

PERMAGRAPH® L

for the computer controlled
measurement of magnetization curves
of hard magnetic materials



• Introduction

The PERMAGRAPH® is the worldwide known standard equipment for the measurement of magnetic characteristics of permanent magnets in research, development, quality control and production.

The PERMAGRAPH® L is an advanced compact version of this automatic computer controlled measuring instrument. Together with the high performance software package PERMA and the tiny measuring and control unit it facilitates quick and reliable measurements. Our instruments are known for their quality and long lifetime.

The system design conforms to the standards IEC 60404-5, ASTM A977/A977M, DIN IEC 60404-5 (replacement for DIN 50470, DIN EN 10332). The temperature extension conforms to IEC 61807TR and DIN IEC 68/190/CDV. The equipment has been optimized over many years and has been made specifically to meet the requirements of our customers.

Among others, the following measurements are possible:

- Automatic measurement of the hysteresis loops of permanent magnets
- Determination of characteristic quantities like remanence, coercivity, maximum energy product, etc.
- Measurements at temperatures up to 200 °C with heating poles and temperature surrounding coils
- Measurements on the surface of magnets using pole coils

Magnet-Physik has 70 years of experience in building measuring instruments for the characterization of magnetic materials.

• Applications

Depending on the model of the PERMAGRAPH[®] L and its particular accessories the following measurements are possible:

Measurements on AlNiCo, Ferrite or Rare Earth magnets (e.g. Sm-Co or Nd-Fe-B)
using J-compensated surrounding coils.

Important:

For the saturation of rare earth magnets an impulse magnