagnetization or calibration capability, number of coils that can be connected (reference 'max number of outputs' in the table), direct temperature control of the coil, etc.

COMPACT	MIDI MAG TS	MAXI MAG TS
15000 J	20000 J	40000 J
800 or 3000 V	800 or 3000 V	800 or 3000 V
± 5 %	± 1 %	± 1 %
No	Yes	Yes
No [1]	Yes	Yes
1	3	3
No	Yes	Yes
No	Yes	Yes
via MPI or RS232	via MPI or RS232	via MPI or RS232

SAFETY

The main characteristic of all our magnetizers is the safe operation and safety to the operator. Safe operation is guaranteed for all working conditions and environments to the highest levels of energy. Our magnetizer products are supplied with safety interlocks to prevent any potential shock hazard if the cabinet is opened or not securely closed.

An analog voltmeter is conveniently mounted on the front panel to provide a direct indication of the voltage on the capacitors for visual control.

- Safety switches on all the panels: the magnetizer switches off immediately when opening a panel;
- Fast connections for the coils, with internal sensor to ensure solid contact;
- Analog voltmeter for indication of capacitors voltage;
- Emergency button disconnects the mains to the magnetizer;

XLE SERIES

Small Magnetizer

The XLE “A” series of magnetizers is a low-energy, capacitive discharge magnet charger. The system consists of a bench top enclosure and a magnetizing fixture (may be user supplied). The XLE “A” series is available in different energy levels, up to 1000 joules.

The bench top enclosure contains the latest capacitor charge and discharge circuitry, the firing device is an SCR that discharges the energy into the magnetizing fixture that is user controlled.

The XLE “A” series magnetizer has the built in capability of being operated remotely from an external controller. Provisions to perform the following operations remotely are accessed through the 15 position terminal block located on the rear panel.

XLE

Small and essential

MAIN FEATURES

- Small and compact
- Remote voltage regulation and discharge
- Analog voltage indicator

TECHNICAL SPECIFICATIONS

	XLE SERIES 250 J	XLE SERIES 500 J	XLE SERIES 1000 J
Max energy level	250 J	500 J	1000 J
Minimum cycle time	5 s	7 s	9 s
Dimensions	520 x 430 x h 300 mm (20.5 x 17 x 12")		
Weight (with max energy)	30 kg (65 lb)		
Power Supply	115 or 220 VAC (±10%) mono phase, 50-60 Hz, 15 A max		
Maximum voltage	800 V		
Voltage regulation	0 ÷ 800 V through decade switch		
Voltage resolution	± 1 % of max V		
Voltage accuracy	± 5 %		
Pulse shape	Aperiodic (magnetization)		
Maximum current	7000 A		
Remote controls	15 position terminal block		
Operative temperature	10 ÷ 45 °C		

CDC-XR SERIES
SMALL DEMAGNETIZER

The CDC-XR series of conditioning equipment is a low-energy, capacitive discharge magnet conditioner. The system consists of a bench-top enclosure (CDC-XR) and a conditioning fixture (the conditioning fixture may be supplied by the user). The CDC series is available in energy levels ranging from 20 to 60 joules.
This bench top product contains the latest capacitor charge and discharge circuitry, and is controlled by firing the energy (discharge and conditioning) into a fixture via a thyristor.
The basic theory of operation of the CDC-XR is that it generates a series of conditioning pulses and discharges them into a conditioning fixture containing the magnet sample. The pulse wave shape is a decaying sine wave. The amplitude of the pulses are set by the COARSE and FINE CONDITION LEVEL via front panel controls. The level of demagnetization can be monitored by a gaussmeter or fluxmeter. The CONDITION LEVEL controls are adjusted until the desired level is achieved, as measured by the external device.
This simple but effective method allows easy and precise conditioning for a wide variety of applications.

MICRO MAG

Small Magnetizer

The Laboratorio Elettrofisico Micro Mag is a low energy magnetizer, designed for small coils and fast current pulses.

The internal capacitors can be adjusted to give a total energy of up to 1400 J – 2500 V. Micro Mag can be set to either magnetize only or to demagnetize only.

The power connections are mounted on the front panel to minimize the internal current path and electrical resistance.
The voltage is controlled by a potentiometer and is displayed on the front panel via an easy to read digital display.
100% safe operation is guaranteed by safety interlocks on all removable panels; if a panel is removed or the front or rear doors are not securely closed, the Micro Mag will not operate.

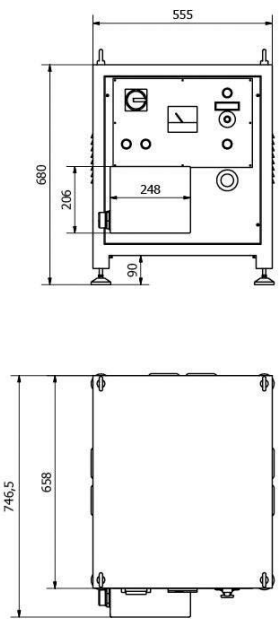
The Laboratorio Elettrofisico Micro Mag magnetizer is suitable for all types of magnetizing coils having small dimensions and low energy requirements.

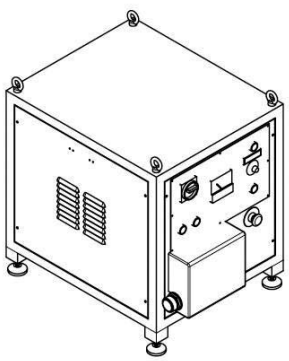
Micro Mag
Small and essential
for fast production

TECHNICAL SPECIFICATIONS

Max energy level	1400 J (1)
Dimensions	555 x 746.5 x h 680 mm (21.8 x 29.4 x 26.8”)
Weight (with max energy)	110 kg (242 lb)
Power Supply	220 VAC (±10%) mono phase, 50-60 Hz, 16 A max Possibility to set 380, 415, 480 VAC three phase
Power consumption	3500 VA max
Maximum voltage	2500 V
Voltage regulation	0 ÷ 2500 V through potentiometer
Voltage resolution	1 V
Voltage accuracy	± 5 %
Pulse shape	Aperiodic (magnetization) (2)
Maximum current	30 kA (short-circuit test)
Max current rise	1000 A/µs
Minimum cycle time	3 s
Controls and PLC	Digital I/O 24 V, PLC
Operative temperature	10 ÷ 45 °C
Cabinet colour	RAL 7030 (colour can be customized)
Documentation	Instruction manual
Certification	CE

(1) Micromag can be set also to 250 J – 3000 V.
(2) Micromag can be set to magnetize only or to demagnetize only.





Micro Mag layout

MAIN FEATURES

- Small and compact
- Fast pulses (especially suitable for small coils for sensors)
- Voltage digital display
- Can be set to magnetize or to demagnetize

MICRO CAL

Small Calibrator

The Laboratorio Elettrofisico Micro Cal is a low energy calibrator, designed for small magnetic devices.

Energy levels can be adjusted (up to 5000 J - 3000V) by adjusting the internal capacitance.

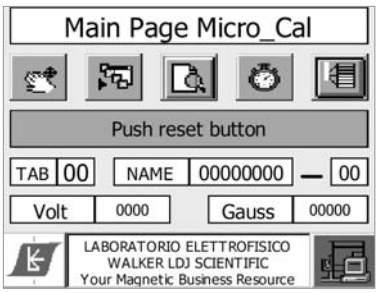
Micro Cal is capable to magnetize, demagnetize and automatically calibrate magnetic devices. The automatic calibration is performed via a suitable instrument, like a gaussmeter or a fluxmeter, depending on the magnetic condition to be achieved.

100% safe operation is guaranteed by safety interlocks on all removable panels and doors; for example, if a panel is removed or a door is not securely closed, the Micro Cal will not operate.

Micro Cal
The most
compact calibrator
in the market

TECHNICAL SPECIFICATIONS

Max energy level	up to 5 kJ
Dimensions	600 x 800 x h 1500 mm (23.6 x 31.5 x 59.1”)
Weight (with max energy)	200 kg (440 lb)
Power Supply	220 VAC (±10%) mono phase, 50-60 Hz, 16 A max Possibility to set 380, 415, 480 VAC three phase
Maximum voltage	800 or 3000 V
Voltage regulation	0-800 V or 0-3000 V
Voltage resolution	1 V
Voltage accuracy	± 1 %
Parameters setting	Through Touch Screen
Pulse shape	Aperiodic pulse (magnetization) and dumped oscillation (demagnetization)
Maximum current	10000 A
Minimum Cycle time	3 s
Controls and PLC	Digital I/O 24 V, PLC
PC control	via MPI or RS232
Instrumentation control	yes (Digital Flux, MV/01, Gaussmeter)
Operative temperature	10 ÷ 45 °C
Cabinet color	RAL 7032 (colour can be customized)
Documentation	Instruction manual
Certification	CE



MAIN FEATURES

- Small and compact
- Automatic calibration with embedded instrumentation
- Fast pulses (especially suitable for small coils for sensors)
- Touch screen

A touch screen display provides an easy and user friendly approach to setting the magnetizing, demagnetizing and calibration parameters. Our exclusive integrated software completely controls the magnetizer and associated instruments and coils.

COMPACT
Magnetizer

The Laboratorio Elettrofisico Compact magnetizer was designed to meet the most demanding applications.
Hundreds of units have been sold all over the World, and are considered the standard for production applications and research laboratories.

The two basic models available are the 800 V and the 3000 V. The design features for the Compact provides the user an easy upgradeable means to increase the storage capability by simply adding more capacitors from 5 kJ to the maximum of 15 kJ.

The charge voltage is regulated by a front panel potentiometer, and as an added safety feature, the voltage on the capacitors is displayed on the front panel via an analog voltmeter.

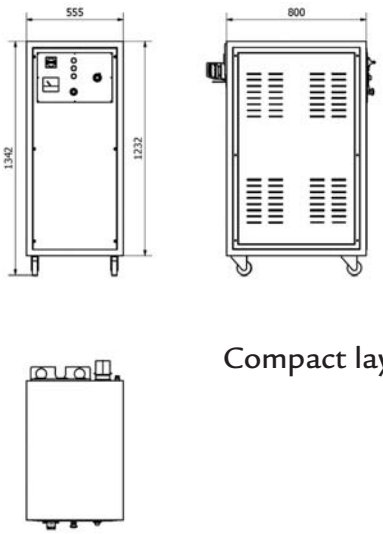
100% safe operation is guaranteed by safety switches on all panels and by fast connectors for the magnetizing coils to prevent incorrect connections, a weak or loose connection to the coils. If a panel is removed or front or rear doors are not securely closed, the Compact will not operate.

The Laboratorio Elettrofisico Compact magnetizer is suitable for all types of magnetizing coils.

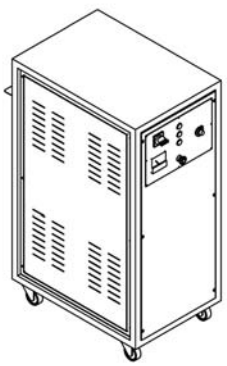
TECHNICAL SPECIFICATIONS

	5K3/08	10K6/08	15K9/08	5K3/30	10K3/30	15K3/30
Max energy level	5 kJ	10 kJ	15 kJ	5 kJ	10 kJ	15 kJ
Maximum voltage	800 V	800 V	800 V	3000 V (1)	3000 V (1)	3000 V (1)
Voltage regulation	0 ÷ 800 V	0 ÷ 800 V	0 ÷ 800 V	0 ÷ 3000 V	0 ÷ 3000 V	0 ÷ 3000 V
Min Cycle time	3 s	6 s	9 s	3 s	3 s	3 s
Weight	250 kg (551 lb)	290 kg (639 lb)	330 kg (728 lb)	250 kg (551 lb)	290 kg (639 lb)	330 kg (728 lb)
Dimensions	600 x 800 x h 1600 mm with wheels (23.6 x 31.5 x 63")					
Power Supply	380 VAC (±10%) three phase, 50-60 Hz, 32 A					
	Possibility to set 215, 415, 480 VAC three phase					
Pulse shape	Aperiodic (magnetization) (2)					
Voltage accuracy	± 5 %					
Voltage regulation	Through potentiometer					
Maximum current	30 kA (short-circuit test)					
Maximum current rise	1000 A/µs					
Capacitors	Metallic paper					
Controls and PLC	Digital I/O 24 V, PLC					
Remote controls	Start, machine ready, stop					
PC control	Via MPI or RS232					
Voltage digital display	Optional					
Polarity reversal	with motor-driven power switch					
Operative temperature	10 ÷ 45 °C					
Cabinet colour	RAL 7030 (colour can be customized)					
Documentation	Instruction manual					
Certification	CE					

(1) With specific modifications to the internal circuitry, it 's feasible to increase the max voltage to 3200 V, with a total energy increase of 14%.
(2) The Compact can be set to magnetize only or to demagnetize only. The Compact does not provide the capability to both magnetize and demagnetize.



Compact layout



Back panel of the Compact magnetizer

Fast connections for coil prevent any incorrect or weak connection of the coil with the power circuit.

MIDI CAL TS and MAXI CAL TS

Premier Magnetizers

The Laboratorio Elettrofisico Midi Cal and Maxi Cal are top of the line magnetizer designs to meet the most demanding applications for magnetic products.
These two models are equipped to magnetize, demagnetize and calibrate any kind of magnet or magnetic device.

The Midi and Maxi differs only in the maximum energy they can store:

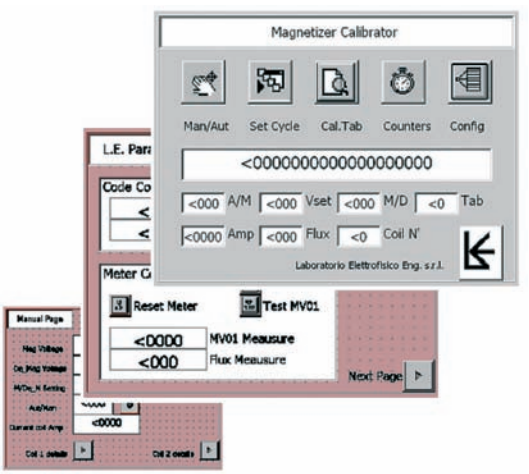
- Midi Cal: 20 kJ max energy
- Maxi Cal: 40 kJ max energy.
- Up to 250 kJ with extra cabinets

Both models are available at 800 V or 3000 V, with a charging accuracy better than ± 1 %.
The design features for these models provides the user an easy upgradeable means to increase the storage capability by simply adding more capacitors from 5 kJ to the maximum.
All models can be set to magnetize only, or they can be set up to magnetize, demagnetize and calibrate. The demagnetizing feature can be added at a later date, providing complete flexibility.

You can connect up to three coils, and each magnetizing coil is controlled independent of each other.

Midi Cal TS – The Premier level Magnetizer

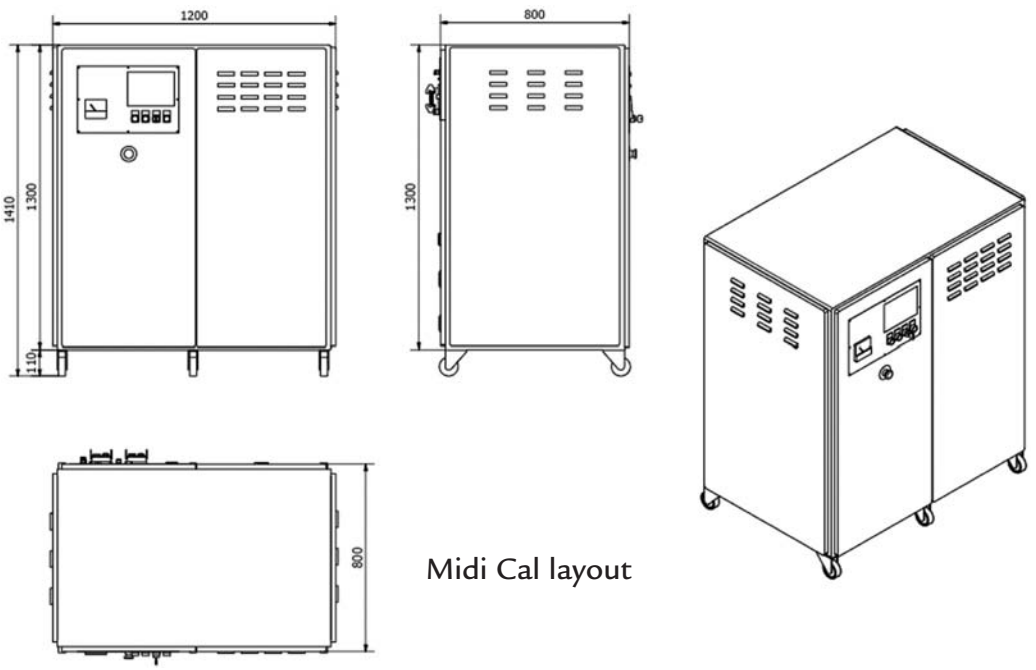
A touch screen display provides an easy and user friendly approach to setting the magnetizing, demagnetizing and calibration parameters. Our exclusive integrated software completely controls the magnetizer and associated instruments and coils. A wide variety of available input/output connections, plus a powerful PLC, provides the necessary control to ensure the complex process cycle meets the design parameters for the application.



Anomalous conditions and status during the cycle are promptly signaled to the operator, providing a real-time status and troubleshooting. As a standard safety feature, the voltage on the capacitors is displayed via an analog voltmeter.

100% safe operation is guaranteed by safety switches on all panels and by the fast connectors for the magnetizing coils to prevent incorrect, weak or loose connections.
If a panel is removed, or the front or rear doors are not securely closed, the magnetizer will not operate.

The Laboratorio Elettrofisico Midi Cal and Maxi Cal magnetizer is suitable for all types of magnetizing coils.



Midi Cal layout

TECHNICAL SPECIFICATIONS

	MIDI CAL	MAXI CAL
Max energy level	20 kJ	40 kJ
Max number of outputs	3	3
Dimensions	1200 x 800 x h 1410 mm with wheels (23.6 x 31.5 x 63”)	1200 x 800 x h 1710 mm with wheels (23.6 x 31.5 x 63”)
Weight (with max energy)	300 kg (660 lb)	780 kg (1720 lb)
Power Supply	380 VAC (±10%) three phase, 50-60 Hz, 32 A max Possibility to set 215, 415, 480 VAC three phase	
Power consumption	12 kW peak power (during capacitors charge)	
Average consumption	Energy/duty cycle	
Maximum voltage	800 or 3000 V (1)	
Voltage regulation	0 ÷ 800 V or 0 ÷ 3000 V	
Voltage resolution	1 V	
Voltage accuracy	± 1 %	
Parameters setting	Through Touch Screen	
Pulse shape	Aperiodic (magnetization) and damped oscillation (demagnetization) (2)	
Maximum current	30 kA (short-circuit test)	
Maximum current rise	1000 A/µs	
Minimum Cycle time	3 s	
Capacitors	Metallic paper	
Controls and PLC	Digital I/O 24 V, PLC, touch screen	
PC control	Via MPI or RS232	
Coil’s temperature control	Yes	
Cooling control	Yes (3)	
Instrumentation control	Yes (Digital Flux, MV/01, Gaussmeters)	
Calibration tables	Optional	
Operative temperature	10 ÷ 45 °C	
Cabinet colour	RAL 7030 (colour can be customized)	
Documentation	Instruction manual	
Certification	CE	

(1) With specific modifications to the internal circuitry, it ‘s feasible to increase the max voltage to 3200 V, with a total energy increase of 14%.
(2) Demagnetization feature on request
(3) The FAN can be set to operate continuously or to switch on only after a settable temperature level

MAGNETIC CALIBRATION

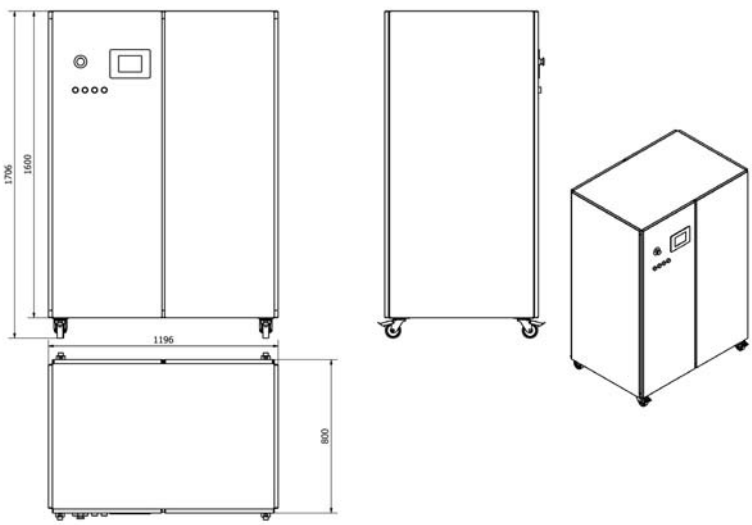
The Midi Cal and Maxi Cal magnetizer/demagnetizer offers magnetic calibration.
Magnetic calibration is required:

- When a specific magnetization level is required to meet the performance characteristic (within a level of tolerance better than ± 1 %);
- To compensate magnetically the mechanical tolerances;
- For magnet stabilization to prevent future variation during operation due to external demagnetizing fields or thermal influences;
- To compensate variability from materials and/or vendors.

The Midi or Maxi Cal is user friendly: simply set the acceptance range and the Midi or Maxi saturates and demagnetizes the magnet to the specified level.
Calibration is controlled via feedback of the magnetic flux or the field level of the magnet. The magnetic parameters are compared at each step during the process with the set acceptance value. The software manages the voltage levels to reduce the overall time of the process to insure the precise magnetic field target is met. 16 tables available.

MAIN FEATURES

- Magnetization, Demagnetization and Calibration
- Expandable up to 40 kJ (Maxi Cal)
- Integrated Touch Screen
- Voltage accuracy up to ± 1 %
- Up to 3 different power outputs
- Coil's temperature monitoring
- FAN control
- Ready for working bench connection

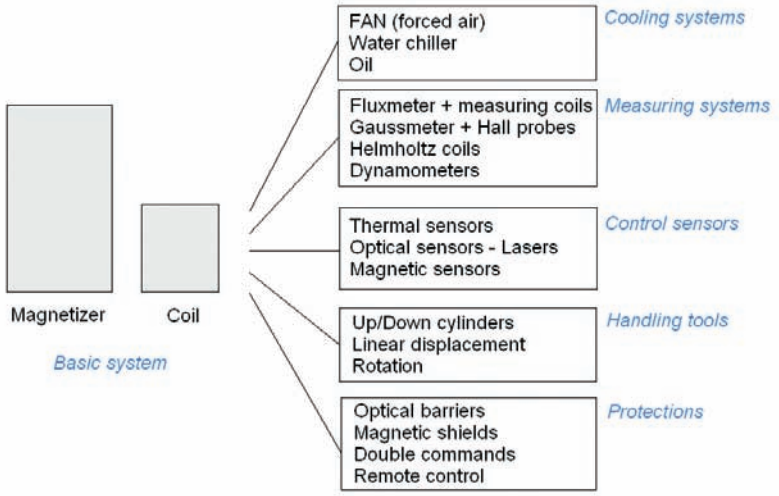


Maxi Cal layout

COMPLETE MAGNETIZATIONS SYSTEMS

Full Working Stations

Laboratorio Elettrofisico offers complete turnkey solutions for all magnetization and calibration requirements for the magnetics industry.
Starting from the basic magnetizer and coil, there are many options and useful devices that can be added to the basic system to provide a complete solution.

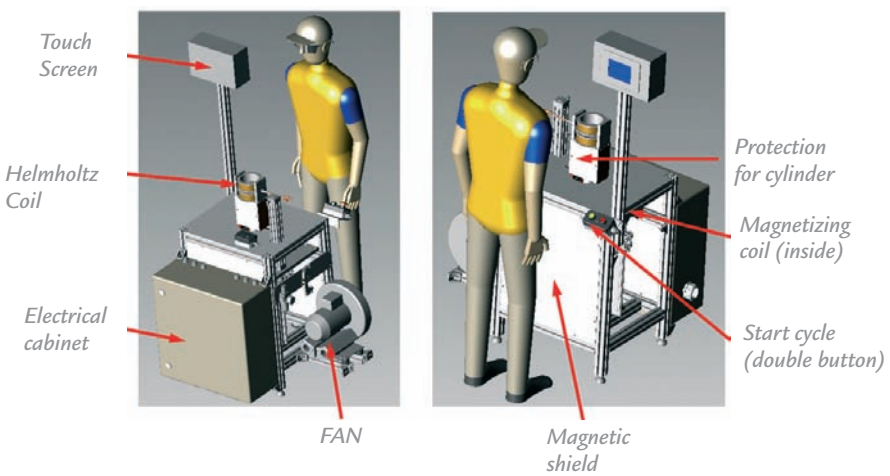


Our entire product range can be combined and assembled into production stations to incorporate automation, handling and controlling tools.

Special devices are necessary to manage magnetized items in and on working benches:

- Non-ferrous parts must be used, to avoid attractive forces with magnetic products;
- Non-magnetic sensors, limit switches and moving tools are preferred, to avoid influences on measurement or calibration;
- Reinforced handling tools designed to move magnetized items inside and outside magnetic coils, due to strong magnetic fields.
- Magnetic shielding to limit and reduce the leakage of stray magnetic fields.

We offer independent work stations and systems to be integrated in a production line



A detailed layout will be included in our proposal

A simple working bench
to magnetize multi
polar NdFeB rotors.

Simple need = Practical solution!

From simple to complex systems:
the most suitable and practical solutions to meet the magnetic industry requirements and standards

SERVICES

Laboratorio Elettrofisico offers services and support in every stage of the industrial activity of magnetic devices:

- Preliminary studies and evaluation
- Material identification
- Calculations and project
- Magnetizing systems
- Production
- Quality control

CONSULTING

Laboratorio Elettrofisico has over 50 years experience providing the best in magnetizing system solutions. We also offer along with complete consulting services during the development for your magnetic product requirements:

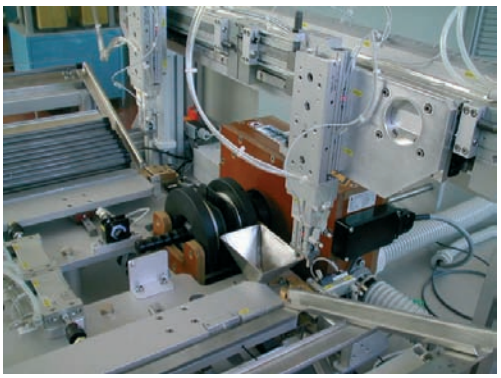
- Electrical motors and actuators
- Loudspeakers
- Magnetic sensors
- Material choice

and for many other types of products.

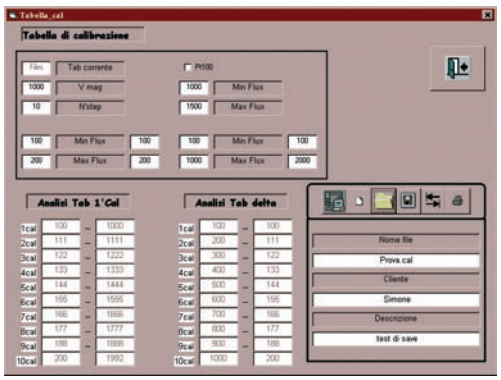
DOUBLE SYSTEM FOR BIG ROTORS AND STATORS

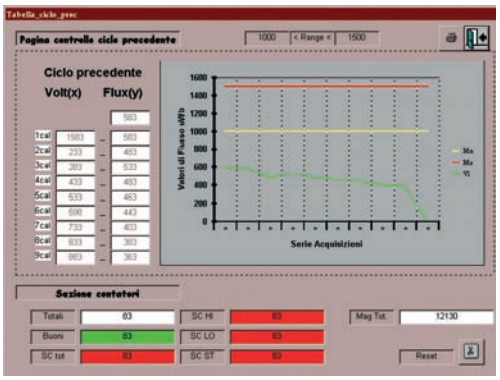
Multi station work bench for large rotors and stators.
The stator is magnetized using multiple angular steps,
to minimize energy needs.

CALIBRATION WORKING STATION



A fully calibrated sample every 10 seconds, with a final tolerance within ± 1%.
The control parameter and the magnetic moment of the sample is controlled by an on line Helmholtz coil and fluxmeter.
An on board PLC monitors the sample's temperature to evaluate the heating effect on the material (for ferrite, the residual induction decreases of 0.2% for each degree Celsius).
Auto-adjusting of voltage settings as a function of temperature.
Options are available for example: loading, unloading, and packaging of the magnets.
Just insert virgin magnets in one side to obtain the calibrated and packaged magnets out the other side and ready for delivery!
Complete data collection of the calibration and statistical controls for the production run is loaded and stored directly on a PC.





MULTIPLE COILS CALIBRATION BENCH

The same magnetizer can be used for a number of coils, providing a pratical solution when there are many different rotor shapes. The picture above illustrates a custom magnetizing solution with an automatic mechanism that provides a simple and fast change out of magnetizing coils for various rotor sizes.
An optical sensor detects the correct position of the rotor before insertion.
A fluxmeter controls the quality of magnetization.

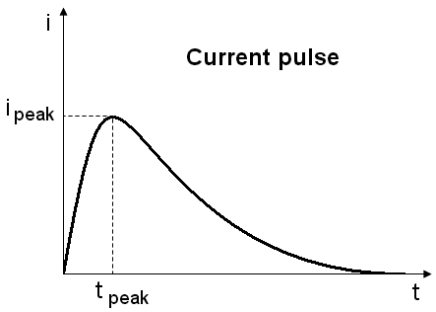
PEAK CURRENT METER MV/01

Monitoring the Current Pulse

The model MV/01 operates with any Laboratorio Elettrofisico magnetization product. The MV/01 is a precision Instrument designed to measure the peak value of the current pulse generated during the magnetizing cycle, to ensure the proper amount of current is delivered to the product being magnetized.

Including the MV-01 current peak detector and the Laboratorio Elettrofisico fluxmeter into your magnetization process provides the ultimate solution to achieve a 'zero failure' production.
The MV/01 is supplied with serial output connection and software to provide the end user the ability to collect data to perform statistical analysis for production quality control.

the control of the current pulse guarantees the quality of the magnetization process



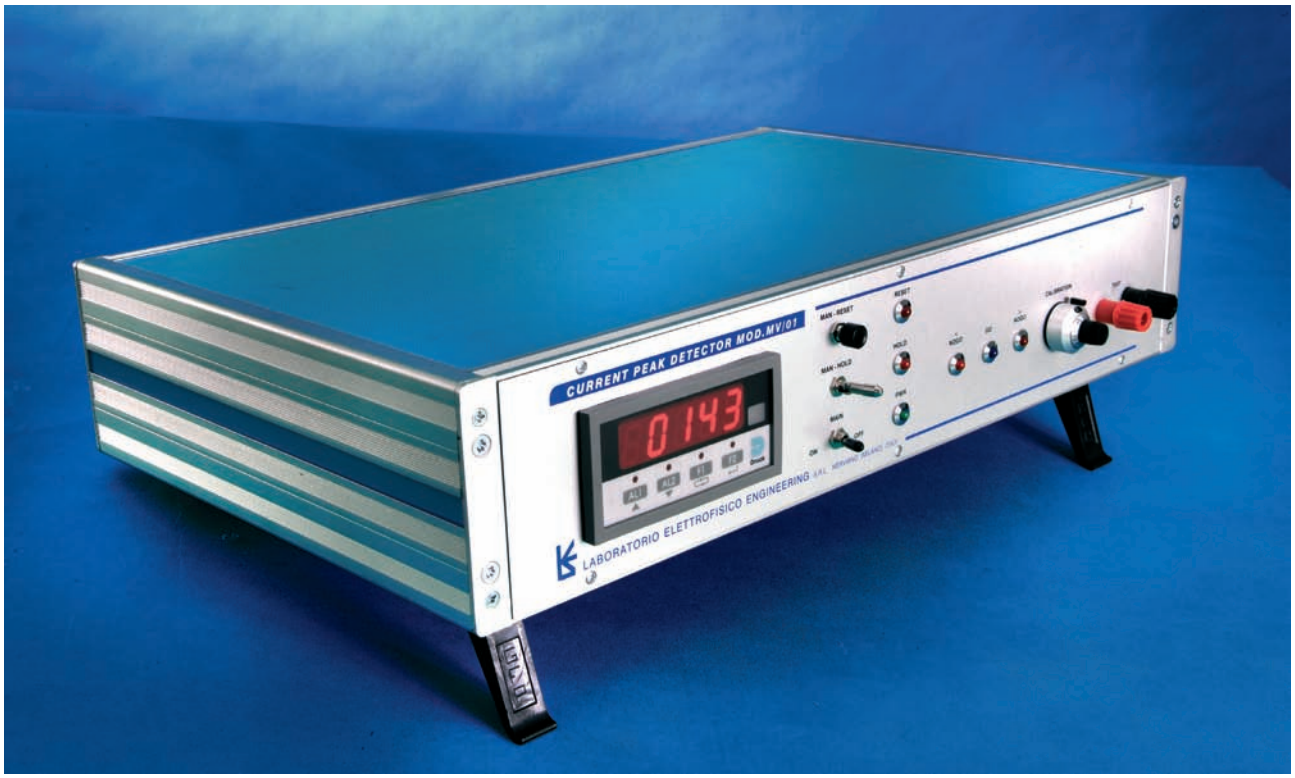
THE MV/01 IS EASY TO SET AND USE:

The current pulse during the magnetization cycle produces a magnetic field around the cables that connect the fixture to the magnetizer, and this magnetic field is proportional to the current. The MV/01 safely detects the magnet field through the use of a Rogowski coil and is completely isolated from the circuit.

The instrument provides 1 A resolution (0 to 20 kA) and 10 A resolution (20 kA to 200 kA), and captures a pulse width as low as 100 ms.

TECHNICAL SPECIFICATIONS

Power supply	110/220 volt 50/60 Hz
Max current absorption	0.3 A
Display	4 $^{1/2}$ digits
Accuracy	± 1%
Resolution	1 A (20 kA range), 10 A (200 kA)
Range	20 kA, 200 kA
Instrument reset	Panel/Remote
Minimum peak duration	100 µs
Minimum time for data acquisition	150 ms
Serial output	RS 232
Analog output	0 - 2 volt
Working temperature	10 - 40 °C
Humidity	80 %
Dimensions	320 x 300 x 120 mm
Weight	5 kg



SERVICES FOR MAGNETIC PRODUCTS

Laboratorio Elettrofisico provides many different services for the magnetic industry.
These services are not limited to our products only, but also to customer's systems.
Our measuring and calibration services are outlined in the measuring section of this catalogue.

FOR MAGNETS AND MAGNETIC DEVICES

- Magnetization of magnets and magnetic devices
- Demagnetization of magnets and magnetic devices
- Calibration of magnets and magnetic devices
- Magnetic measurements and tests
- Verification of saturation
- Prototype magnetization
- FEA analysis

FOR MAGNETIZATION SYSTEMS

- Periodic maintenance
- Functional tests
- Coil's characterization (current pulse, heating, insulating test, etc.)
- Field mapping and determination of working distance
- Magnetic field shielding and protections
- Noise reduction systems
- Calibration of embedded magnetic instrumentation

PROTOTYPE AND LOW SERIES MAGNETIZATION

When there is a need for prototype testing, or when the production is limited to low quantities, Laboratorio Elettrofisico offers the possibility to order a custom laboratory coil, which will be used only for a limited series. The magnetization and/or calibration of the prototypes are provided as a service, so that the customer doesn't need to purchase a magnetization system, keeping the total cost at a minimum level.
The prototype coils are designed to fully guarantee the results on the magnetic product, but their construction is done with minimum finishing for internal internal use only, in our laboratories. The coil can be then completed in a second stage to meet production requirements.

MEASURING
systems

Index

- **HELMHOLTZ COILS**
  Precise uniform magnetic fields
- **ELECTROMAGNETS**
  Electromagnets
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- **GAUSSMETER**
  MG-4D
  MG-4D Gaussmeter Probes

- **REFERENCE MAGNETS**
- **DIGITAL FLUX**
- **HELMHOLTZ COILS**
  Controlling the quality of permanent magnets
- **FIELD COILS**
- **POTENTIAL COILS**
- **CUSTOM MEASURING COILS FOR ELECTRICAL MOTORS**
- **MEASUREMENT METHODS FOR MAGNETIC MATERIALS**
- **MEASURING SYSTEMS**
  AMH-300 Hysteresisgraph
  AMH-DC-T-S- DC Permeameter
  AMH-DC-TB-S DC Permeameter
  AC/DC Permeameter
    AMH-1K-S
    AMH-20K-S
    AMH-50K-S
    AMH-1M-S
  COMBO SYSTEM
    AMH-1K-HS
    AMH-20K-HS
    AMH-50K-HS
    AMH-1M-HS
  AMH-5800 Hard Metal Magnetometer
  CR/01 AND CR/02 Coercimeter
  PFMM Permeameter
  MAGNETOSCAN

- **MEASURING SERVICES**

HELMHOLTZ COILS

Precise uniform magnetic fields

The Helmholtz coil system concept, developed over a century ago, is a system that is normally used to generate magnetic field levels of specified volume and uniformity. These coils provided scientists and engineers accurate means to perform numerous experiments and testing functions that require a known ambient magnetic field. Helmholtz field generation can be either static, time-varying DC or AC, depending on applications requirements.

Applications range from cancelling the Earth's magnetic field for certain experiments as well as generating magnetic fields for applications such as determining magnetic shielding effectiveness, determining the susceptibility of electronic equipment to magnetic fields, calibration of magnetometers and navigational equipment and for many bio-magnetic studies, just to name a few.

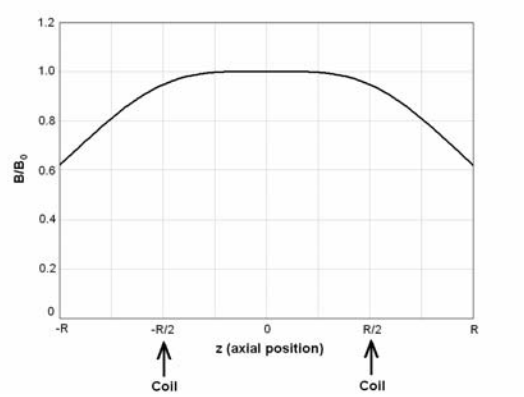
Round, Single Helmholtz
For susceptibility testing

Round, Single Helmholtz
With stand included
as part of the coil design

LABORATORIO ELETTROFISICO OFFERS
THE COMPLETE SOLUTION OF MOST OF EXPERIMENTS

- DC power supply, for static uniform fields;
- Power amplifier with function generators, for any AC or arbitrary time-changing field;
- Gaussmeters and magnetometers, for field verification can be incorporated as part of a closed loop system;
- Cooling systems;
- Control Software.

Helmholtz coils can also be used to determine the magnetic moment of permanent magnet samples. This is described in another section of this catalogue.



Axial magnetic field vs. distance from the centre of the coils. The field changes of 1% only at a distance of 31% of the radius.

DESCRIPTION

Single Axis Helmholtz Coil systems consists of two identically wound layered coils, wired in series, with a specific geometry wherein the mean radius is equal to the mean coil spacing. When either AC or DC power is applied to the coil geometry, a magnetic field volume is produced in which uniform conditions exist. The strength of the magnetic field generated is directly proportional to the number of conductor turns in the coils, the applied current, the physical size and the inter coil spacing between the coils.

Coil configurations of greater complexity are sometimes necessary in order to accommodate a particular application. Systems that consist of two (biaxial) or three (triaxial) coil pairs are often required. Each coil pair or axis is usually independently controlled through a dedicated power supplies. As a result, the magnetic vector generated by each coil pair can be regulated to complement other coil pairs in providing a desired uniformity over a specified sample volume or coil center line. Triaxial systems, for example, can be used to negate the effects of the Earth's field (between 400- 750 milligauss).

TYPICAL APPLICATIONS

- Generation of precise-controlled magnetic field
- Magnetometer and Hall probe calibration
- Earth's field cancellation for zero-field tests
- Calibration for navigational equipment
- Susceptibility measurements
- Magnetoresistance measurement
- CRT adjustments

HELMHOLTZ DESIGN REQUESTS

The combined values of Laboratorio Elettrofisico experience, reliability, quality and performance has resulted in the production of many proven AC and DC Helmholtz coil system designs. Single, Biaxial or Triaxial Helmholtz Coils with single or multi-pair coil sets, fixed or rotatable, are offered in round, square or rectangular configurations.
Field levels from the gamma range (1 gamma = 1 nT = 10^{-5} G) to the kilogauss level can be generated with uniformity in parts per million (ppm) over a specified sample volume.
Information related to any Helmholtz design request should be provided by completing a list of specifications, such as:

- Field Volume and the shape and size
- Field orientation (single, double or three axes)
- Field strength
- Field uniformity
- Field frequency (DC or max AC frequency)
- Physical spacing between coils
- Duty Cycle
- Available power source, if any
- Necessary accessories: power source, gaussmeter, control software, etc.

Round, Triaxial Helmholtz System
With controller to test magnetic compasses

Square, Triaxial Helmholtz Coil System
Earth's field cancellation for
bio-magnetic studies

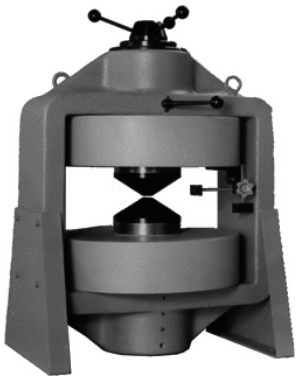
ELECTROMAGNETS

Electromagnets are the classical solution to produce high magnetic fields of variable strength. Basically, an electromagnet is a soft iron magnetic circuit with a variable gap. The field is produced by a current in the excitation coils and, amplified by the iron, becomes accessible in the air gap.

All Laboratorio Elettrofisico standard electromagnets are of the proven “H” frame, designed to provide superior homogeneity over a wide field range. With the use of our special water cooled coils, which have proven to produce the highest magnetic field per kilowatt, as compared with other methods of coil construction, we are able to provide extremely high fields at a moderate cost.

Our method of coil construction achieves a 40% greater fill factor over other methods of coil construction which results in greater accessibility to the working gap. It also enables more ampere turns to be condensed into a smaller volume nearer the magnet poles for minimized stray fields resulting in the highest magnetic field per kilowatt of power per cubic inch of coil volume for a given coil construction.

HV-4H



HV-7V

HV-7H

The entire magnet yoke is made by a quality controlled soft iron, enabling us to provide the most uniform and field efficient variable gap electromagnets on the market. A ramp locking mechanism is built into each movable pole to firmly lock each pole in position during operation so as to achieve fixed gap magnet performance.

All magnets are factory aligned and tested to specified field levels and homogeneity prior to shipment using NMR (Nuclear Magnetic Resonance) techniques where possible.

FEATURES

- Proven “H” frame construction for high inherent homogeneity over a wide field range
- High efficiency tape wound coils for highest magnetic field per kilowatt input
- Pure magnet iron cast frames for all variable gap electromagnets
- Positive ramp locking for all variable gap electromagnets
- A wide selection of associated current and field regulated power supplies are also available

APPLICATIONS

- Magnetic hysteresis studies
- Magnetic susceptibility measurements
- Hall effect studies
- Magneto-optics experiments
- NMR (Nuclear Magnetic Resonance) studies
- EPR (Electron Paramagnetic Resonance) studies
- Quantum mechanics analysis
- Biological studies

Laboratorio Elettrofisico offers a complete solutions, with a wide range of accessories:

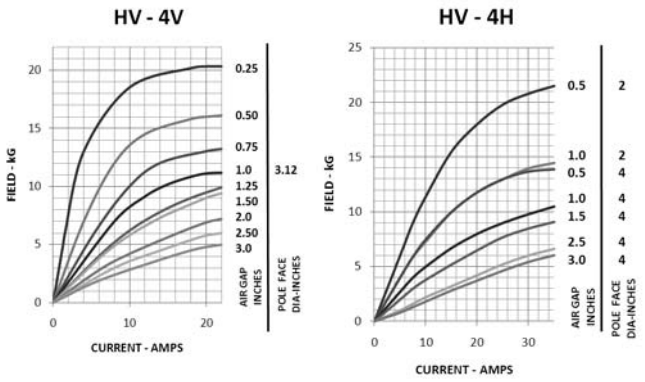
- Tapered poles
- Power supply
- Polarity switches
- Cooling systems
- Temperature poles
- Gaussmeters for feedback control of the field

TECHNICAL SPECIFICATIONS

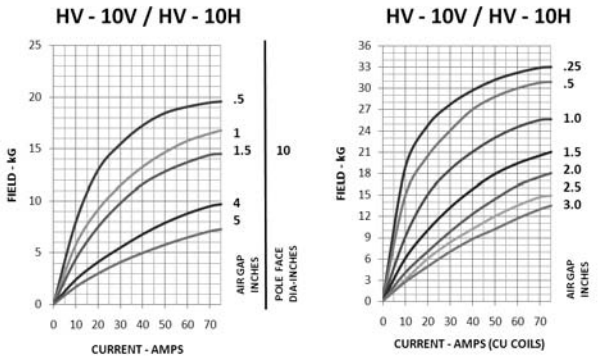
SIZE	TYPE			ELECTRICAL				FACILITY REQUIREMENTS		FACILITY REQUIREMENTS	
				Input Power kW		Power Sources				Weight	
(in)	Model # Field Direction	Air Gap and Range	Intercoil Spacing	Recom.	Max	Recom.	Max.	Max Inlet Temperature and Pressure	Flow Rate	Magnet Only	Ship Weight
4	HV-4V Vertical	Variable .065-3.25" 1.6-83 mm	6.00" 15.24 cm	2.2	2.2	HS-525	-	80°F 27°C 30-80 psi	1 gpm 4 lpm	350 lb 159 kg	425 lb 193 kg
	HV-4H Horizontal	Variable .065-4.00" 1.6-102 mm	4.00" 10.16 cm	1.25	2.45	HS-525	HS-735	80°F 27°C 30-80 psi	1 gpm 4 lpm	400 lb 181 kg	425 lb 192 kg
7	HV-7V Vertical	Variable .065-4.25" 1.6-108 mm	7.25" 18.42 cm	5.0	8.5	HS-1050	HS-1365	80°F 27°C 30-100 psi	3 gpm 11 lpm	1200 lb 544 kg	1350 lb 612 kg
	HV-7H Horizontal	Variable .065-7.25" 1.6-184 mm	7.25" 18.42 cm	5.0	8.5	HS-1050	HS-1365	80°F 27°C 30-100 psi	3 gpm 11 lpm	1225 lb 556 kg	1375 lb 624 kg
10	HV-10V Vertical	Variable .065-5.5" 1.6-140 cm	8.25" 20.96 cm	11.25	14.5	HS-1575	HS-1785	80°F 27°C 30-100 psi	5 gpm 19 lpm	2800 lb 1270 kg	3000 lb 1361 kg
	HV-10H Horizontal	Variable .065-8.25" 1.6-210 mm	8.25" 20.96 cm	11.25	14.5	HS-1575	HS-1785	80°F 27°C 30-100 psi	5 gpm 19 lpm	2850 lb 1293 kg	3050 lb 1383 kg
12	HF-12H Horizontal	Fixed 6" max. 152 mm	7.60" 19.30 cm	8.5	14.5	HS-1365	HS-1785	80°F 27°C 30-100 psi	4-6 gpm 15-23 lpm	5800 lb 2631 kg	6050 lb 2744 kg

12" electromagnet with power supply

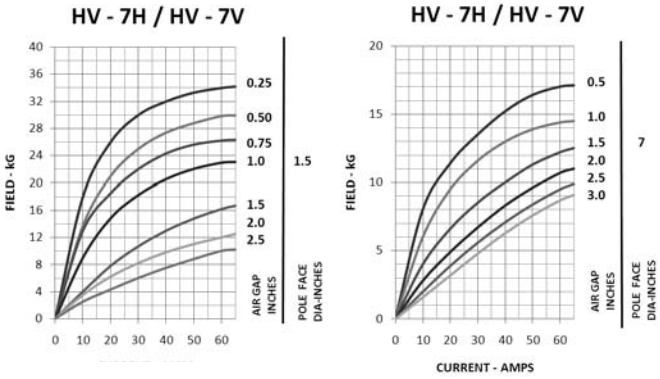
4 INCHES ELECTROMAGNET



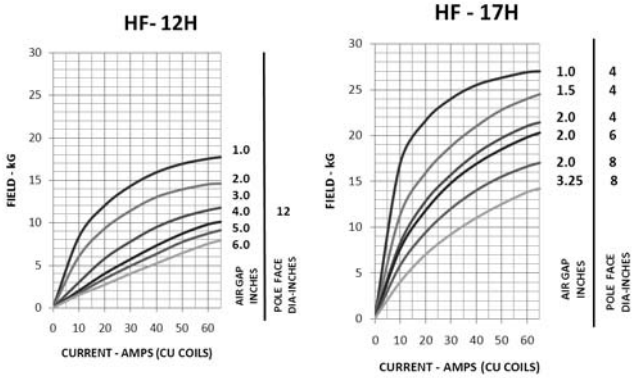
10 INCHES ELECTROMAGNET



7 INCHES ELECTROMAGNET



12 INCHES ELECTROMAGNET



FIELD VS. CURRENT, GAP AND POLE DIAMETER

For the following diagrams, please remember the basic properties of electromagnets:

- H increases with increasing current
- H increases with decreasing of air gap
- H increases with decreasing of pole diameter

Electromagnet model LEP/100-4S

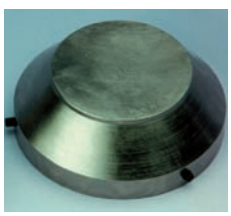
The Laboratorio Elettrofisico electromagnet model LEP/100-4S is used in all AMH Hysteresisgraphs, for the measurement of hard magnetic materials and cemented carbides.
The model LEP/100-4S is a precision 120 mm pole diameter vertically oriented electromagnet with a continuously adjustable upper pole. This allows varying the air gap from zero to 80 mm for maximum versatility. The pole is locked in place by a socket head screw located on the top portion of the yoke frame.
Its special design permits to use the electromagnet without any cooling, providing a moderate working power level. The coils can either be connected electrically to any source of DC power.

A set of tapered poles with various diameter permits different combination of field amplification and uniformity: LP-40, LP-60, LP-80, LP-100, LP-120 (the number indicates the pole's diameter, in mm).
Special temperature poles are also available, to provide a heating surface for experiments and measurements at temperatures up to 220 °C.
The electrical unit model IS-TP permits to power the Electromagnet with a suitable DC power supply, reverse the polarity and heat the temperature poles, manually or remotely through a PC.

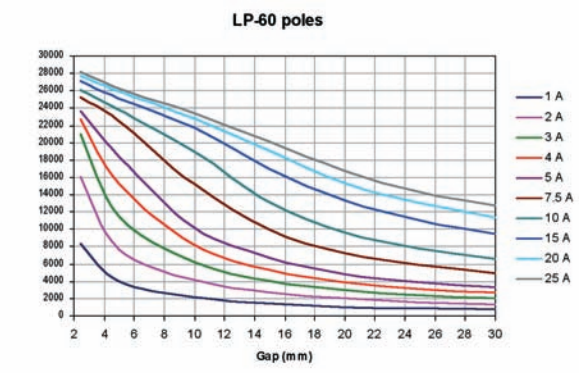
MAIN SPECIFICATIONS:	
Shaft's diameter	120 mm (4.72")
Coil's resistance (two coils)	2.4 Ω
Max excursion (without poles)	80 mm (3.15")
Cooling	Static air
Max current	30 A
Lock	Included
External dimensions	328 x 388 x 491 mm (12.9" x 15.3" x 19.3")
Intercoil spacing	135 mm (5,31")
Weight	330 kg (726 lb)

AVAILABLE POLES

Poles	Temperature poles
LP-40	LPT-80
LP-60	LPT-100
LP-80	LP80-9/9
LP-100	
LP-120	

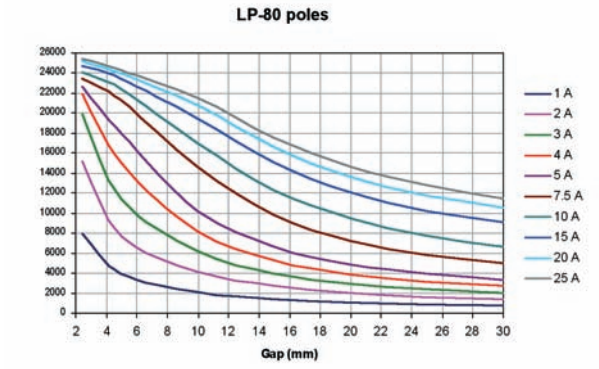


FIELD DIAGRAMS



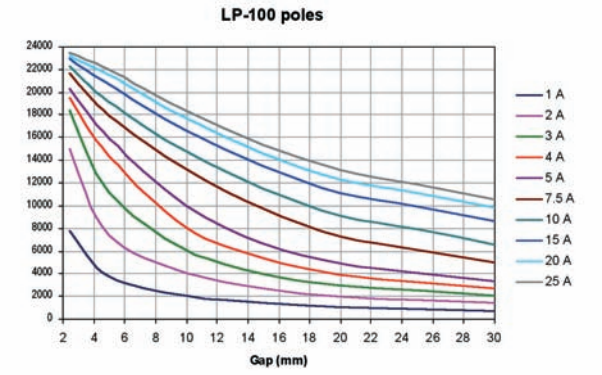
POLES LP-60

Diameter	60 mm
Gap adjustment	0-30 mm
Current 25 A:	
H @ 5 mm	2.63 T
H @ 10 mm	2.34 T
H @ 20 mm	1.67 T



POLES LP-80

Diameter	80 mm
Gap adjustment	0-50 mm
Current 25 A:	
H @ 5 mm	2.43 T
H @ 10 mm	2.15 T
H @ 20 mm	1.46 T



POLES LP-100

Diameter	100 mm
Gap adjustment	0-60 mm
Current 25 A:	
H @ 5 mm	2.20 T
H @ 10 mm	1.84 T
H @ 20 mm	1.31 T

MG-4D

Hand-held gaussmeter

The Laboratorio Elettrofisico/Walker LDJ Scientific MG-4D hand-held Hall effect gaussmeter is designed for DC and AC (RMS) magnetic field measurements. Light weight and small in size, the MG-4D provides both the convenience of hand-held portability and the accuracy of a bench top laboratory instrument.

Three bipolar ranges of ± 100 gauss, ± 1 kilogauss and ± 10 kilogauss with 100% over-range and resolution of 0.05%, allows measurement of DC and AC fields from ± 0.1 gauss to ± 19.99 kilogauss (using 1X probe) with true RMS readings from 10 Hz to 20 kHz; readings are displayed on a $3^{1/2}$ digit ± 0.1% bipolar LCD meter.

The MG-4D gaussmeter is a Hall effect instrument: a Hall probe is used as a sensor to measure the magnetic field. Laboratorio Elettrofisico offers a wide selection of transverse and axial Hall probes. The measuring range of the MG-4D gaussmeter can be extended to ±150 kilogauss with select probes.

STANDARD ACCESSORIES INCLUDE:
Carrying case, a 6' extension probe cable, and batteries. An optional battery eliminator provides AC operation. Alkaline batteries can also be replaced with "AA" rechargeable batteries.

TECHNICAL SPECIFICATIONS

DISPLAY (digital)	$3^{1/2}$ digit ± 0.1% bipolar LCD	
RANGE	3 Full Scale Ranges	± 100.0 gauss, ± 1.000 kgauss and ± 10.000 kgauss with 100% over-range (10 G - 10.00 kG range)
RESOLUTION (with 100% over-range)	0.05% (± 100 mG - 100.0 G range, ± 1 G - 1.000 kG range, ± 10 G - 10.00 kG range)	
INSTRUMENT ACCURACY (less Probe)	Range Setting	DC Accuracy FS
	100 G-DC	±0.5%
	1 kG-DC	±0.5%
	10 kG-DC	±0.5%
		RMS Accuracy 1%- FS
	100 G-RMS	± 1% 10 Hz - 10 kHz, ± 10% - 20 kHz (5% - 100% F.S.)
	1 kG-RMS	± 1% 10 Hz - 10 kHz, ± 2% - 20 kHz (1% - 100% F.S.)
	10 kG-RMS	± 1% 10 Hz - 10 kHz, ± 2% - 20 kHz (1% - 100% F.S.)
POWER	AC - 100 to 125 V/50-60 Hz or 200 to 240 V/50-60 Hz DC - 6 V Sealed lead acid rechargeable battery	
BATTERY LIFE	Exceeds 10 hours continuous operation with fully charged batteries, charge time, 12 hour maximum	
OPTIONAL	Battery Eliminator - 105 V - 250 V/50-60 Hz. Charge rate 5 mA.	
PHYSICAL (Less Probe)	Size: 2.125”H x 3.63”W x 6.13”L 5.4 cm H x 9.2 cm W x 15.6 cm L Net Weight: 14 ounces - 0.4 kg Shipping Weight: 1.5 lb - 0.7 kg	
ANALOG OUTPUT	± 100 mV with 100% over-range (black)	

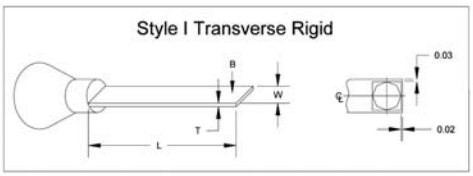
FEATURES

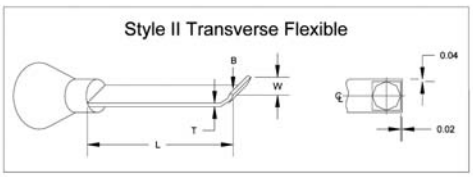
- $3^{1/2}$ digit 0.1 bipolar display
- DC and AC Fields, ± 100 mG to ± 19.99 kG with 1X probes
- True RMS readings to 20 kHz
- Analog Output
- 6’ probe extension cable
- Wide selection of 1X, 10X and 100X probes
- Operates with standard ‘AA’ alkaline batteries
- Optional battery eliminator

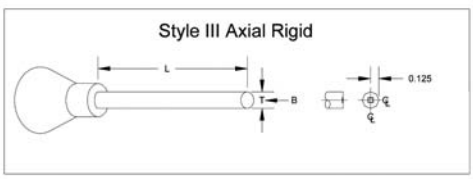
APPLICATIONS

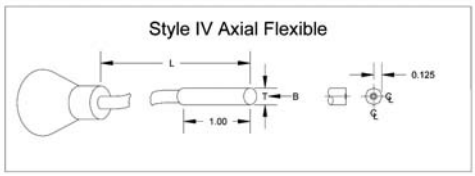
- Measure residual fields
- Analyze magnetic circuits and components
- Measure Absolute and differential fields
- Plot field uniformity
- DC and AC Motor Testing
- Relay and Solenoid
- Loudspeaker Testing

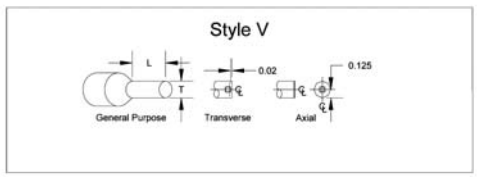
MG-4D Gaussmeter Probes











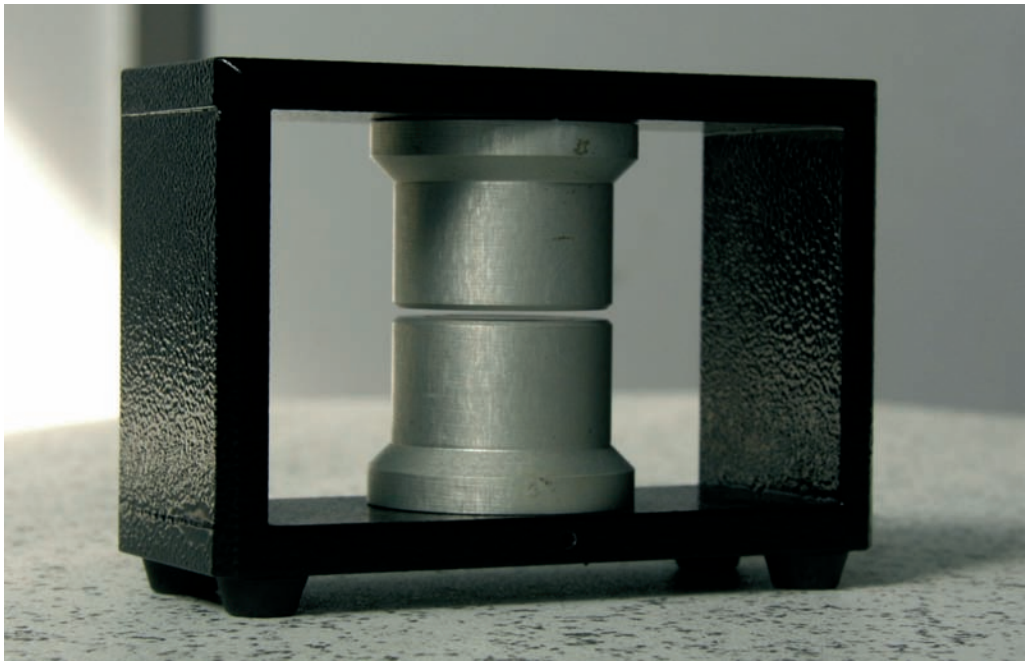
	Model	% Linearity of Reading	Temperature Coefficient % 1ºC	Temperature Range ºC	Stem Style	Stem Size L x W x T	Active Area L x W
TRANSVERSE	HP-14S	± 1% to 20kG	-0.1	-55 to +100	V-1X	0.5" (12.70mm)	.040" x .080" (1 x 2mm
	HP-145S HP-145F HP-145R	± 1% to 20kG	-0.1	-55 to +100	I-1X II-1X I-1X	4"(10.16cm) 0.155"(3.94mm .043 "(1.09mm) 4"(10.16cm) 0.165"(4.19mm .053" (1.35mm) 4"(10.16cm) 0.175"(4.45mm .063" (1.60mm)	.040" x .080" (1 x 2mm)
	HP-345S * HP-345F * HP-345R * note: * specify	± 0.25% to 10kG -(10) ± 0.5% to 20kG -(20) ± 1.0% to 30kG - (30)	-0.04	-40 to +100	I-10X II-10X I-10X	4"(10.16cm) 0.155"(3.94mm .043 "(1.09mm) 4"(10.16cm) 0.165"(4.19mm .053" (1.35mm) 4"(10.16cm) 0.175"(4.45mm .063" (1.60mm)	.040 Dia. (1mm)
	HP-645S HP-645F HP-645R	± 0.1% to 30kG	±0.005	-40 to +100	I-100X II-100X I-100X	4"(10.16cm) 0.155"(3.94mm .043 "(1.09mm) 4"(10.16cm) 0.165"(4.19mm .053" (1.35mm) 4"(10.16cm) 0.175"(4.45mm .063" (1.60mm)	.040" Dia (1mm)
	HP-1145S HP-1145F HP-1145R	±1% to 30kG / ± 1.5% to 150kG	±0.005	-40 to +100	I-100X II-100X I-100X	4"(10.16cm) 0.155"(3.94mm .043 "(1.09mm) 4"(10.16cm) 0.165"(4.19mm .053" (1.35mm) 4"(10.16cm) 0.175"(4.45mm .063" (1.60mm)	.040" Dia (1mm)
AXIAL	HP-24S	± 1% to 30kG	-0.1	-55 to +100	V-1X	0.5" (12.70mm) 0.250" (6.35mm)	.040" x .080" (1 x 2mm)
	HP-245S HP-245F	± 1% ti 20kG	-0.1	-55 to +100	III-1X IV-1X	5.0" (12.70cm) 0.263" (6.68mm)	.040" x .080" (1 x 2mm)
	HP-845S* HP-845F* HP-845R* note: * specify	± 0.25% to 10kG - (10) ± 0.5% to 20kG - (20) ± 1.0% to 30kG - (30)	-0.04	-40 to +100	III-10X IV-10X	9.0" (22.86cm) 0.263" (6.68mm)	.040" Dia (1mm)
	HP-1045S HP-1045F	± 0.25% to 30kG	±0.005	-40 to +100	III-100X IV-100X	9.0" (22.86cm) 0.263" (6.68mm)	.020" Dia (0.5mm)
	HP-1245S HP-1245F	± 1% to 30kG / ± 1.5% to 150kG	±0.005	-40 to +100	III-100X IV-100X	9.0" (22.86cm) 0.263" (6.68mm)v	.020" Dia (0.5mm)

Model Number Suffix
S - Standard
F - Flexible
R - Ruggedized

Note: Thickness of standard probe applies to 1/2" from tip only
Probe Stem Styles: I - Transverse, Rigid; II - Transverse, Flexible; III - Axial, Rigid;
IV - Axial Flexible; V - 0.5" L x 0.250" Dia., cylindrical

REFERENCE MAGNETS

Standard Reference Magnets from Laboratorio Elettrofisico provide a convenient and reliable means of verifying the calibration of magnetic measuring instruments such as gaussmeters, fluxmeters and their respective sensors.



Transverse units have an extra-large aperture to accommodate a wide selection of Hall probes and search coils. Both transverse and axial units provide a large area of field uniformity, which makes instrument and sensor calibration easy and accurate by allowing fast and precise probing of the reference magnet's peak field.

FEATURES

High stability permanent magnets have been selected which are pre-aged and screened to reduce instability caused by extreme temperature variation, careless handling and accidental exposure to strong external magnetic fields.

Monolithic construction has been used to enhance temperature stability and insure that long-term calibration accuracy will not be affected by day-to-day handling.

Heavy duty shielding is used to reduce stray fields that might be generated from within the magnet and reduce the effect of external fields that are generated outside the magnet, which might otherwise affect the magnet's calibration.

SERIES RF TRANSVERSE REFERENCE FIELDS

External dimensions: 150 x 100 x 60 mm (5.91" x 3.94" x 2.36")
Weight: 3 kg (6.6 lb)

TECHNICAL SPECIFICATIONS

MODEL	AIR GAP (mm)	POLE DIAMETER (mm)	FIELD STRENGTH IN AIR GAP (kA/m)	INDUCTION IN AIR GAP (T)
RF/100G	10	40	8	0.01
RF/1KG	10	40	80	0.1
RF/2.5KG	10	40	200	0.25
RF/5KG	5	40	400	0.5
RF/10KG	2	30	800	1

DIGITAL FLUX

Fluxmeter

The Laboratorio Elettrofisico digital fluxmeter utilizes sense coil technology to measure magnetic flux. Our precision electronics performs the integration of the volt-second signal from the coil to provide accurate measurement of average flux density or total flux.

$$V = -\frac{d\Phi}{dt}$$

Faraday's induction law:
A variation of flux linked with
a coil produces a voltage at its terminals

$$\Delta\Phi = -\int V dt$$

Fluxmeter's principle:
The integration of the inducted voltage
gives the flux variation

The exclusive Auto-Null feature automatically removes uncompensated thermocouple voltages to minimize integrator drift without compromising measurement sensitivity. Measurement range, scale sensitivity and the proper units are immediately selected via easy to read display menus or key buttons.

The bright backlight display has two lines of 20 alphanumeric characters, and is readable from any viewing angle. Corrected and uncorrected analog outputs, plus RS-232 interface provides flexible interfacing to a PC or other equipment.

KEY FEATURES

- Analogue fast integration and digital signal elaboration
- High stability and automatic drift control
- 7 ranges, for the best resolution and accuracy
- Multifunction easy-to-use menu
- Direct reading in volt-seconds, webers, maxwells
- Corrected and uncorrected analogue output
- High input resistance
- Elegant modern design
- 19'' rack compatible
- Wide variety of measuring coils options available

MAIN APPLICATIONS

- Magnetic field measurement
- Measure of the properties soft and hard magnetic materials
- Quality control of magnetic devices (holders, motors, loudspeakers, etc.)
- Direct in-line control of the magnetic systems after magnetization and calibration
- Used in BH tracer for DC and AC materials characterization

FUNCTIONS

- Direct measure bipolar or absolute value
- Max-Min hold
- Peak
- Alarms (2 alarms, min-max)
- Manual/automatic drift control
- Manual/remote reset
- Manual/remote range changing
- Uncorrected/corrected analogue output

TECHNICAL SPECIFICATIONS

GENERAL

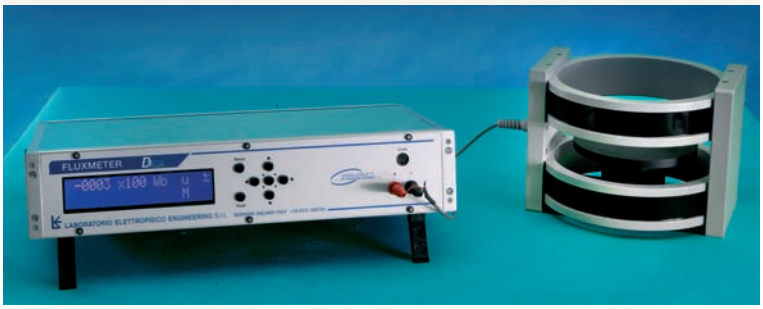
Inputs	2 inputs available, in front and back panels
Input resistance	10 kΩ x range
Maximum Input Voltage	60 Vpp
Keypad	7 Keys
Display	2 Lines x 20 Character LCD LED backlight
Display Update Rate	Selectable between 1 to 25 updates/second
Display Units	volt · second, weber, maxwell
Display Parameters	Measurement Mode: Normal bipolar, unipolar, peak, max-min hold, alarm status
Display color	White characters, blue background

MEASUREMENTS

Display and serial output	
Ranges	2000 x (1, 2, 5, 10, 20, 50, 100) µWb
Measurement Resolution	1, 2, 5, 10, 20, 50, 100 µWb
Display Resolution	To $4^{1/2}$ digits
Accuracy	±0.5 % of reading, ± 1 digit
Drift	Less than 1 digit/minute
Frequency Response	DC - 1 kHz
Interfaces	RS-232 (2400, 4800, 9600 baud), Threshold Limit Relays
Analog Outputs	
Connectors Type	BNC (minimum load - 50 Ω)
Type	Corrected-uncorrected (selectable)
Scale	±2 V Full Scale
Accuracy	±1 % of reading, ± 1 mV

PHYSICAL

Power Requirements	Continuous between 100 - 240 VAC 50/60 Hz
Max current absorption	0.3 A
Working temperature	10 to 40 °C
Warm up time	30 minutes
Size	483 x 380 x 88 mm (19.02" x 14.96" x 3.46 '')
Weight	5 kg (11 lb)
Approval	CE mark



HELMHOLTZ COILS

Controlling the quality of permanent magnets

Integrating fluxmeters are often used to control permanent magnet devices by the use of sense coils.

The Laboratorio Elettrofisico Helmholtz coils are an easy addition to any fluxmeter for a fast, accurate and low cost measuring technique to control the quality of permanent magnets. Our design consists of a pair of identical wound coaxial coils, connected in series at a fixed distance equal to their radius. This configuration permits the sample to be placed in a large uniformity central volume.

MEASURING PRINCIPLE

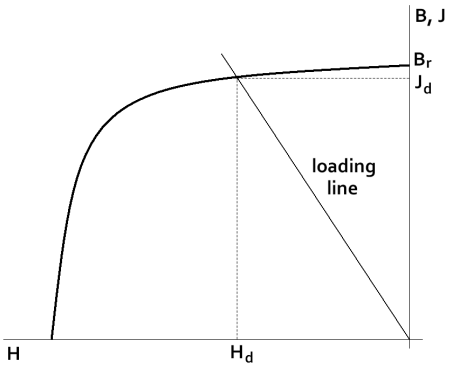
When connected to a fluxmeter, the Helmholtz coil provides an output flux Φ proportional to the magnetic moment $\mathbf{M}$ of the sample: $\Phi = K_H \cdot \mathbf{M}$, where K_H is the coil's constant (each coil is given with the proper certified constant). This measurement procedure is described in the International Standard IEC 60404-14.

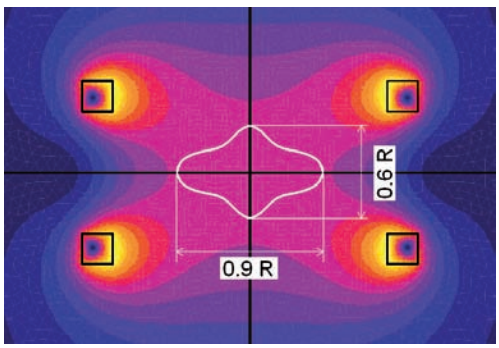
The magnetic moment is an essential magnetic property. For a permanent magnet sample, the magnetic moment $\mathbf{M}$ is the product of its magnetic polarisation J_d (in the working point) and its volume V; this gives directly the Helmholtz coil's formula:

$$J_d = \frac{K_H \cdot \Phi}{V}$$

For example: for ferrites and rare earth magnets, having essentially a linear *J* vs. *H* relationship in the second quadrant, the J_d is very close to the magnetic remanence B_r.

Magnetic polarization in the working point (Jd) of an anisotropic permanent magnet. Helmholtz coils measures Jd, that, for anisotropic magnets, is very close to Br.



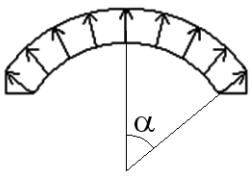


How to chose the right Helmholtz coils model

The wide uniformity volume in the center of Helmholtz coils is approximately an ellipsoid having one axis of 0.93 R and the other axis of 0.62 R. The magnet to be measured should fit in this volume to have the best reading (uniformity within 1 %)

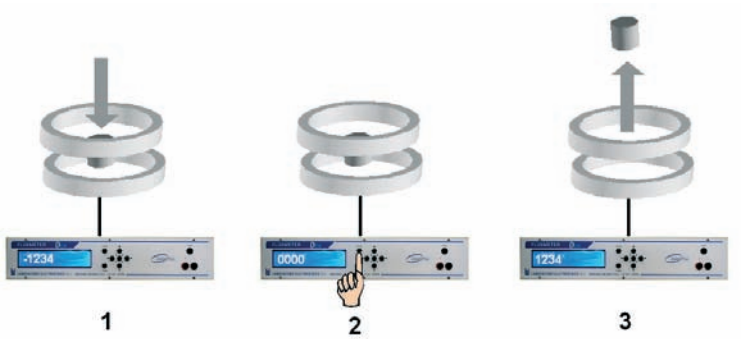
The Helmholtz coils can be used with radially magnetized arcs, such as those used in PM electrical motors, using an additional factor that considers the curvature of the arc:

$$J_d = \frac{K_H \cdot \Phi}{V} \cdot \frac{\alpha}{\sin\alpha}$$



MEASURING PROCEDURE

The Helmholtz coils are widely accepted due to the simplicity of use and accurate results:



Insert the magnet in the coil

Reset the fluxmeter

Remove magnet and read the flux

The Helmholtz coil measurement resultant is an absolute quantity (the magnetic moment) that can be used as the reference quantity for inter-comparison (between the supplier, customer or between different quality laboratories within the same company).

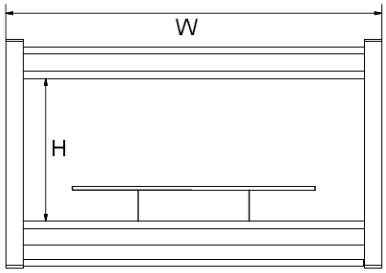
MAIN MEASURING APPLICATIONS

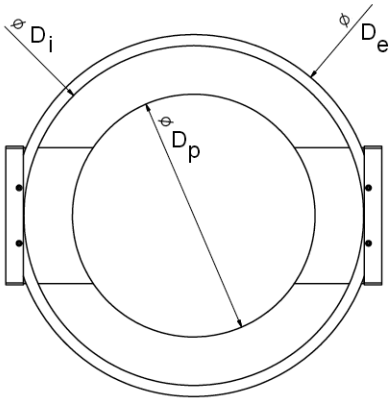
- Control of permanent magnets quality (Br)
- Controls magnetization of permanent magnets
- Measure of anisotropy axes of permanent magnets
- Determines the working point and loading line
- Estimation of recoil permeability
- Feedback control for calibration and magnetization systems

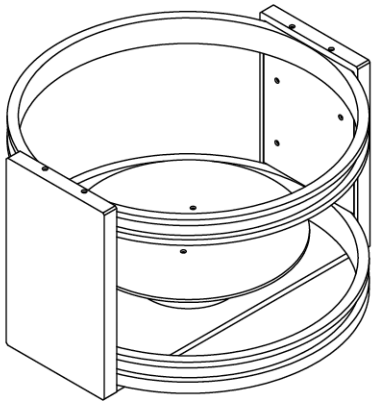
See also the relative section in this catalogue on Helmholtz coils used to generate magnetic fields

TECHNICAL SPECIFICATIONS

MODEL	Di	K_H (TYPICAL)	MEASUREMENT VOLUME	WEIGHT
HM/R15	30 mm (1.18”)	$4.5 \cdot 10^{-6}$ m	Ø 12 mm (0.47”) H 9 mm (0.35”)	1.2 kg (2.6 lb)
HM/R32	64 mm (2.52”)	$1.1 \cdot 10^{-4}$ m	Ø 29 mm (1.14”) H 19 mm (0.75”)	4 kg (8.8 lb)
HM/R58	116 mm (4.57”)	$4.5 \cdot 10^{-4}$ m	Ø 53 mm (2.086”) H 34 mm (1.338”)	6 kg (13.3 lb)
HM/R100	200 mm (7.87”)	$2.8 \cdot 10^{-3}$ m	Ø 90 mm (3.543”) H 60 mm (2.362”)	10 kg (22.1 lb)
HM/R150	300 mm (11.81”)	$7.3 \cdot 10^{-3}$ m	Ø 135 mm (5.314”) H 90 mm (3.543”)	12 kg (26.5 lb)
HM/R250	500 mm (19.69”)	$8.8 \cdot 10^{-3}$ m	Ø 225 mm (8.86”) H 500 mm (19.7”)	16 kg (35.2 lb)







Customized Helmholtz coils are available. Contact our technical sales group

FIELD COILS

Measuring a magnetic field with fluxmeter

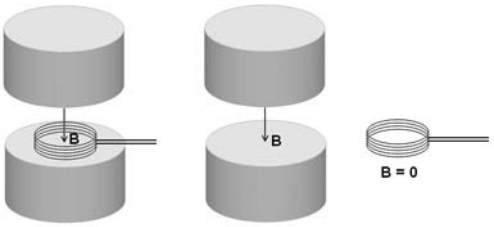
Laboratorio Elettrofisico designs and manufactures customized sensors to inductive meet specific needs of customers with different field conditions. Small field coils with many turns or large field coils that require greater cross section can be manufactured to meet the most demanding requirements.

A flat coil, made of N turns of area A, positioned in a uniform magnetic field B perpendicular to the coil, is linked to a flux $\Phi = B \cdot N \cdot A$.
Detecting the flux Φ with a fluxmeter, and knowing the coil's constant $N \cdot A$, it's simple to determine the field strength B.

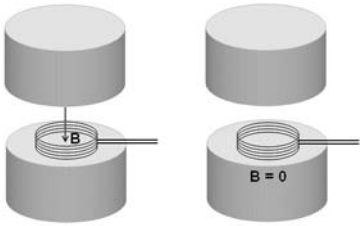
A fluxmeter integrates a voltage from a flux variation generated from the field coil(s).

There are different methods to produce such variation. For example:

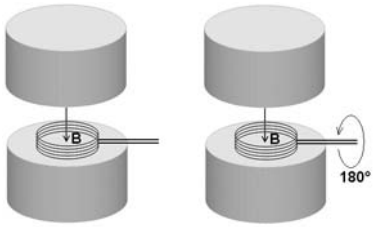
1. moving the coil from the region where the field exist, to a region where the field is zero;
2. switching off the field;
3. reversing the coil, to have a double reading.



1. $\Delta\Phi = BNA$



2. $\Delta\Phi = BNA$



3. $\Delta\Phi = 2BNA$

The reading is independent on how fast is moved the field coil.

MODEL LPH-200

Laboratorio Elettrofisico produces one standard model the LPH-200 field sensor. The LPH-200 has a magnetic area N · A of 7000 mm^2 (equivalent to 1.4 gauss for every µWb of flux).

Stem length:	120 mm
Thickness:	2.5 mm
Active area (diameter):	10 mm
Magnetic area:	7000 mm^2

To measure a AC magnetic field, $B(t) = B_0 \sin(\omega t)$ it's possible to connect the coil directly to a Voltmeter, and read the inducted voltage $V = - NA\omega B_0/\sqrt{2}$ (NA=magnetic area of the coil).

Contact you local Laboratorio Elettrofisico Sales Application Engineer to assist in designing a measuring coil to meet you technical needs.

POTENTIAL COILS

Measuring magnetic potential

The magnetic potential *P* is a scalar quantity defined by the relationship: *H=–dP/ds,* where *s* is the direction of variation of *H*. The difference of magnetic potential between two points A and B is given hence by:

$$P_A - P_B = \int_A^B H(s)\, ds$$

The magnetic potential is measured with potential coils. The potential coil is essentially a long winding made of many turns wounded in a thin tube.

The potential coil is connected to a fluxmeter and is mainly used to measure the demagnetization field H_d inside permanent magnets.

The measurement is made by positioning the end of the coil on one surface of the magnet, then resetting the fluxmeter and removing the coil to a zero-field region. The measured flux Φ is related to H_d by the relationship:

$$H_d = \frac{2 \cdot \Phi \cdot K_p}{d}$$

where K_p is the coil's constant and d is the thickness of the magnet.

Laboratorio Elettrofisico offers different models with different lengths and sensitivities.

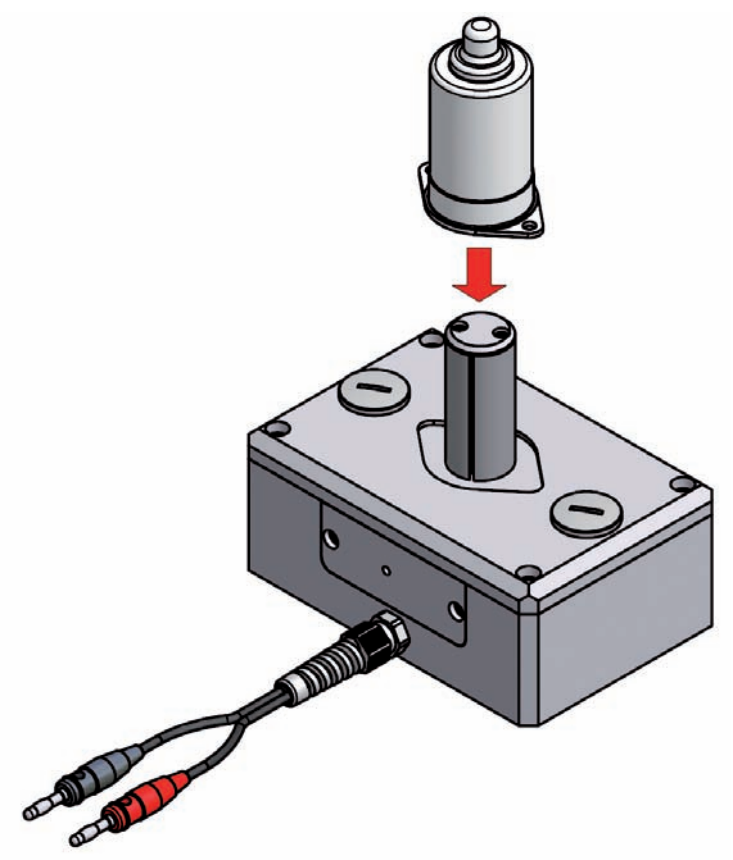
MODELS

MODEL	K_P (TYPICAL) (A/µWb)	SENSITIVITY (A/m/µWb · mm_{mag})	LENGTH (mm)
PM / S83	4.6	9.2	83
PM / S214	5.7	11.4	214
PM / S410	8.7	17.4	410

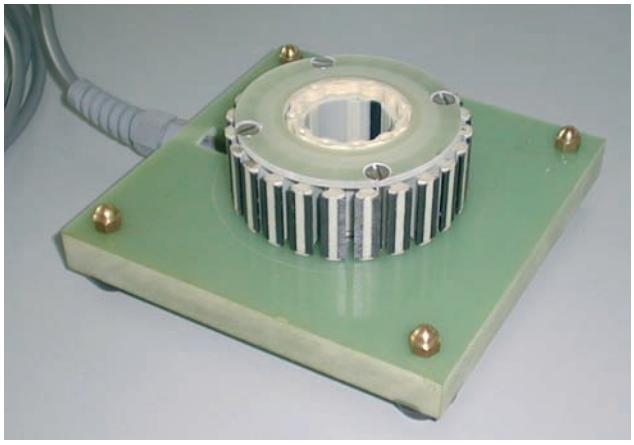
CUSTOM MEASURING COILS FOR ELECTRICAL MOTORS

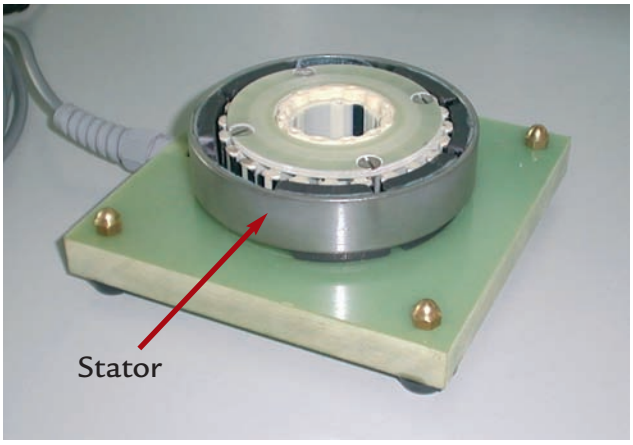
Measurement for total magnetic flux

Stators and rotors containing permanent magnets can be controlled with inductive coils fixtures.
The magnetic flux produced by a single pole or by the total number of poles of a stator or rotor assemble are induced to coils wound on a matched measurement fixture.



A custom design is necessary to ensure the measuring fixture matches the exact dimensions of the assembly to provide accurate measurements.





When connecting the measurement fixture to the Laboratorio Elettrofisico fluxmeter, measurements can be selected for the total flux of all the poles, or the measurement of a single pole.
If a single measurement is selected then rotor or stator must be rotated to match the measuring position and the pole under test.

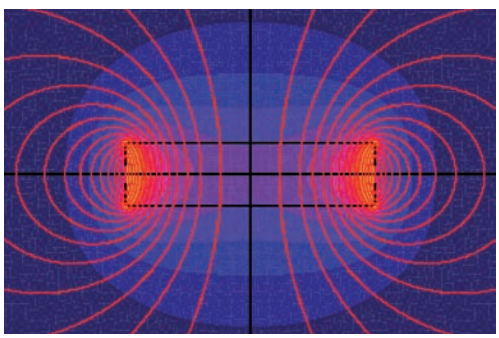
Contact Laboratorio Elettrofisico expert team of Sales Application Engineers to discuss the most suitable measurement coil for your application.

MEASUREMENT METHODS FOR MAGNETIC MATERIALS

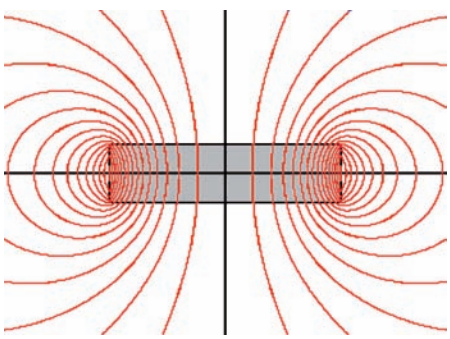
Introduction

The magnetic characterization of a material is performed measuring how its magnetization **M** (or magnetic polarization **J** = μ_0**M**) changes in function of the magnetic field **H**.
The most important curves are the hysteresis loop and the normal magnetization curve.

These curves have the same basic definition for both magnetically hard and soft materials, but the practical information taken by the curves is different, due to the differences in their applications.

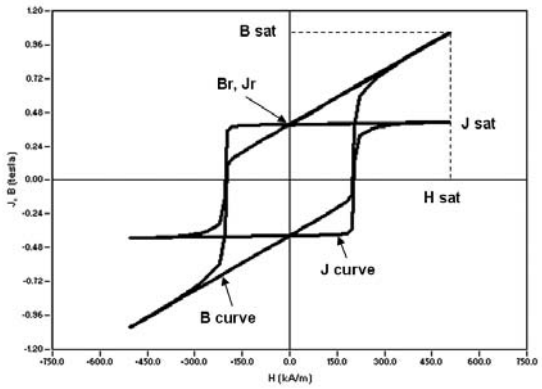


Hard materials (magnets) are used to produce permanent fields, so the most important parameters are obtained measuring the second quadrant of the hysteresis loop. For example; remanence Br, coercivity HcB, intrinsic coercivity HcJ, and the energy product BHmax.

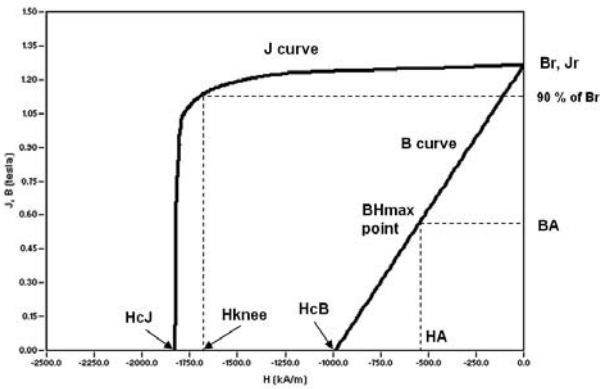


Soft magnetic materials are used to enhance and drive the magnetic field produced by electrical currents or permanent magnets. In this case the normal magnetization curve is very important, providing information of permeability μ of the material, and its saturation values Jsat, and Bsat. The hysteresis cycle reveals important parameters such as coercivity Hc, the remanence Br, and the loop area, especially when the material is used in AC applications.

HARD MAGNETIC MATERIAL

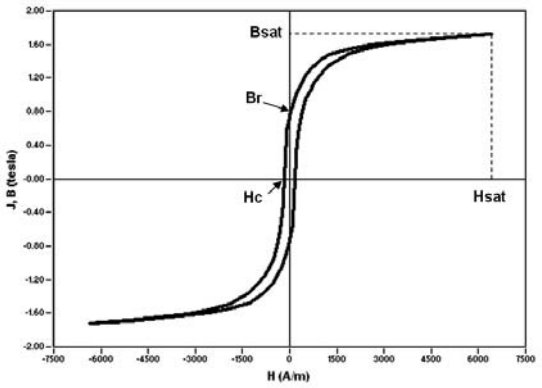


Hysteresis cycle
of a Hard Magnetic Material

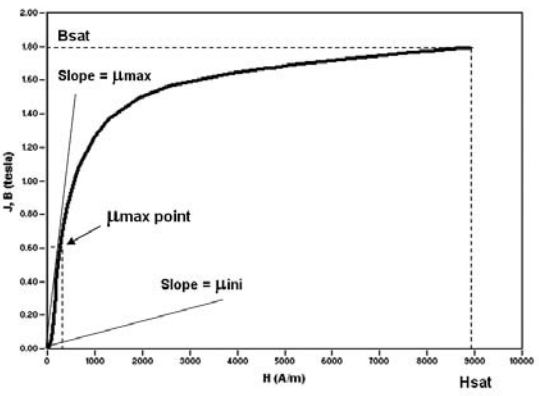


Second quadrant of hysteresis cycle
of a Hard Magnetic Material

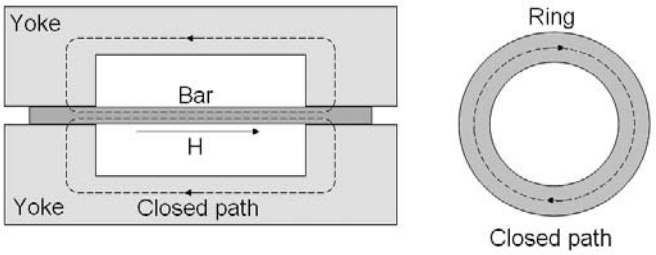
SOFT MAGNETIC MATERIAL



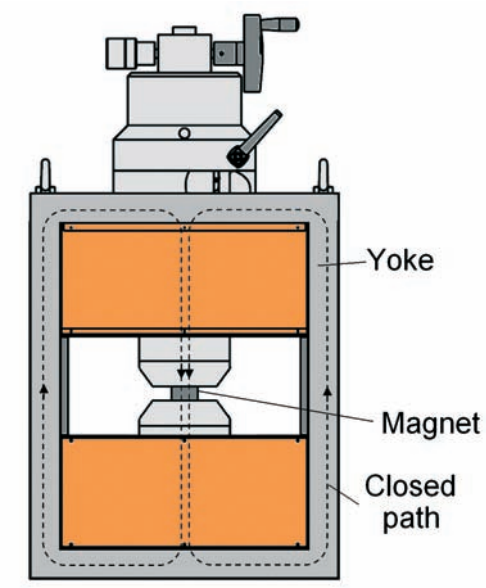
Hysteresis cycle
of a Soft Magnetic Material



Normal magnetization curve
of a Soft Magnetic Material

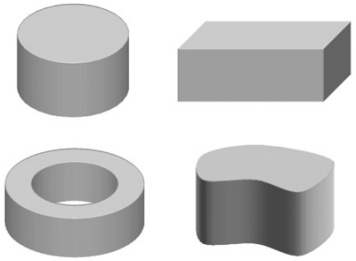


Magnetic closed path
for bars and ring



Magnetic closed path
for permanent magnets

Due to demagnetizing effects on open circuit samples, the intrinsic relationship between M and H depends on the shape of the sample: M is generally not uniform inside the sample and the effective H is difficult to evaluate. Only when the measurement is performed in a closed circuit conditions the demagnetization field is reduced or zeroed, M becomes uniform and the H field coincides with the external applied field.



Allowed shapes for Hard

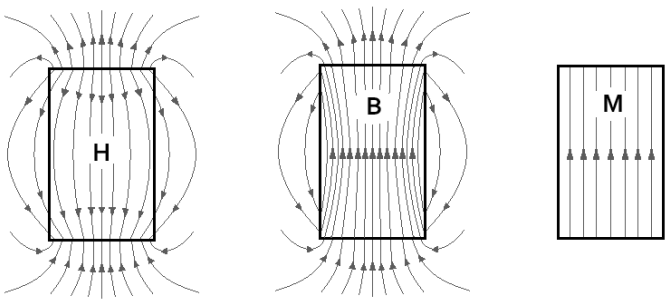
Bars, strips, rings: allowed shapes for Soft

Closed circuit conditions can be obtained by closing the extremity of the sample in a yoke with high permeability material or closing the flux on the sample itself, like for rings or strips in Epstein configuration.

The closed circuit conditions limit the suitable shapes, and prevents the measurement in some conditions or applications, especially for samples in their final configuration. Most International Standards recommend closed circuit methods; some standards lists open circuit measurements techniques, however, this generally limits the number of resulting parameters, such as the coercivity or the saturation magnetization.

DEMAGNETIZATION FIELD

By definition, the lines of *H* start from the north pole of a magnet and terminate to the south pole.



Reference Figure (a), the *H* lines have opposite directions outside and inside the magnet.
Inside the magnet, *H* is contrary to its magnetization *M*, and tends to demagnetize the magnet.
The internal *H* field is named the demagnetizing field (H_d) and is proportional to the magnetization *M*:

$$H_d = - N \cdot M$$

where *N* is the demagnetizing factor. *N* depends on the shape of the sample and on the permeability.

The exact value of *N* is difficult to determine in the measuring process. For this reason the preferred measuring method is a closed circuit configuration, for which condition $H_d = 0$.

MEASURING SYSTEMS

Laboratorio Elettrofisico provides a complete product line for the characterization of magnetic materials in accordance with the foremost International Standards for closed and open circuit testing conditions (see table). In addition to our standard accessories and products, there are custom devices for quantitative quality control on non-standard shapes, such as arc magnets, single strips, etc.

Material	Shapes	Condition	Frequency	LEE model	Ref. Standard
Hard magnets	Cylinder, rect. Prism, Parallelepiped, Ring, Arc (1)	Closed circuit	DC	AMH-300	IEC 60404-5 ASTM A977
Soft magnets	Ring	Closed circuit	DC	AMH-DC-T-S	IEC 60404-4 ASTM A773
	Ring, Bar, Strip	Closed circuit	DC	AMH-DC-TB-S	IEC 60404-4 ASTM A773
	Ring Strip (2)	Closed circuit	DC, AC	AMH-1K-S AMH-20K-S AMH-50K-S	IEC 60404-2 IEC 60404-4 IEC 60404-6 ASTM A773
	Any shape	Open circuit	DC	CR-01 CR-02	IEC 60404-7
Hard & Soft magnets	Hard: cylinder, rect. prism, parallelepiped, ring, arc (1). Soft: ring, strip (2)	Closed circuit	Hard: DC Soft: DC, AC	AMH-1K-HS AMH-20K-HS AMH-50K-HS	IEC 60404-5 IEC 60404-2 IEC 60404-4 IEC 60404-6 ASTM A977 ASTM A773
Hard metal and cemented carbides	Any shape	Open circuit	DC	AMH-5800	ASTM B886 ASTM B887
Feebly magnetic materials	Bar	Open circuit	DC	PFMM	ASTM A342

(1) with proper shaped poles - (2) with Epstein frame and/or with Single Strip Fixture

Laboratorio Elettrofisico modular measuring systems provide the ultimate in flexibility: all models can be combined configured in various ways to perform other kind of measurements.

For example, starting with the basic AMH-300 (measures Hard magnetic materials), and adding only a gaussmeter and a measuring coil, will enable and expand the instrument to measure Cemented Carbides like our model AMH-5800.

Other examples:

Starting model		Additional tools		Additional model
AMH-DC-TB-S	+	Solenoid	=	CR/01
AMH-DC-T-S	+	Solenoid, measuring coil	=	PFMM
AMH-300	+	Positioning tool	=	AMH-DC-T-S
AMH-DC-T-S	+	Gaussmeter Hall probe SB yoke	=	AMH-DC-TB-S

Larger cabinets are available upon request if upgrading the instrument is something you may need in the future. Contact you local Sales Application Engineer for additional information.

AMH-300 Hysteresisgraph

The measure of permanent magnets

The Laboratorio Elettrofisico AMH-300 Hysteresisgraph is a DC automatic measuring system for characterization of hard magnetic materials, such as Alnico, Ferrite, NdFeB, SmCo and bonded magnets.
The AMH-300 meets International Standard IEC 60404-5 and ASTM A977.
Measurements can be done either at room temperature or temperatures up to 220 °C with the optional temperature poles, that meets International Standard IEC/TR 61807.

Fast and easy characterization of all Hard Magnetic Materials

Samples are measured in closed circuit conditions using the Laboratorio Elettrofisico electromagnet. The fields produced by the electromagnet magnetize and demagnetize the magnet, while the compensated coils measures the field H and the magnetic polarization J.

The AMH-300 provides a fast and easy method to characterize hard magnetic materials. The measuring cycle is fully automatic, and is controlled by Laboratorio Elettrofisico exclusive software (Hyst2009), resulting in complete characterization of the material under test.

- Automatic measurement of 1st and 2nd quadrant, complete hysteresis loop, recoil line
- Remanence Br, coercivity HcB, HcJ, max energy product BHmax, Hknee, μ recoil, etc.
- Temperature measurements up to 220 °C
- Easy-to-use software and hardware
- Wide range of accessories for any sample shape or size

STANDARD CONFIGURATION

- The basic system consists of Fluxmeters, Power supply, Heating unit and Polarity switch
- Electromagnet + poles
- Measuring coil
- PC and printer
- Dedicated software Hyst2009 V2
- Reference sample, for day-to-day control

TECHNICAL SPECIFICATIONS

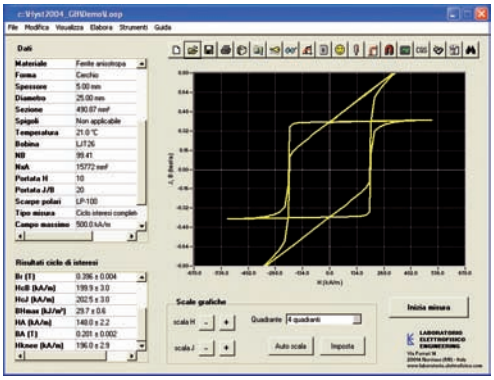
GENERAL	
Measurable materias	Alnico, Ferrite, NdFeB, $SmCo_5$, Sm_2Co_{17}, bonded magnets *IMPORTANT NOTE: rare earth magnets need to be saturated externally (for example with a pulse magnetizer)*
Measurable quantities	Br, HcB, HcJ, BHmax, Hknee, HA, BA, μrecoil, Jsat, Hsat, temperature coefficients α_{Br}, α_{HcJ}, loading line, working point, squareness, etc.
Accuracy	Br ± 1 % HcB, HcJ ± 1.5 % BHmax ± 2 %
Sample shape	Cylinder, rectangular parallelepiped, ring, any rectus prism with parallel bases
Sample size	Diameter or diagonal between 3 mm to 82 mm, height between 1 to 50 mm Diameter bigger than 10 mm, height between 3 to 50 mm with embedded coils
Max H field	Up to 3 T (2400 kA/m) with 60 mm poles (see electromagnet diagrams)
Testing time	Less than 30 seconds
MAIN ELECTRICAL CABINET	
Voltage	220 V (±10%) single-phase+ground, 50-60 Hz, 16 A max absorption
Power	3 kVA
Dimensions	535 x 950 x 750 (height) mm (21.06" x 37.40" x 29.52")
Weight	90 kg (198 lb)
FLUXMETER DF (2 UNITS) (see relative section for more information)	
Ranges	(1, 2, 5, 10, 20, 50, 100) x 2000 μWb
Resolution	From 1 μWb (range 1) to 100 μWb (range 100)
Accuracy	± 0.5%
Drift	Less than 1digit/minute
Input impedance	10 kΩ x range
MAGNETIC YOKE LEP/100-4S (see relative section for more information)	
Poles diameter	100 mm (4")
Maximum air gap	80mm (3.14")
Max field intensity	3 tesla in 2 mm gap with LP-60
Movement operating	Manual
Poles setting	Micrometric
Dimensions	330 x 410 X 491 mm (12.9" x 16.1" x 19.3"), excluded upper poles adjustment
Weight	350 kg (approx.) (780 lb)
POWER SUPPLY LKW-4-L	
Max Volt-Amp	60 V, 25 A
Power supply	220 V single-phase, 50-60Hz
Average consumption	1.5 kVA
Dimensions	Rack width 482 mm (19"), h 1U
Communication	RS232
PC AND SOFTWARE	
PC	PC, monitor, printer and all connection cables included
Operative system	Windows XP Professional O.S. based
Software	Hyst2009 (English or Italian)
Connection	USB
ACCESSORIES	
Compensated coils	Diameters from 10 to 82 mm
Ferrite arc measurement	Custom
Ferrite powder measurement	Kit with 100 mm diameter
Embedded coils	Coils with 6 or 10 mm
Reference samples	Any material and dimension for each kind of measure, for day-to-control
MANUALS AND DOCUMENTATION	
Instruction manual includes Hardware, Softwaare, Electrical Diagrams, and maintenance instructions in English.	

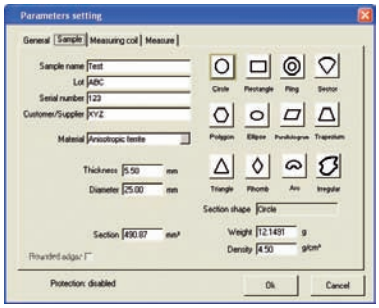
HYST2009: a powerful software to manage automatically the measurement

The Hyst2009 Software is the main communication and control software for the AMH-300 Hysteresisgraph and it's also an active part of the measuring system.

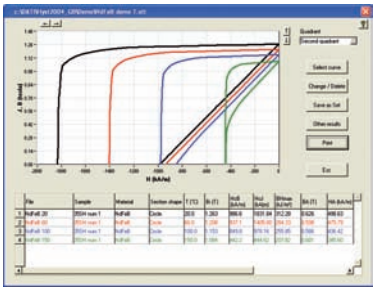
The systems accuracy is determined by precision instrumentation and our Hyst2009 Software. This operating software maintains the overall accuracy controlling all the parameters to ensure the measurement is precise and prevents operator's errors.

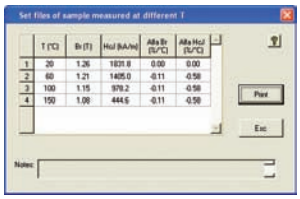
The Hyst2009 software provides additional help to overcome several physical limitations; extrapolation of the curve at higher or lower temperatures, interpolation of the curve when incomplete or irregular, curve's completion for high-coercivity magnets, etc.



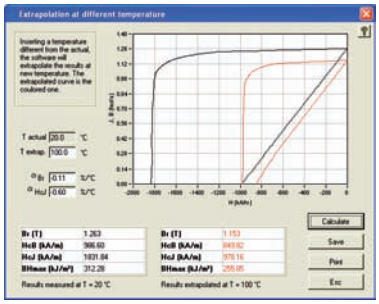


Parameters setting





Set of curves at different temperature and thermal coefficient evaluation



Curve extrapolation at a lower or higher temperature

To evaluate the temperature behaviour of the magnet without making the measurement at high or low T.

TYPE OF MEASURE

- 1st quadrant, 2nd quadrant, 1st and 2nd quadrant, complete hysteresis cycle, recoil permeability.

RESULTS

- Br, HcJ, HcB, BHmax, BA, HA, Hknee, Hsat, Jsat, Bsat, recoil permeability, magnetic moment, anisotropy parameters, loading line, working point, temperature coefficients and advanced results;
- Magnetic units in SI and CGS, measures in mm and inches, temperature in °C and °F.

SETTING OF MEASURING PARAMETERS

- Manual or automatic settings of magnetizing and demagnetizing field, speed, resolutions and many other parameters;
- Setting of acceptance limit for direct quality control.

PROTECTION

- Password protection for access and selected parameters.

SET OF MEASURES

- Possibility to group together different measurements in the same graph, to manage them in a collective way. The software recognizes the group type and provides additional results such as temperature coefficient or some statistical data (average, standard deviation, etc.).

DATA BASE AND FILE SEARCHING

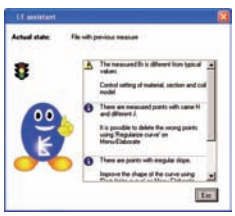
- Data base of measuring files with fast search options, ordering, selection, etc;
- Full compatibility with all main elaboration program, such as Microsoft Excel™.

PRINTING A REPORT

- 6 pre-set reports with different sizes and contents;
- Customized reports for changing the information and the language: 10 languages available for the printing (European languages plus Chinese and Hindi);
- Direct print or automatic creation of graphical and/or text file;
- Reports can be opened and saved with other spread sheet programs, like Microsoft Word™.

DATA ELABORATION

- Curve comparison;
- Extrapolation of the curve at higher or lower temperature, for a quick evaluation of the measured curve at different T;
- Curve's interpolation, automatic or using a mathematical function from a list;
- Extrapolation of uncompleted curves (such those of high-HcJ materials);
- Correction of poles' saturation;
- Elaboration of curves made with shaped poles;
- Automatic control of the Fluxmeter's drift.

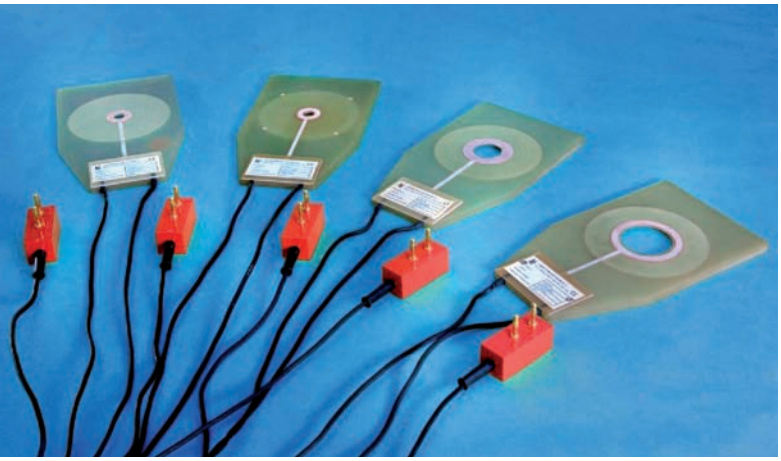


LEE ASSISTANT

Real-time 'friendly' Help assistant for suggestions or warnings that constantly updates the status of the machine and during the measurement cycle. With just a click of the mouse, the Assistant display the status, with a list of suggestions and/or warnings. When the amount of errors, anomalies or hardware problems exceeds a specific level, the Assistant automatically sends an alert.

Accessories

MEASURING COILS



COMPENSATED COILS

Our standard LEE Compensated coils measures the J-component to improve accuracy and resolution, with less dependency on the H field measurement. A second set of windings are used to measure H component.
Total B field is determined via the software.

Available models:
Model LJA-XX with thickness of 1 mm, only for R.T. measurements
Model LJT-XX with thickness of 2.5 mm, for measures up to 220 °C

TYPE	THICKNESS	Ø SAMPLE	POLE MODELS	TEMPERATURE RANGE
LJA-10	1 mm	0 – 10 mm	LP-60, 80, 100, 120	from +10 to +40 °C
LJA-15	1 mm	10 – 15 mm	LP-60, 80, 100, 120	from +10 to +40 °C
LJA-26	1 mm	15 – 26 mm	LP-60, 80, 100, 120	from +10 to +40 °C
LJA-42	1 mm	26 – 42 mm	LP-80, 100, 120	from +10 to +40 °C
LJA-64	1 mm	42 – 64 mm	LP-100, 120	from +10 to +40 °C
LJT-10	2.5 mm	0 – 10 mm	LP-60, 80, 100, 120	from -100 to +220 °C
LJT-15	2.5 mm	10 – 15 mm	LP-60, 80, 100, 120	from -100 to +220 °C
LJT-26	2.5 mm	15 – 26 mm	LP-60, 80, 100, 120	from -100 to +220 °C
LJT-42	2.5 mm	26 – 42 mm	LP-80, 100, 120	from -100 to +220 °C
LJT-64	2.5 mm	42 – 64 mm	LP-100, 120	from -100 to +220 °C
LJT-73	2.5 mm	64 – 73 mm	LP-100, 120	from -100 to +220 °C
LJT-82	2.5 mm	73 – 82 mm	LP-120	from -100 to +220 °C

Search coil LPH-200

SEARCH COIL FOR H MEASUREMENTS, MODEL LPH-200

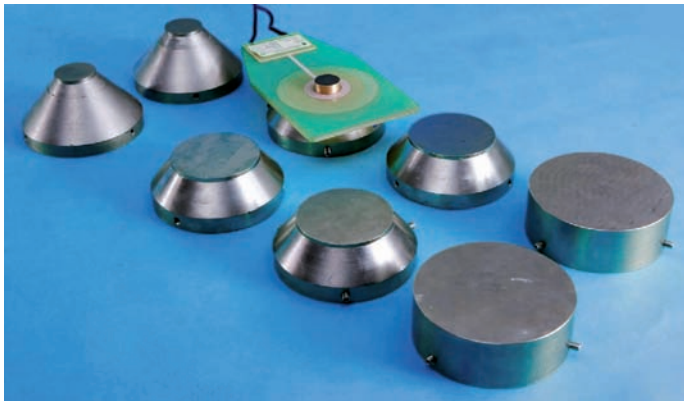
LPH-200 can be used alone or combined with embedded poles.

Typical magnetic area	7000	mm^2
Stem length	120	mm
Thickness	2.5	mm
Active area (diameter)	10	mm

POLES

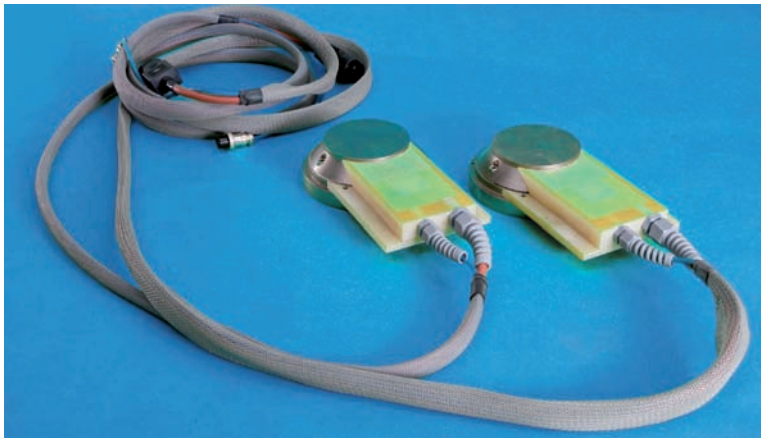
IRON POLES

Several models of interchangeable poles are available to ensure the best measurement accuracy. Pure iron pole caps guarantees a uniform field in the gap with a negligible residual field.
Pole cap diameters smaller than 120 mm are tapered to concentrate the field produced by the electromagnet:
For example: (up to 3 T in 2 mm gap with LP-60 Pole caps).



TYPE	MAX Ø SAMPLE	SUGGESTED COIL
LP-40	15 mm	10 – 15
LP-60	26 mm	10 – 26
LP-80	42 mm	10 – 42
LP-100	73 mm	10 – 73
LP-120	82 mm	10 - 82

See the Electromagnet part for the curve H vs. field and gap



HEATING POLES, FOR HIGH TEMPERATURE MEASUREMENTS

Heated Pole caps permit measurements above 220 °C, meeting International Standard IEC/TR 61807.
Easy connection to the AMH-300 unit and electromagnet.

CHARACTERISTIC\MODEL	LPT-80	LPT-100
Temperature range	20 – 220 °C	20 – 220 °C
Diameter	80 mm	100 mm
Uniformity area	45 mm	75 mm
Field at 2.5 mm gap	2.4 T	2.2 T
Weight	6 kg	10 kg

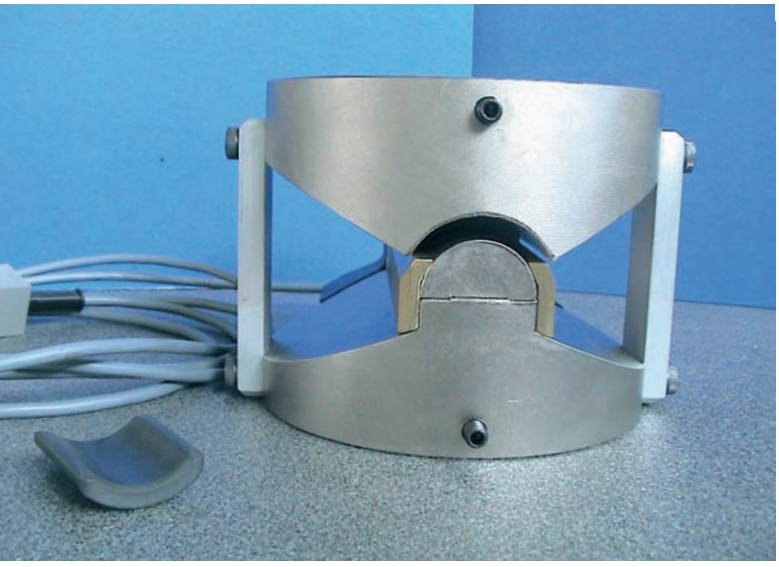
Accessories

POLES

EMBEDDED COILS

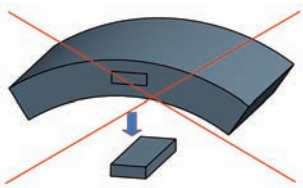
Pole caps with a magnetic sensor embedded in the surface are availlable. The embedded coils are useful for large ferrite samples, (for example loudspeakers magnet) or for deformable samples, (bonded ferrite). These coils are compensated for use with the H sensor, model LPH-200.

TYPE	Ø POLE	Ø COIL	WEIGHT
LP80/6-6	80 mm	6 mm	6 kg
LP80/10-10	80 mm	10 mm	6 kg



SHAPED POLES FOR FERRITE ARC MAGNETS

Shaped poles permit the non-destructive quality control on arc-shaped ferrite magnets.
This eliminates the difficulty to cut a regular-size sample from a fragile arc.
The measurement of B is performed by the coils wound directly in the pole, while the H measurement is done by the sensor LPH-200.
The shape of arc magnets can vary depending on the application. Laboratorio Elettrofisico can provide custom poles to fit your arc shapes.
The measurement is conducted with a fixed gap without using a closed circuit set up. This configuration simulates the performance of the magnet in the final application (typically electric motors).



It's no longer necessary to cut measurement material from ARC shaped magnets

POLES

KIT FOR FERRITE POWDERS MEASUREMENT

The Kit allows the measurement of ferrite magnetic powder at different pressures and densities. The powder is enclosed in a small case and pressed by associated accessories having different thicknesses. The differences in thickness result in different pressures and densities to the powder. The software Hyst2009 expands that data, to evaluate the magnetic qualities vs. density. Additional accessories needed: compensated coil LJT-26 or LJA-26.

REFERENCE SAMPLES

Reference samples are used for the day-to-day control of Hysteresisgraph calibration. They to can be used to validate other measuring system. Reference samples are included with AMH-300 or available on demand in any size and material.

MODEL	MATERIAL
HYS-F	Ferrite
HYS-Nd	NdFeB
HYS-Al	Alnico
HYS-Sm	SmCo
HYS-Ni	Nickel

AMH-DC-T-S DC Permeameter

For Soft Magnetic Rings

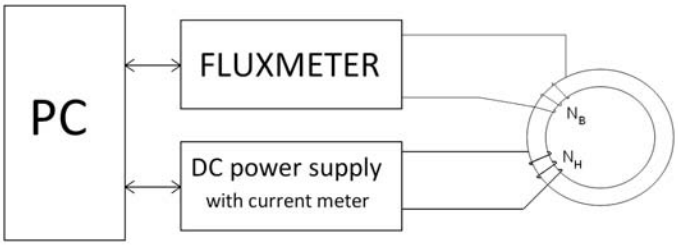
The Laboratorio Elettrofisico model AMH-DC-T-S Permeameter is a DC automatic measuring system to characterize toroids or ring shape soft magnetic materials, such as Fe. Soft toroids or ring shapes are the best configuration for the magnetic characterization measurements. Due to the naturally closed circuit, the demagnetizing field inside the material is zero.

Rings samples can be prepared in 3 different basic ways:

1. as a unique dense piece of material, obtained by mechanical works or by casting, sintering;
2. stacking several disks with the same inside and outside diameter, that can be obtained by punching, or laser cutting;
3. a unique thin strip wound as a clock-spring.

One single piece | Stacked rings | Wound thin strip

The sample must be wound with a primary set of turns N_H around the sample for excitation. A secondary set of turns N_B must also be wound around the sample to detect the magnetic flux.
The H field is determined measuring the current i in the primary winding: $H = N_H \cdot i / l$, where l is the magnetic path (the same of the averaged circumference, if the outside diameter D_e is not too large then the inside diameter D_i).
The B field is determined measuring the flux Φ from the secondary winding: $B = \Phi/(N_B A)$, where A is the cross section of the specimen.



The AMH-DC-T-S provides a fast and easy method to characterize materials in ring samples. The measuring cycle is fully automatic, and is controlled by Laboratorio Elettrofisico exclusive software (Soft2009-P), resulting in complete characterization of the material under test.

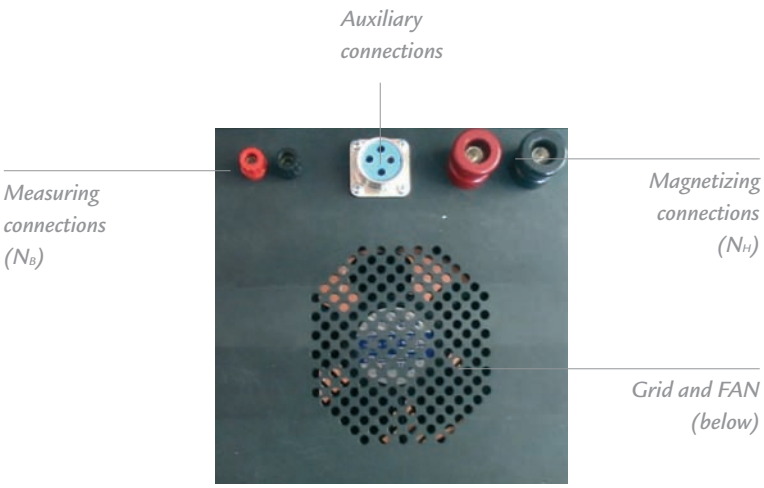
The AMH-DC-T-S meets the International Standards IEC 60404-4 and ASTM A773.

KEY CHARACTERISTICS

- Automatic measurement of complete hysteresis loop, normal magnetization curve, permeability curve
- Remanence Br, coercivity Hc, saturation values Hsat, Bsat, Jsat, cycle area, relative permeability, etc.
- Easy-to-use Software and Hardware

STANDARD CONFIGURATION

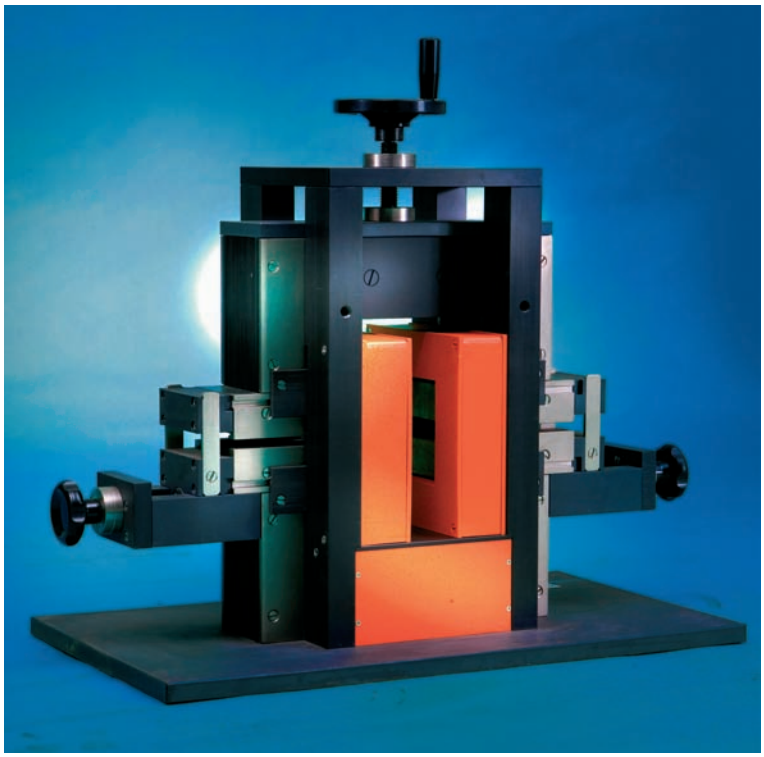
- The basic system consists of a Fluxmeter, a DC Power supply, with incorporated precision current meter, and Polarity switch
- Connection tool for ring sample
- PC and printer
- Dedicated software Soft2009-P
- Reference sample, for day-to-day control



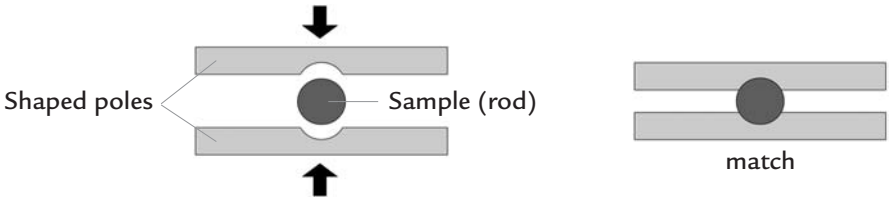
AMH-DC-TB-S DC Permeameter

For Soft Magnetic Rings, Bars, Strips

The Laboratorio Elettrofisico model AMH-DC-TB-S permeameter is a variation of the model AMH-DC-T-S. This model provides additional features to measure toroid, ring shapes samples plus bar and strip shapes.
The measurement of bars and strips are made in a closed circuit condition using the model LEP-SB electromagnet (Sanford-Bennet type), made of highly permeability material.



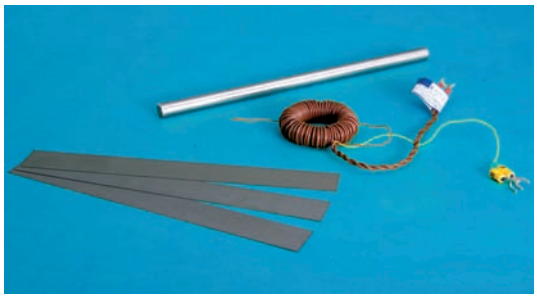
The bar samples must be linear with a uniform cross section area. Pole shoes are used to complete the closed circuit configuration for the measurement.



The H field is determined by measuring the excitation field closest to the sample with a Hall probe. This measurement is accomplished by detecting the tangential components of H field in the separation surfaces of the magnetic media. The induction B inside the material is determined measuring the flux Φ from a pick-up coil. Example: $B = \Phi/(N_B \cdot A)$, where A is the cross section of the specimen and N_B is the number of turns of the coil.
When measuring bar samples, windings are not necessary. The sample is simply inserted into a pick-up inductive coil with the proper diameter, which contains the Hall probe.

The measuring cycle is fully automatic, and is controlled by Laboratorio Elettrofisico exclusive software (Soft2009-P), resulting in complete characterization of the material under test.

The Model AMH-DC-TB-S meets the International Standards IEC 60404-4 and ASTM A773.



KEY FEATURES:

- Automatic measurement of complete hysteresis loop, normal magnetization curve, permeability curve
- Remanence Br, coercivity Hc, saturation values Hsat, Bsat, Jsat, cycle area, relative permeability, etc.
- Easy-to-use Software and Hardware

STANDARD CONFIGURATION

- The basic system consists of a Fluxmeter, two DC Power Supplies, with an incorporated precision current meter, a Gaussmeter and Polarity switch
- Transverse Hall probe
- Pick-up inductive coil
- Electromagnet LEP-SB
- Connection tool for Toroids and Ring samples
- PC and printer
- Dedicated software Soft2009-P
- Reference bar, for day-to-day control
- Reference ring, for day-to-day control

TECHNICAL SPECIFICATIONS

	AMH-DC-T-S	AMH-DC-TB-S
GENERAL		
Measurable materials	Soft Magnetic Materials	
Measurable quantities	Bsat, Jsat, Hsat, Br, Hc, cycle area, μ_{rel}	
Measurable shapes	Ring	Ring, Bar, Strip
Sample size Ring	No physical limitation (size affects the max H field)	No physical limitation for rings (size affects the max H field)
Sample size Bar	-	Min height/diameter: 5 mm Max height/diameter: 25 mm Min length: 100 mm
Typical accuracy Ring	Hsat, Hc: ± 1 % Bsat, Br: ± 1 % μ_r: ± 2 %	Hsat, Hc: ± 1 % Bsat, Br: ± 1 % μ_r: ± 2 %
Typical accuracy Bar	-	Hsat, Bsat: ± 1 % Br, Hc: ± 2 % μ_r: ± 3 %
Test time	60-120 seconds (typical)	
Operating temperature range	15 ÷ 40 °C	
Frequency	DC	
MAIN CABINET		
Power Supply	220 Vac, 50-60 Hz, 16 A max absorption	
Units	12 U (16 U on demand)[1]	16 U
Dimensions	535 x 655 x h628 mm	535 x 855 x h806 mm
Weight	80 kg (178 lb)	90 kg (200 lb)
POWER SUPPLY LPS[2]		
Power output	100 W: 8 V / 8 A or 20 V / 4 A	
Resolution	5 mV / 1 mA	
Current accuracy (reading)	0.14 % + 5 mA	
POWER SUPPLY HPS[2]		
Power output	400 W: 36 V / 12 A	
Resolution	10 mV / 3.6 mA	
Current accuracy (reading)	0.4 % + 40 mA	
GAUSSMETER		
Ranges	-	3 G, 30 G, 300 G, 3 kG, 30 kG
Resolution	-	From 10 µG to 1 G
Accuracy	-	± 0.05 %
Communication port	-	RS232, IEEE 488
HALL PROBE		
Type	-	Transverse
Stem material	-	Aluminium
Dimensions	-	200 x 4.6 x 1.5 mm (8 x 0.18 x 0.06 ")
Linearity	-	0.25 % to 30 kG
Cable length	-	1.5 m (5 ft)
YOKE LEP/SB-1		
Max Field	-	1230 Oe (100 kA/m)
Max Current	-	12 A
Diameter	-	50 mm (1.97")
1 % uniformity length	-	110 mm (4.33")
Dimensions	-	280 x 225 x 410 mm (11.0 x 8.86 x 16.14")
PC AND SOFTWARE		
PC	PC, monitor, printer and all connection cables	
Operative system	Windows XP Professional O.S. based	
Software	Soft2009-P (English or Italian)	
Connection	LAN	
MANUALS AND DOCUMENTATION		
	Instruction manual (English or Italian) Calibration certificate CE mark	

Accessories

LEP/SB-1

Sanford-Bennet yoke, made with high-permeability materials, is designed to have the best magnetic circuit closure on bars terminals.

Max field: up to 100 kA/m (1250 Oe)
Max diameter or height of the bar: 25 mm
Max width of the bar: 30 mm

PICK-UP COILS

Pick-up coils are used for the measurement of bars and strips without winding turns over its cross section. The coil provides the capability to position the probe close to the sample's surface.

Different diameters are available for different bar sizes: 8, 10, 15, 20, 25 mm diameter, and for 3 x 30 mm strips and bars with rectangular cross sections.
Custom Pick-up coils designs are available.

<-- Notes:

1 • The AMH-DC-T-S can be purchased with the optional 16U enclosure to provide the capability to upgrade to the AMH-DC-TB-S that includes a Gaussmeter and the LEP/SB-1 Yoke

2 • The Power supply can be customized to meet the power demands of various sizes of materials.

• For measurement of Hard Ferrite and Alnico materials the AMH-DC-TB-S can be enhanced with the use of special poles and measuring coils.

POLE ADAPTORS

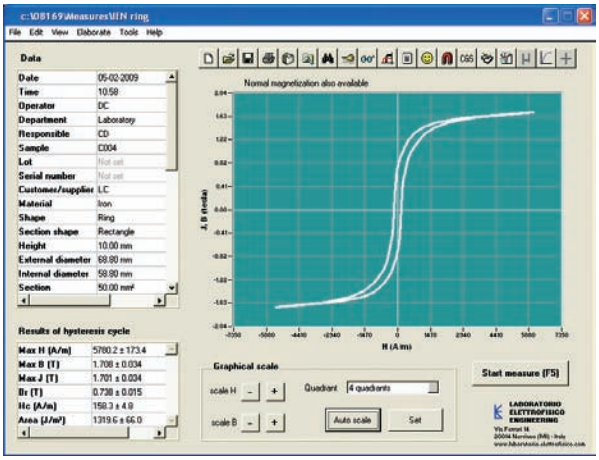
The Pole Adaptors are made of pure soft iron, and permit the matching the sample's cross section to the poles of the LEP/SB-1.

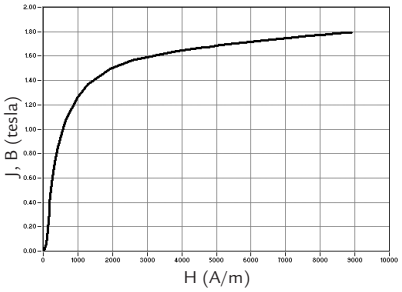
Different diameters are available for bar sizes: 8, 10, 15, 20, 25 mm diameter, and for 3 x 30 mm for strips and bars with rectangular cross section.
Custom pole adaptors diameters are available.

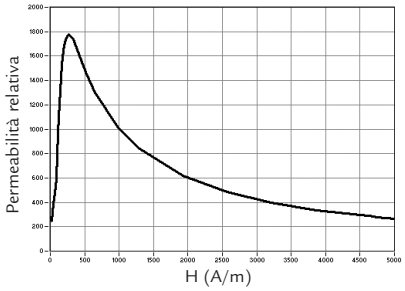
The Soft2009-P Software is a powerful tool to manage and automatically measure the samples

The Soft2009-P Software completely and automatically manages the measurements of the AMH-DC-T-S and AMH-DC-TB-S permeameters. The total accuracy is not dependent only on single instrument accuracy. The Laboratorio Elettrofisico permeameter overall accuracy is based on a set of executed commands from the software that ensures the measuring process is accurate and absolute. The software also prevents the operator from improperly setting the samples parameters.

The Automatic Assistant notifies the operator and makes suggestion for the appropriate procedures or settings. The software also provides automatic creation for printing reports, database search feature and curve comparison.







TYPE OF MEASUREMENT

- Hysteresis loop, normal magnetization curve and relative permeability, first order reversal curves;
- Demagnetization of the sample.

RESULTS

- Hsat, Bsat, Jsat, Br, Hc, loop area, relative permeability and many advanced results;
- Magnetic units in SI and CGS, measures in mm and inches, temperature in °C and °F.

SETTING OF MEASURING PARAMETERS

- Manual or automatic settings of magnetizing and demagnetizing field, speed, resolutions plus other parameters;
- Setting the acceptance limits for direct quality control.

PROTECTION

- Password protection for access and selected parameters.

SET OF MEASURES

- The possibility to group different measurements within the same graph, and manage the data collectively. The software recognizes the type of groups and provides additional results including statistical data for example the average, standard deviation, etc.

DATA BASE AND FILE SEARCHING

- Data base of measurement files with fast search options, ordering, selection, etc;
- Full compatibility with other database programs, such as Microsoft Excel™.

PRINTING A REPORT

- 6 pre-set reports with different sizes and contents;
- The capability to customize reports for changing the information and the language: 2 languages available for the printing (English and Italian);
- Direct print or automatic creation of graphical and/or text file;
- The report can be opened and saved with other word processing programs, such as Microsoft Word™.

DATA ELABORATION

- Curve comparison;
- Curve's interpolation, automatic or using a mathematical function from a list;
- Automatic control of the Fluxmeter's drift;
- Merging of different curves.

LEE ASSISTANT

Real-time 'friendly' Help assistant for suggestions or warnings constantly updating the status of the instrument at idle and during the measurement. With a click of the mouse, the Assistant will display the actual state, with a list of suggestions and/or warnings. When the specific amount of errors, anomalies or hardware problems exceeds a pre specified level, the Assistant comes on automatically.
Help files (with a list of suggestions to index).

AC/DC Permeameters

For Soft Magnetic Rings and Strips

Models:

AMH-1K-S (DC-1 kHz)
AMH-20K-S (DC-20 kHz)
AMH-50K-S (DC-50 kHz)
AMH-1M-S (DC-1 MHz)

Laboratorio Elettrofisico manufactures a complete line of combination permeameters for soft magnetic materials from DC to 1 MHz.
DC measurements provide analysis for the intrinsic and static properties. The AC measurement offers analysis for the behavior of the materials under dynamic conditions.
Dynamic properties are affected by many factors depending on the particular application conditions. Laboratorio Elettrofisico AC permeameter provides the designer with realistic characteristics of power losses, saturation field and induction performance relating to thickness of the material and the electrical resistivity.

The Laboratorio Elettrofisico AMH Series offers a wide range of permeameter models for AC/DC measurement for soft magnetic ring or strips.
Listed below in the chart are the various models that describe the performance range .

	AMH-1K-S	AMH-20K-S	AMH-50K-S	AMH-1M-S
Max frequency	1.2 kHz	20 kHz	50 kHz	1 MHz
Min frequency	DC	DC	DC	DC
Max power	1800 VA	1800 VA	4000 VA	700 VA
Sampling rate	1.25 MS/s	2 GS/s	2 GS/s	2 GS/s
Resolution (bits)	16	12	12	12

All models are supplied with our exclusive, ready to use soft magnetic ring fixture.
The ring (toroid) is placed at the center of the fixture and is connected to the drive and sense connections. The fixture is supplied with a cooling fan to reduce the temperature effects on the samples during measurement.

OPTIONAL FIXTURES ARE AVAILABLE FOR MAGNETIC STRIPS:

- Model EF-3266 Epstein frame
- Model ST-100 Single Strip Yoke

OPERATING PRINCIPLE

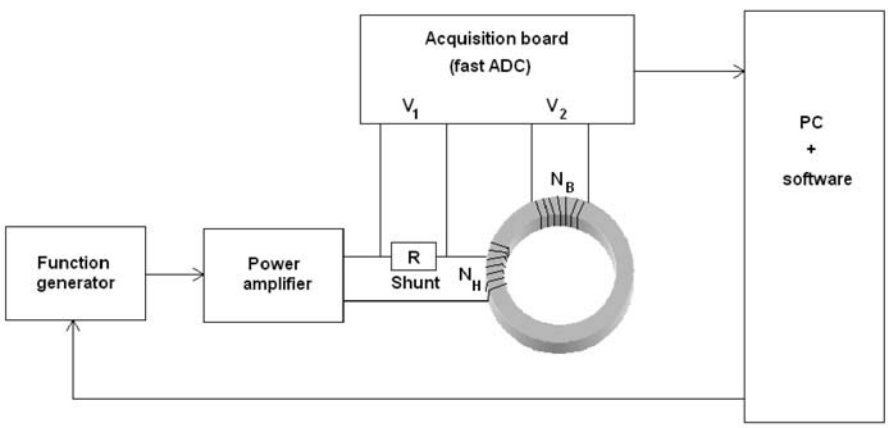
Ring or the toroids are the best shape for the magnetic characterization, since it's a naturally closed circuit, and the demagnetizing field within the material is zeroed.

As for DC measurement, the ring can be prepared in 3 basic ways:

- a unique dense piece of material, obtained by mechanical works or by casting, sintering, etc.
- by stacking several disks with the same internal and external diameter, that can be obtained by punching, laser cutting, etc.
- by a unique thin strip wound as a clock-spring.

For AC measurements, the eddy currents found in electrically conductive material will affect the final results, so it's very important to perform the test using the material in conditions that are similar to the designed application. For example, if the design calls for a thickness of 0.5 mm, the measurement should be made with stacked rings of 0.5 mm thickness, each one electrically insulated from each other.

The sample has to be prepared with winding a primary set of turns N_H (Drive) around the sample for excitation and a secondary set of turns N_B (Sense) to detect the magnetic flux.

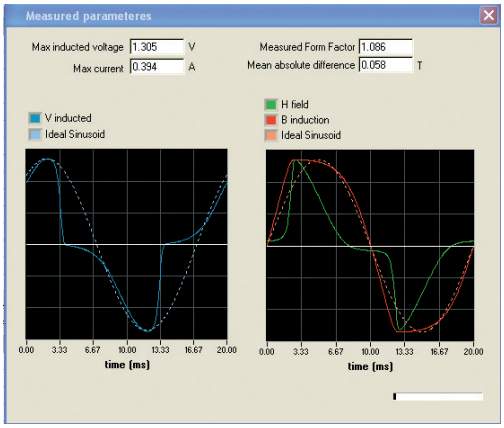


The H(t) field is determined measuring the current *i* (t) in the primary winding:
$H(t) = N_H \cdot i(t)/l$, where l is the magnetic path. The current is measured by measuring the voltage across a low-inductance resistance R (shunt).
For DC measurements, B is measured through the flux Φ by use of a fluxmeter.
For AC measurements, the B(t) field is determined by integrating the voltage V(t) from the secondary winding:

$$B = -\frac{1}{N_B A}\int V(t)dt$$

where A is the cross section of the specimen.

An Arbitrary Function Generator generates a voltage at the desired frequency that is amplified by a power amplifier to reach a suitable level of excitation current.
A general condition required is that B must change as a sinusoidal function respect time t: $B(t) = B_0 \sin(2\pi f \cdot t)$.
Due to the non-linearity of magnetic materials, generally this condition is achieved only by a feedback control by the software, that drives the Arbitrary Function Generator to supply the suitable voltage V(t) to reach the requested condition.
This feedback can be hidden to non expert operators, or can be displayed during the measurement, if desired.



Feedback window to obtain sinusoidal B

The measuring cycle is fully automatic, and is controlled by Laboratorio Elettrofisico exclusive software (Soft2009), resulting in complete characterization of the material under test.

The AC/DC AMH-XX-S meet the International Standards IEC 60404-4, IEC 60404-6, IEC 60404-2 and ASTM A773.

KEY FEATURES:

- Automatic measurement of complete DC or AC hysteresis loop, normal magnetization curve, permeability curve
- Remanence Br, coercivity Hc, saturation values Hsat, Bsat, Jsat, cycle area, relative permeability, losses, losses separation, etc.
- Easy-to-use Software and Hardware

STANDARD CONFIGURATION

- The basic system consists of a Fluxmeter, an Arbitrary Function Generator, a Power amplifier and a fast Acquisition Unit.
- Connection tool for ring sample
- PC and printer
- Dedicated software Soft2009
- Reference sample, for day-to-day control

TECHNICAL SPECIFICATIONS

	AMH-1K-S	AMH-20K-S	AMH-50K-S	AMH-1M-S
GENERAL				
Frequency range	DC ÷ 1.2 kHz	DC ÷ 20 kHz	DC ÷ 50 kHz	DC ÷ 1 MHz
Max power	1800 VA	1800 VA	4000 VA	700 VA
Measurable materials	Soft Magnetic Materials			
Measurable quantities	Bsat, Jsat, Hsat, Br, Hc, cycle area, μ_{rel}, specific losses P, losses separation			
Measurable shapes	Ring, Strip[1]			
Sample size Ring	No physical limitation (size affects the max H field)			
Sample size Strip	With Epstein: 30 mm x 300 mm (multiple of 4)			
Typical accuracy Ring	Bsat, Br: ± 1 %; Hsat, Hc: ± 1 %, μ_r: ± 2 %; Losses: ± 3 %			
Typical accuracy Strip	Bsat, Br: ± 1 %; Hsat, Hc: ± 1 %, μ_r: ± 2 %; Losses: ± 3 %			
Test time	60-120 seconds (typical)			
Operating temperature range	15 ÷ 40 °C			
POWER AMPLIFIER				
Power output	1800 VA	1800 VA	4000 VA	700 VA
Bandwidth	25 kHz	25 kHz	50 kHz	1 MHz
ACQUISITION UNIT				
Frequency ranges	DC to 1.2 kHz	DC to 100 MHz	DC to 100 MHz	DC to 100 MHz
Channels (analog in.)	8	4	4	4
ADC Resolution 1	16 bits	12 bits	12 bits	12 bits
Sampling rate	1.00 MS/s multi-ch	2 GS/s	2 GS/s	2 GS/s
Max voltage range	± 11 V	± 20 V	± 20 V	± 20 V
Max input voltage	± 11 V	± 300 Vpeak	± 300 Vpeak	± 300 Vpeak
FUNCTION GENERATOR				
Frequency	1 µHz to 20 MHz (1 µHz resolution). Max measuring frequency is limited by amplifier			
Voltage amplitude	20 mVpp to 20 Vpp (4 digit resolution)			
Amplitude resolution	14 bits			
THD	0.04 %			
FLUXMETER				
Model	Digital Flux			
Ranges	(1, 2, 5, 10, 20, 50, 100) x 2000 µWb			
Resolution	From 1 µWb (range 1) to 100 µWb (range 100)			
Accuracy	± 0.5 %			
Drift	Less than 1 digit/minute			
PC AND SOFTWARE				
PC	PC, monitor, printer and all connection cables			
Operative system	Windows XP Professional O.S. based			
Software	Soft2009 (English or Italian)			
Connection	LAN			
MAIN CABINET				
Power Supply	220 Vac, 50-60 Hz, 16 A max absorption			
Units	28 U (16 U on demand)			
Dimensions	535 x 855 x 1336 mm (1390 mm with wheels)			
Weight	235 kg (517 lb)	245 kg (539 lb)	260 kg (572 lb)	260 kg (572 lb)
MANUALS AND DOCUMENTATION				
	Instruction manual (English or Italian)			
	Calibration certificate			
	CE mark			

Notes:

- When the AMH-XX-S is ordered in the 28U cabinet, it is ready for immediate upgrade to AMH-XX-HS, to measure both hard and soft magnetic materials;
- The power supply can be customizable in case of particular sizes/materials.

Accessories

EPSTEIN FRAME, MODEL EF-3266

The EF-3266 Epstein Frame Test Set is a 25 cm Epstein test set designed for the measurement of the magnetic characterization of electrical iron sheet materials in accordance with IEC 60404-2, ASTM A343 and A348 test methods for electrical sheet steel.
When used in conjunction with AMH permeameter, power losses and magnetizing characteristics at commercial frequencies can be measured by the means of a stack of rectangular test specimens.

- Frequency: designed to test from DC to 400 Hz
- Max Field: 350 Oe
- Sample size: 30 mm wide by 300 mm long
- Path length: 0.94 m
- Number of turns: 700 (H), 700 (B)

SINGLE STRIP TEST FIXTURE, MODEL ST-100

The ST-100 Single Strip Test Fixture is used to characterize the magnetic properties of materials in accordance with ASTM A804 standard test methods for alternating magnetic properties of materials at power frequencies using sheet-type test specifications. When used in conjunction with our AMH permeameter, the fixture can measure specific core loss, peak permeability, saturation induction, coercivity (H_c) and residual induction (B_r) of sheet specimens. The Single Strip Test Fixture consists of a specially laminated yoke and excitation/measurement coil.

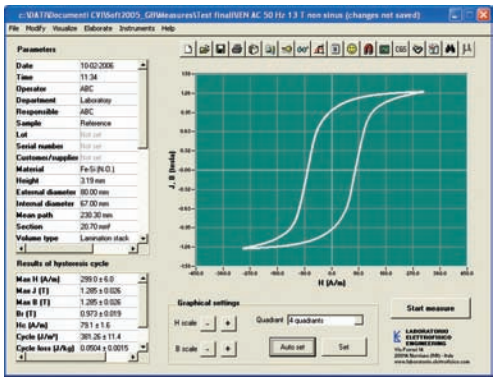
The coil contains both primary and secondary windings. The primary winding carries the voltage and current to excite the strip specimen. The H field experienced by the specimen is directly proportional to the primary current. The secondary winding senses the voltage induced by the changing magnetization of the specimen. The B field is proportional to the integral of the secondary voltage. An adjustable air flux compensator is included as part of the fixture to eliminate secondary winding signals which are due solely to the mutual inductance of the primary and secondary windings. The Single Strip test is a *relative* test and should be correlated with Epstein frame data if absolute measurements are required. If the Epstein frame is also to be used, the strips should be cut to the required size for the Epstein frame (30/mm wide by 300/mm long).

- Conforms to ASTM-A804.
- Frequency Designed to test from DC to 400 Hz.
- Max Field 100 Oe
- Sample size 5.9” (15 cm) minimum length (longer lengths are allowed to extend outside the fixture), 0.75” to 1.5” (2-4 cm) width and 0.025” (0.64 mm) maximum sample thickness.

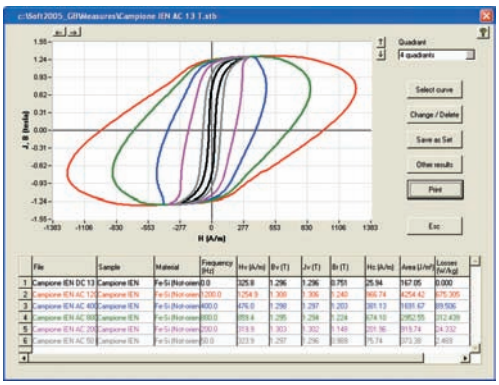
Soft2009: Software automatically controls and manages the measurement

The Soft2009 Software completely and automatically manages the measurements of the AMH-Series of AC/DC permeameters. The total accuracy is not dependent on only dependent to single instruments accuracy: the Laboratorio Elettrofisico permeameter overall accuracy is based on a set of executed commands from the software that ensures the measuring process is accurate and absolute. The software also prevents the operator from improperly setting the samples parameters.

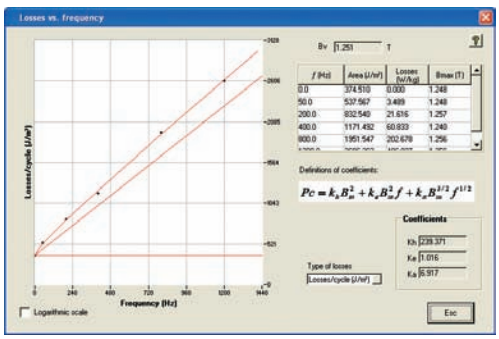
The Automatic Assistant notifies the operator and makes suggestion for the appropriate procedures or settings. The software also provides automatic creation for printing reports, database search feature and curve comparison.

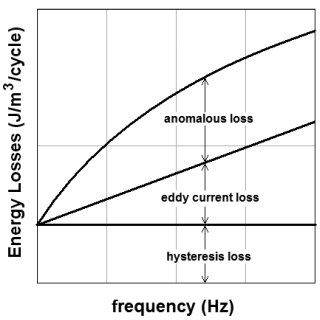


AC curve of a Fe-Si ring at 50 Hz (main panel)



Comparison of curves with same Bv at different frequencies. This allows to evaluate the losses separation and relative coefficients.





Losses separation and relative coefficients

TYPE OF MEASUREMENT

- Hysteresis loop, normal magnetization curve and relative permeability, in DC and AC conditions;
- Sinusoidal B condition;
- First order reversal curves (DC only);
- Demagnetization of the sample.

RESULTS

- Hsat, Bsat, Jsat, Br, Hc, loop area, relative permeability, specific power losses, losses separation, Steinmetz coefficient and many advanced results;
- Magnetic units in SI and CGS, measures in mm and inches, temperature in °C and °F.

SETTING OF MEASURING PARAMETERS

- Manual or automatic settings of magnetizing and demagnetizing field, speed, resolutions and many other parameters;
- Setting of acceptance limit for direct quality control.

PROTECTION

- Password protection for access and selected parameters.

SET OF MEASURES

- Possibility to group together different measures in the same graph, to manage them in a collective way. The software recognizes the type of group and gives additional results such as statistical data (average, standard deviation, etc.)

DATA BASE AND FILE SEARCHING

- Data base of measuring files with fast search options, ordering, selection, etc.
- Full compatibility with other spread sheet programs, such as Microsoft Excel™.

PRINTING A REPORT

- 6 pre-set reports with different sizes and contents
- Customized report option for changing the information and the language: 2 languages available for the printing (English and Italian).
- Direct print or automatic creation of graphical and/or text file
- The report can be opened and saved with other word processor programs, like Microsoft Word™.

DATA ELABORATION

- Curve comparison
- Curve's interpolation, automatic or using a mathematical function from a list;
- Automatic control of the Fluxmeters drift;
- Merging of different curves.

LEE ASSISTANT

Real-time 'friendly' Help assistant for suggestions and provides the updated status of the instrument in the idle and measurement modes. With a click of the mouse, the Assistant displays the actual state, with a list of suggestions and/or warnings. When the amount of errors, anomalies or hardware problems exceeds a certain level, the Assistant comes on automatically.
Help file (with suggested solution index).

COMBO SYSTEMS

Hand and Soft Magnetic Materials Measurements

Models:

AMH-1K-HS AMH-20K-HS
AMH-50K-HS AMH-1M-HS

The AMH Combo System series HS are combinations of AC and DC permeameters for the measurement of Soft and Hard magnetic materials.
The model number signifies the performance parameters.
Example: model AMH-1K-HS, is a combination of the AMH-1K-S and the AMH-300, to provide total capability of both single systems.

AMH-1K-S	+	**AMH-300**	=	**AMH-1K-HS**
AMH-20K-S	+	**AMH-300**	=	**AMH-20K-HS**
AMH-50K-S	+	**AMH-300**	=	**AMH-50K-HS**

For more information on our single AMH Instruments contact your local Laboratorio Elettrofisico Application Engineer.

STANDARD CONFIGURATION

- Our standard system consists of two Fluxmeters, a DC Power Supply, an Arbitrary Function Generator, a Power amplifier and a fast Acquisition Unit.
- Connection tool for ring sample
- Electromagnetic yoke
- PC and printer
- Dedicated software Soft2009
- Dedicated software Hyst2009
- Reference sample, for day-to-day control

TECHNICAL SPECIFICATIONS

	AMH-1K-HS	AMH-20K-HS	AMH-50K-HS	AMH-1M-HS
GENERAL				
Frequency range	DC ÷ 1.2 kHz	DC ÷ 20 kHz	DC ÷ 50 kHz	DC ÷ 1 MHz
Max power	1800 VA	1800 VA	4000 VA	700 VA
Measurable materials	Soft Magnetic Materials			
Measurable quantities	Bsat, Jsat, Hsat, Br, Hc, cycle area, μ_{rel}, specific losses P, losses separation			
Measurable shapes	Ring, Strip[1]			
Sample size Ring	No physical limitation (size affects the max H field)			
Sample size Strip	With Epstein: 30 mm x 300 mm (multiple of 4)			
Typical accuracy Ring	Bsat, Br: ± 1 %; Hsat, Hc: ± 1 %, µr: ± 2 %; Losses: ± 3 %			
Typical accuracy Strip	Bsat, Br: ± 1 %; Hsat, Hc: ± 1 %, µr: ± 2 %; Losses: ± 3 %			
Test time	60-120 seconds (typical)			
Operating temperature range	15 ÷ 40 °C			
POWER AMPLIFIER				
Power output	1800 VA	1800 VA	4000 VA	700 VA
Bandwidth	25 kHz	25 kHz	50 kHz	1 MHz
ACQUISITION UNIT				
Frequency ranges	DC to 1.2 kHz	DC to 100 MHz	DC to 100 MHz	DC to 100 MHz
Channels (analog inp.)	8	4	4	4
ADC Resolution	16 bits	12 bits	12 bits	12 bits
Sampling rate	1.00 MS/s multi-ch	2 GS/s	2 GS/s	2 GS/s
Max voltage range	± 11 V	± 20 V	± 20 V	± 20 V
Max input voltage	± 11 V	± 300 Vpeak	± 300 Vpeak	± 300 Vpeak
DC POWER SUPPLY				
Max power	60 V – 25 A			
FUNCTION GENERATOR				
Frequency	1 µHz to 20 MHz (1 µHz resolution). Max measuring frequency is limited by amplifier)			
Voltage amplitude	20 mVpp to 20 Vpp (4 digit resolution)			
Amplitude resolution	14 bits			
THD	0.04 %			
FLUXMETER				
Model	Digital Flux			
Ranges	(1, 2, 5, 10, 20, 50, 100) x 2000 µWb			
Resolution	From 1 µWb (range 1) to 100 µWb (range 100)			
Accuracy	± 0.5 %			
Drift	Less than 1 digit/minute			
ELECTROMAGNET				
Model	LEP/100-4S			
PC AND SOFTWARE				
PC	PC, monitor, printer and all connection cables			
Operative system	Windows XP Professional O.S. based			
Software	Soft2009, Hyst2009 (English or Italian)			
Connection	LAN			
MAIN CABINET				
Power Supply	220 Vac, 50-60 Hz, 16 A max absorption			
Units	28 U (16 U on demand)			
Dimensions	535 x 855 x 1336 mm (1390 mm with wheels)			
Weight	247 kg (543 lb)	255 kg (561 lb)	270 kg (594 lb)	270 kg (594 lb)
MANUALS AND DOCUMENTATION				
	Instruction manual (English or Italian)			
	Calibration certificate			
	CE mark			

AMH-5800 Hard Metal Magnetometer

Magnetic characterization of Cemented Carbides

The new AMH-5800 is the latest in magnetic measurement technology for the measurement of magnetic properties of Cemented Carbides (WC in Co or Ni matrix) and semi-hard magnetic materials. This revolutionary instrument utilizes a technique that provides the fastest, repeatable and accurate measurements in the market today.

The AMH-5800 measures the following parameters:

- Coercivity HcJ,
- Magnetic moment M_{sat},
- Weight-specific saturation magnetization σ_{sat},
- Magnetic polarization J_{sat},
- %Co or any other magnetic material in the alloy.

The AMH-5800 provides accurate magnetic parameters to evaluate other correlated properties; for example: hardness or the presence of undesired phases

Our exclusive open circuit measurement technique allows measurement of samples with irregular shapes and sizes. A complete line of optional inductive sensors are available that provides a wide range samples sizes to facilitate almost all measurement applications.

The AMH 5800 is completely automatic: all you need to do is insert the weight and/or the volume of the sample under test and start the measurement cycle.

The AMH 5800 is supplied with the latest state of the art hardware, Windows operating system and exclusive LEE software that makes the most tedious measurements simple and easy to understand. Included in the software is a data collection application, print options, and a troubleshooting guide.

AMH-5800 meets the IEC and ASTM standards for measurement and is supplied with calibration certificate.

STANDARD CONFIGURATION

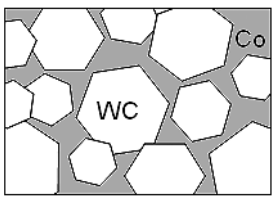
- Main cabinet equipped with Fluxmeter, Gaussmeter, DC power supply and polarity control
- Electromagnet
- Hall Probe
- Inductive Sensor Assembly with sample holder
- Digital scale
- Latest PC processor class with Windows XP OS and LCD Flat Screen Monitor

MAGNETIC PROPERTIES OF CEMENTED CARBIDES

Cemented carbides are composite materials made by tungsten carbide (WC) mixed in a binder metal, mainly cobalt.
The addition of Co allows to the final alloy to have both an excellent hardness and a good toughness.The weight percentage of Co in the alloy is usually between 3 to 30 %.

The measurement of magnetic properties of Cemented Carbides gives useful information on the metallurgical process:

- The Magnetic Moment providers direct information for the quantity of Co not alloyed in non-magnetic phase. With the 5800 so it is possible to evaluate the goodness of the metallurgical bond and the eventual presence of undesired phases;
- The Coercivity HcJ data provides an indication of the grain size: for example the higher HcJ reading, the finer the grain size.



TECHNICAL SPECIFICATIONS

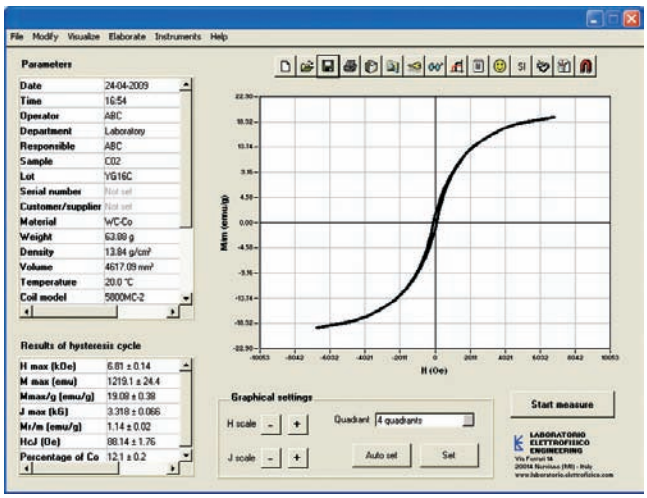
MEASURABLE MATERIALS	Semi hard and Cemented Carbides
MEASURABLE QUANTITIES	Msat, Hc, Jsat, weight specific saturation moment σsat, %Co
H MEASUREMENT	
Accuracy	Gaussmeter: 0.25% reading + 0.1% range Probe: 0.5% linearity
Resolution	0.1 Oe (300 Oe range), 1 Oe (3000 Oe range)
Hc MEASUREMENT	
Accuracy	±2% for Hc>500 A/m
Ms MEASUREMENT	
Accuracy	±2% on reading
Resolution	10^{-4} µWbm (10^{-10} Tm^3, 10^{-1} emu)
SAMPLE SIZE	
With Coil 5800 MC-1	Ø 37 mmx h 19 mm (1.45" dia x 0.75" H)
With Coil 5800 MC-2	Ø 27 mm x h 13.6 mm (1" dia. x 0.6" H)
POLES DIAMETER	100 or 120 mm (4" or 4.7")
MAX H FIELD	
With LP-100 mm pole	9700 Oe (776 kA/m)
With LP-120 mm pole	7750 Oe (620 kA/m)
TEST TIME	1 minute (typical)
OPERATING TEMPERATURE RANGE	10° C to 35° C
COMMUNICATION PORT	RS-232 / USB2
MAIN ELECTRICAL CABINET	
Power supply	220 V, 50 / 60 Hz
Dimensions	535x655x550 mm (21x 26x 2 2")
Weight	58.5 kg (129.3 lb)
FLUXMETER	DIGITAL FLUX
Ranges	(1, 2, 5, 10, 20, 50, 100) x 2000 µWb
Resolution	From 1 µWb (range 1) to 100 µWb (range 100)
Accuracy	± 0.5%
Drift	Less than 1digit/minute
Imput impedance	10k Ω x range
Communication	RS232/USB
MAGNETIC YOKE (Electro Magnet)	LEP/100-4S
Max Pole diameter	120 mm (4.7")
Movement operating	Manual
Poles setting	Micrometric
Dimensions	330 x 410 X 491 mm (12.9 x 16.1 x 19.3")
Weight	350 kg (approx.) (780 lb)
PC AND SOFTWARE	
PC	Latest PC processor class with LCD Flat Screen Monitor
Operative system	Windows XP Professional O.S.
Software	5800SW
MANUALS AND DOCUMENTATION	
Instruction manual	

5800SW: operating software manages the measurement process and the data collection

The program manages the AMH-5800 and the measurement process in a completely automatic way.
Data collected during the measurement can be elaborated by the software to provide advanced results, like comparison of different curves and statistical analysis.
A virtual Assistant guides the operator during all the phases of the measurement to assist in managing the entire process.

Advanced and accurate data elaboration
Completely automatic measure
Virtual Assistant

The main features and the great potentialities of this software are described below.



Main Page with parameters set, results and graph

TYPE OF MEASUREMENT

- Measure of hysteresis cycle
- J_{sat}, saturation magnetic moment, weight specific saturation moment σ_{sat} , percentage of magnetic material in the alloy
- Magnetic units in SI and CGS

SETTING OF MEASURING PARAMETERS

- Manual or automatic operation.
- Automatically weighs the sample with an electronic scale connected to the AMH-5800.
- The final list of parameters are shown on the main page
- Automatic fluxmeter drift control

SET OF MEASURES

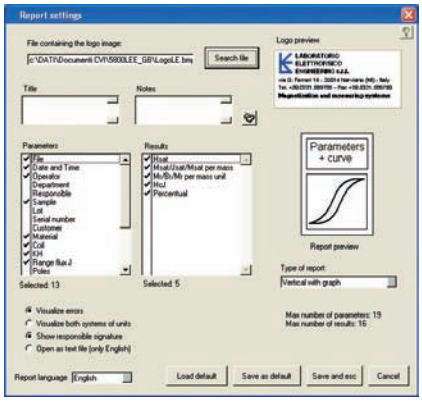
- Curve comparison provides the grouping of more curves in sets for comparison and statistical analysis

DATA BASE AND FILE SEARCHING

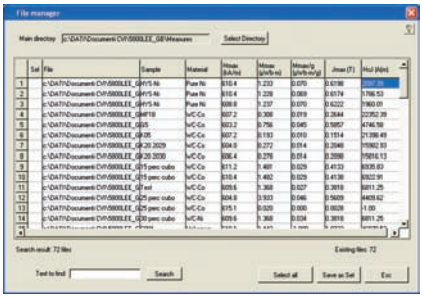
- A complete Data Base of measurements are stored with custom search capabilities.
- Compatible with Microsoft Excel™.

PRINTING A REPORT

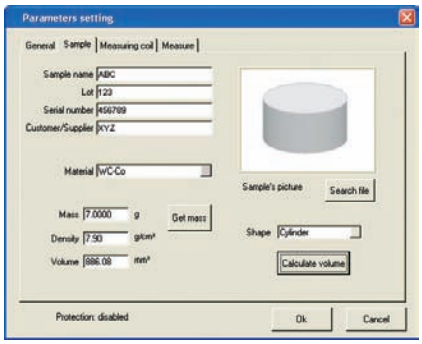
- Customization of reports and formats: 2 languages are available for the printing
- Prints a graphical report.
- Measured data can be opened and saved in Microsoft Word™ or other work processing programs



Customizable reports



Data base of measuring file



Parameters Settings

LEE ASSISTANT

The real-time Assistant provides updated situations of the status of the AMH-5800, even during the measurement cycle. With a click of the mouse, the Assistant shows the actual state, with a list of suggestions and/or warnings. Should a series of errors or anomalies occur in the hardware or software, that will prevent accurate measurements, the Assistant automatically provides notification.
Troubleshooting index

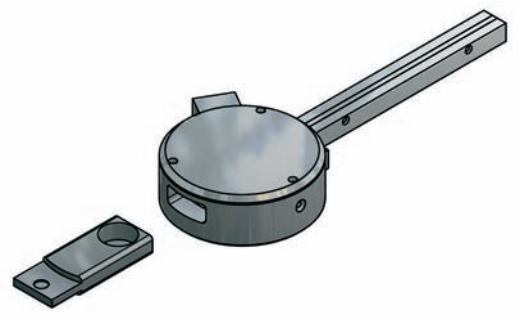
Accessories

MEASURING COIL

The measuring coil has an embedded sensor and a slot to insert a Hall probe. The samples are placed in the sample holder and then inserted into the measuring coil.

The sample holder has the following dimensions:

	Diameter	Height
MC-1	37 mm	19 mm
MC-2	27 mm	13.6 mm



MC-1 and MC-2 Measuring Coil

Poles

POLES

Two types of poles are available for AMH-5800:
LP-100 (100 mm diameter) and LP-120 (120 mm).

STANDARD SAMPLE

For the best performance a reference standard is availabe for periodic control and calibration.

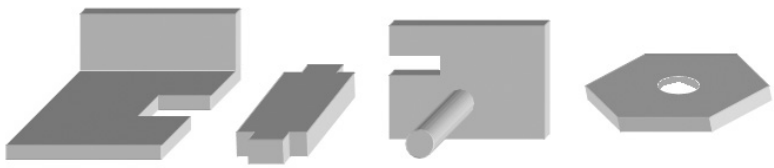
Model: HYS-Ni
Material: Nickel

Reference Sample

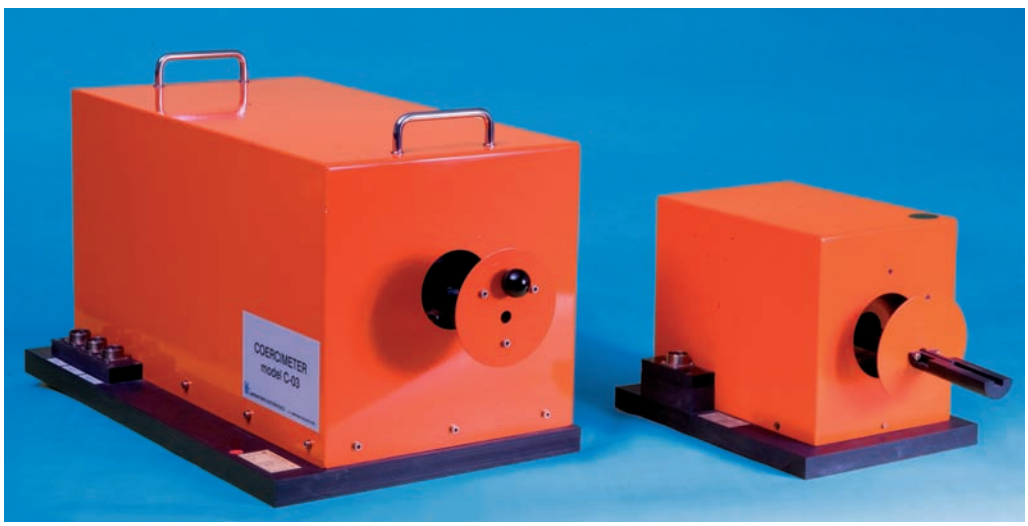
CR/01 and CR/02 Coercimeters

Coercivity measurements for Soft Materials

The Laboratorio Elettrofisico coercimeter facilitates measurement of samples that are not in the standard toroidal, strip or bar shapes. The CR/01 will measure irregular shapes when closed-circuit measurements are not possible or convenient, which is the case in most applications. No longer do you need to cut the material which alters the sample testing and often has a negative affect on the magnetic characteristics.



Samples having irregular shapes can be measured

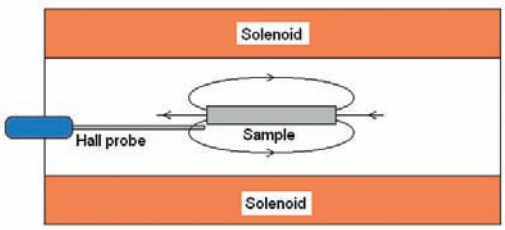


Solenoids with shield and positioning tool for probe and sample

The Laboratorio Elettrofisico coercimeter detects the stray field emitted from a magnetized sample with a Hall probe in close proximity. By applying an increasing demagnetizing field with the solenoid coil, the stray field is reduced to zero. In this condition, the demagnetizing field coincides with the coercivity of the material.

The CR/01 measurement is automatic and very easy to use with supplied custom software.
The measurement meets International Standard IEC 60404-7.

When Hc is lower than 40 A/m, it's required to shield the sample, to avoid influences from external magnetic fields (also the Earth magnetic field can affect the results).
An optional Mu-metal shield is provided to guarantee the reduction of external influences to negligible levels, that permits accurate measurement of Hc lower than few A/m.



Coercimeter's measuring principle

STANDARD CONFIGURATION

- Heavy duty cabinet containing the DC power supply and Gaussmeter
- Hall probe
- Solenoid with positioning tool for samples
- Mu-metal shield (optional)
- PC with dedicated software + printer

Fast and easy characterization of samples having irregular shape

TECHNICAL SPECIFICATIONS

	CR/01	CR/02
GENERAL		
Measurable materials	Soft Magnetic Materials	
Measurable shapes	Regular or irregular	
Measurable quantities	HcJ, Hsat	
HcJ ranges	1 to 10000 A/m	(0.012 to 125 Oe)
	1 to 20000 A/m	(0.012 to 250 Oe)
HcJ resolution (max)	0.1 A/m (1.25 mOe)	0.1 A/m (1.25 mOe)
Accuracy		
HcJ	± 1 %	
Hsat	± 1 %	
Transversal field	± 0.5 %	
Sample size	Max Ø 15 mm	Max Ø 30 mm
	Length 40 mm	Length 100 mm
Test time	30 seconds (typical)	
Operating temperature range	15 ÷ 40 °C	
Frequency	DC	
MAIN ELECTRICAL CABINET		
Power Supply	220 Vac, 50-60 Hz, 16 A max absorption	
Dimensions	535 x 655 x 550 mm (21 x 26 x 22'')	
Weight	55 kg (121 lb)	
GAUSSMETER		
Ranges	30 G, 300 G, 3 kG, 30 kG	
Resolution	From 100 µG to 1 G	
Accuracy	± 0.05 %	
Communication port	RS232, IEEE 488	
HALL PROBE		
Type	Transverse	
Stem material	Aluminium	
Dimensions	200 x 4.6 x 1.5 mm (8 x 0.18 x 0.06'')	
Linearity	0.25 % to 30 kG	
Cable length	1.5 m (5 ft)	
SOLENOID		
Max Field	720 Oe (57.3 kA/m)	1600 Oe (128 kA/m)
Max Current	7 A	25 A
Diameter	38 mm (1.49")	50 mm (1.97")
1 % uniformity length	40 mm (1.57")	110 mm (4.33")
Dimensions	308 x 275 x 390 mm (12.13 x 10.83 x 15.35")	280 x 225 x 410 mm (11.02 x 8.86 x 16.14")
SHIELD		
Material	Mu metal	
Thickness	1.5 mm (0.06")	
Dimensions	250 x 225 x 360 mm (9.84 x 8.86 x 14.17")	300 x 300 x 545 mm (11.81 x 11.81 x 21.46")
PC AND SOFTWARE		
PC	PC, monitor, printer and all connection cables	
Operative system	Windows XP Professional O.S. based	
Software	COERC13 (English or Italian)	
Connection	USB	
MANUALS AND DOCUMENTATION		
	Instruction manual (English or Italian)	
	Calibration certificate	
	CE mark	

The solenoid, shield and power supply can be customized

Software COERC13

The Laboratorio Elettrofisico Coerc13 software automatically controls the measurement process. Once the operator inputs the parameter settings, accurate measurements are made in less than 30 seconds; the CR/01 displays the coercivity, performs a quality control routine, and stores data for statistical elaboration. Other available options are: integrated database, customizable print options and data management.

TYPE OF MEASURE

- Coercivity Hc and Hsat
- Double-polarity measurements

SETTING OF MEASURING PARAMETERS

- Manual or automatic settings of parameters.
- Magnetic units in SI and CGS

DATA ELABORATION

- Limit setting for good/rejected results
- Statistical evaluation of the results

PRINTING A REPORT

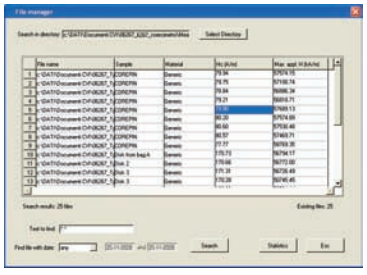
- Customized print options for information and language
- Direct print of a graphical report on printer or file
- The report can be opened and saved with other word processor programs such as Microsoft Word™

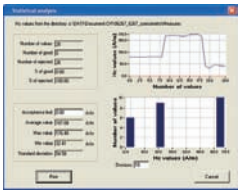
DATA BASE AND FILE SEARCHING

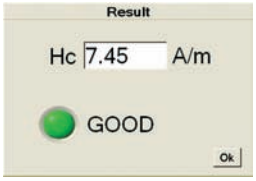
- Data base of measuring file with fast search capability, ordering and selection
- Full compatibility with other spread sheet programs, such as Microsoft Excel™

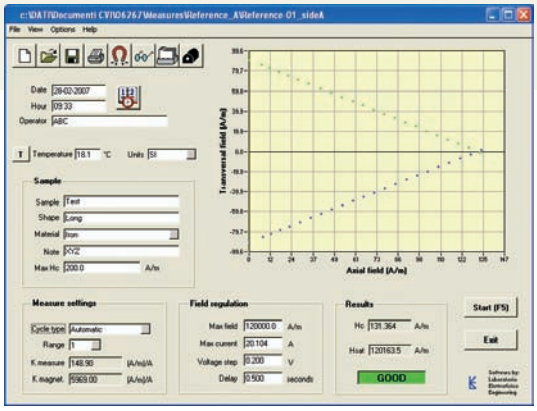
HELP

- Help file, with index
- Manual on line









PFMM Permeameter

The measurement of Feebly Magnetic Materials

The model PFMM (Permeameter for Feebly Magnetic Materials) is an instrument to verify that a non magnetic material (for example austenitic stainless steel) is really “non-magnetic”.
The permeameter PFMM quantifies the magnetic “weakness” of the material by measuring its magnetization curve, relative permeability μ_r and susceptibility χ.

FEEBLY MAGNETIC
MEASUREMENT APPLICATIONS:

- Turbo Generators
- NMR Instrumentation
- Ionic Devices
- Electron Beam Devices
- Precision Weights

When a non-magnetic material is used in an application where the interaction with magnetic fields must be very low, the control of its magnetization and permeability is fundamental.
The permeameter PFMM measures the relative permeability in the range between 1.001 and 4, with a typical total accuracy less than ±2%.
When low values of permeability and susceptibility are required, the Laboratorio Elettrofisico PFMM is necessary tool. The sensitivity of the coil must be very high: for example, the PFMM can accurately measure the susceptibility of good stainless up to 10^8 times lower than the susceptibility of a typical Fe-Ni, that can be measured with a permeameter for ferromagnetic materials.
The permeameter PFMM meets the ASTM A342 Standard.

PRINCIPLE OF OPERATION

The Laboratorio Elettrofisico PFMM is based on the measurement of the magnetic polarization J of the material under an increasing external field H. The ratio between J and H provides the susceptibility χ, and relative permeability $\mu_r = 1 + \chi$.
The accurate measurement of J it is critical: for example, for a material with $\mu_r = 1.001$, applying a field H of 10000 gauss, the polarization J will be 10 gauss only!
An extremely accurate compensation coil facilitates and performs automatically this measurement.
The sample must be in the shape of a bar with a uniform cross-section and be placed inside a solenoid using a proper positioning tool (provided). The J field is measured with an inductive sensor, while the H field is determined by the current through the solenoid.
With the standard diameter of the solenoid (Ø 50 mm), the length of the specimen must be greater than 100 mm and the cross section not less than 20 mm^2.
The measurement of specimens that have different dimensions is possible with custom solenoids and measuring sensors, that are available on request.

STANDARD CONFIGURATION

- Heavy duty cabinet containing the DC power supply and Fluxmeter
- Solenoid with positioning tool for samples
- Compensated measuring coil
- PC with dedicated software + printer

TECHNICAL SPECIFICATIONS

GENERAL	
Measurable materials	Feebly Magnetic Materials
Measurable shapes	Straight Bars, with regular cross section
Measurable quantities	J vs. H curve, permeability μ_r, susceptibility χ
μ_r range	1.001 ÷ 4
χ range	0.001 ÷ 3
Accuracy	
μ_r, χ	Better than ± 2 %
J	± 1 %
H	± 1 %
Sample size	
Length	100 ÷ 500 mm
Cross section	20 ÷ 1800 mm^2
Ratio length/diameter	Bigger than 4 for $\mu_r < 1.1$ Bigger than 20 for $1.2 < \mu_r < 2.0$ Bigger than 30 for $2.0 < \mu_r < 4.0$
Test time	30 seconds (typical)
Operating temperature range	15 ÷ 40 °C
Frequency	DC
MAIN ELECTRICAL CABINET	
Power Supply	220 Vac, 50-60 Hz, 16 A max absorption
Dimensions	535 x 655 x 550 mm (21 x 26 x 22'')
Weight	50 kg (110 lb)
FLUXMETER	
Model	Digital Flux (see specifications)
SOLENOID	
Max Field	750 Oe (60 kA/m)
Diameter	90 mm (3.54")
Useful diameter for sample	48 mm (1.89")
Length	500 mm (9.69")
1 % uniformity length	180 mm (7.09")
External dimensions	330 mm x 630 mm, H = 300 mm (12.99 x 24.80 x 11.81'')
PC AND SOFTWARE	
PC	PC, monitor, printer and all connection cables
Operative system	Windows XP Professional O.S. based
Software	PFMM-V02 (English, French or Italian)
Connection	USB
MANUALS AND DOCUMENTATION	
	Instruction manual (English, French or Italian) Calibration certificate CE mark

Software PFMM-V02

The software PFMM-V02 is an integrated element of the permeameter PFMM and manages the system and creates a user friendly interface between machine and user.
It allows the setting of the measurement parameters and the view of the results at the end of the measurement.
The main features of this software are shown below.

The exclusive Laboratorio Elettrofisico PFMM-V02 software automatically controls the measurement process. Once the operator inputs the parameter settings, accurate measurements are made in less than 30 seconds: the PFMM displays the J vs. H curve and the permeability. The other available options are: integrated database, customizable print options and data management.

TYPE OF MEASURE

- J vs. H, permeability μ_r, susceptivity χ

SETTING OF MEASURING PARAMETERS

- Manual or automatic settings of parameters
- Magnetic units in SI and CGS

DATA ELABORATION

- Limit setting for good/rejected results
- Statistical evaluation of the results

PRINTING A REPORT

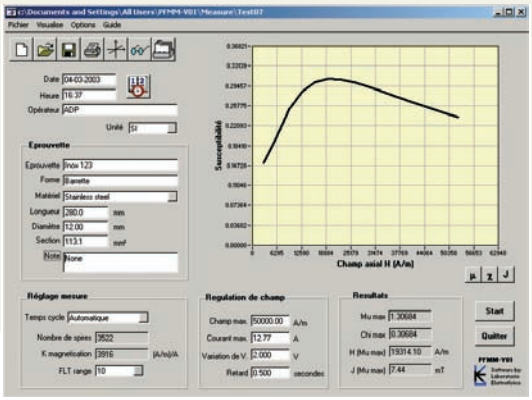
- Customized print options for information and language
- Direct printing of a graphs and data on printer of file
- The report can be opened and saved with other Word processor programs such as Microsoft Word™

DATA BASE AND FILE SEARCHING

- Data base of measuring file with fast search capability, ordering and selection
- Full compatibility with other spread sheet programs, such as Microsoft Excel™

LEE ASSISTANT

- Help file



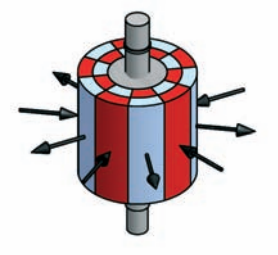
MAGNETOSCAN

Measurement of Superficial Magnetic Induction

The magnetic measuring scanner Magnetoscan is designed to measure the superficial magnetic induction of permanent magnet devices, for example rotors or stators, that exhibit axial or radial multi polar magnetization. The control of the magnetic profile provides the user effective methods to evaluate the integrity and quality of the magnetization process and to predict the performance or the assembly.

DIFFERENT CONFIGURATIONS GENERALLY
NEED CONTROL OF SPECIFIC PARAMETERS:

- Field peak amplitude
- Pole's width
- Sinusoidal shape and Total Harmonic Distortion (THD)
- Angular differences between mechanical and magnetic references
- Peak to peak variation, and magnetic field slope
- Constance of the peak amplitudes
- Angular control for skewed rotors



Radial magnetization

Axial magnetization

The basic principle is to rotate the device and record the magnetic field vs. angular displacement at a particular level and distance.
The measurement is performed by a Hall probe that is connected to a gaussmeter. The Hall probe is positioned with micrometrical accuracy at every distance from the surface of the sample by a precise mechanical tool with 3 axis.
The sample is fixed to the rotating base through a shaft holder chuck; an interchangeable holder allows measurement of the samples by with a shaft dimensions between 0.5 to 15 mm.

The measurement is fully automated and is controlled by a dedicated software program that records 10.000 measurements per revolution, with a resolution accuracy of 0.036°. The software provides a wide variety of elaboration of scanned data, for example: visualization of diagram angle-induction, peak detection, angular shift, harmonic distortion, FFT, comparison between different measurements, printout etc.

APPLICATIONS

- Rotors, stators
- Flywheels
- Magnetic sensors (automotive, ABS, etc.)
- Magnetic encoders

STANDARD CONFIGURATION

- Mechanical position tool, with axes micrometrical controls
- Electrical base, containing DC electrical motor, encoder, and all electrical circuitry
- Gaussmeter (model could vary with application)
- Hall probe (model could vary with application)
- Position tool for Hall probe and samples (customized)
- Set of holders for different shaft's diameters
- PC and printer
- Software
- Instructions manual

TECHNICAL SPECIFICATIONS

GENERAL	
Measurable Materials	Magnetized devices containing hard magnetic materials
Measurable quantities	B-field profile, FFT
Type of magnetization	Axial and radial multi polar magnetization on 2 or 3 axes
Max sample's weight	2 kg
MECHANICAL SPECIFICATIONS	
Available shaft holders	from 0.5 to 15 mm
Available movement	Longitudinal, lateral and vertical
Linear displacement resolution	5 mm
Angular resolution	0.036°
Number of data/revolution	10000
Scansion speed	Adjustable (typical: 20÷30 seconds)
ACQUISITION BOARD	
Analog inputs	16 SE 200 kS/s, 16 bits
Digital I/O lines	8 DIO
Counters/timers	2, 24 bits, 20 MHz
GAUSSMETER (STANDARD MODEL)	
Range (resolution)	300 G (0.1 G), 3 kG (1 G), 30 kG (10 G)
Accuracy	± 1 %
Frequency Bandwidth	DC – 20 kHz
Sampling rate	5 sample/s
Reading	gauss, tesla, A/m
Communication port	USB
HALL PROBE (STANDARD MODEL)	
Type	Axial
Linearity	0.5 % / 30 kG
Active area	0.381 mm (0.015") diameter
Temperature range	0 ÷ 75°C
Zero stability with temperature	± 0.3 G/°C
Calibration stability with temperature	- 0.05 % /°C
Frequency range	DC to 20 kHz
Stem material	Rigid phenolic
ELECTRICAL MOTOR	
Speed	8 round/minute at 12 V
Max power	2.1 W
Max torque	600 mN·m (continuous); 1800 mN·m (peak)
Reduction ratio	500:1
PHYSICAL	
Power	220 Vac, 50/60 Hz
Dimensions	640 x 320 x 950 mm (25.2 x 12.6 x 37.4 n)
Weight	57 kg (126 lb)
ACCESSORIES	Magnetic zero chamber Set of clamps Key for clamps
MANUALS AND DOCUMENTATION	Instruction manual in English CE mark Calibration certificate

Software MS-03

The software MS-03 manages and controls the measurement with Magnetoscan. The software program enables automatic data collection saved to a file. The operator only has to select the parameters prior to the measurement, the MS-03 does the rest.
It's also possible to set the rotation speed for the sample, type of magnetization requirement (axial or radial), distance between probe and sample surface, and the number of poles. The software automatically samples the measured data and compares it with the applications set of parameters to provide a complete analysis of the results.

TYPE OF MEASURE

- Superficial Magnetic Induction and H-field profile

RESULTS

- Angle-induction diagram, Bmax, Bmin, positive and negative average, total average angular shift, harmonic distortion, FFT and more advanced results
- Magnetic units in SI and CGS

SETTING OF MEASURING PARAMETERS

- Manual or automatic settings of parameters. The final list of parameters is shown in the main page
- Possibility to change graphical parameters, scanning speed and calibration coefficient
- Limit setting, with possibility to have notification on how many poles are in specifications.
- Settings of the photo switch. The middle angle of the mechanical reference can be used to calculate distance between peaks and zero (deltas).
- Speed setting with the possibility to rotate the sample of an arbitrary angle in CW or CCW sense

DATA BASE AND FILE SEARCHING

- Data base of measuring files with fast search options, ordering, selection, etc.
- Compatible with spreadsheet programs, such as Microsoft Excel™.

PRINTING A REPORT

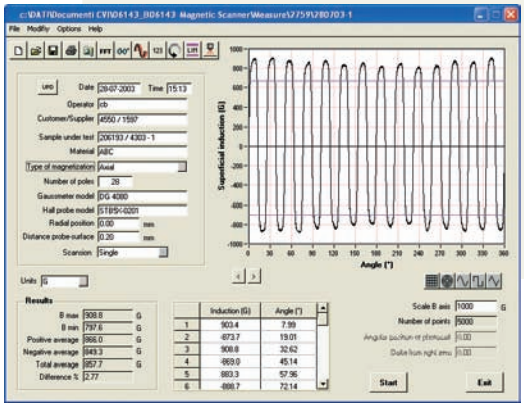
- Print reports containing data and graph, or only a text report containing only data
- The report can be opened and saved with other editors, like Microsoft Word™.

DATA ELABORATION

- Curve comparison
- Fourier Analysis through Fast Fourier Trasform (FFT) algorithm.
- Math elaboration to calculate parameters such as zero crossing, pole width, slopes, area, etc.
- Two available graphical representation of data: Cartesian graph and Polar graph
- Indication of the angle of mechanical reference (photocell) on the graph and in the parameters
- Pole out of specification are marked in red

HELP FILE

- Help file (with troubleshooting guide).



Main panel

MEASURING SERVICES

Laboratorio Elettrofisico maintains certified magnetic laboratories in Italy and the USA. These locations offer a wide variety of measurement and calibration services.

INSTRUMENTS AND COILS CALIBRATION

- Fluxmeter
- Gaussmeter
- ELF meter
- Fluxgate magnetometer
- Transversal Hall probe
- Axial Hall probe
- Reference magnetic field
- Helmholtz coil
- Potential coil
- Field coil

HARD MAGNETIC MATERIALS

TYPE OF CHARACTERIZATION	MATERIAL	INSTRUMENT USED	IEC STANDARD
Magnetic moment	All	Helmholtz coil, Fluxmeter	60404-14
Second quadrant at room T	All	AMH-300	60404-5
Second quadrant at high T (220 °C max)	All	AMH-300 + LPT-80	60404-5
Hysteresis cycle, First quadrant (magnetization curve) at room T	Alnico, Ferrite	AMH-300	60404-5
Hysteresis cycle, First quadrant (magnetization curve) at high T (220 °C max)	Alnico, Ferrite	AMH + LPT-80	60404-5
Irreversible losses after thermal cycle (max 220 °C)	All	Helmholtz coils, oven	-
Mapping of superficial induction	All	MagnetoScan MMS	-
Verification of saturation	All	Magnetizer, Helmholtz coil	60404-14
Saturation curve (in open circuit)	All	Magnetizer, Helmholtz coil	-

SOFT MAGNETIC MATERIALS

TYPE OF CHARACTERIZATION	MATERIAL	INSTRUMENT USED	IEC STANDARD
DC Hysteresis cycle	All	AMH-DC-TB-S	60404-4
DC Normal magnetization curve	All	AMH-DC-TB-S	60404-4
AC Hysteresis cycle (max frequency: 20 kHz)	All	AMH-20K-S	60404-6
AC Normal magnetization curve (max f: 20 kHz)	All	AMH-20K-S	60404-6
Specific losses, losses separation (up to 20 kHz)	All	AMH-20K-S	60404-6
Measure with Epstein frame	All	AMH-20K-S	60404-2
Coercivity in open circuit	All	Coercimeter CR-02	60404-7

HARD METAL AND CEMENTED CARBIDES

TYPE OF CHARACTERIZATION	MATERIAL	INSTRUMENT	IEC STANDARD
Saturation magnetic moment (Msat)	All	AMH-5800 or AMH-300	-
Saturation magnetic polarization (Jsat)	All	AMH-5800 or AMH-300	-
Saturation specific magnetic moment (σsat)	All	AMH-5800 or AMH-300	-
Coercivity	All	AMH-5800	-
Co percentage in the alloy	WC cem. carbides	AMH-5800 or AMH-300	-

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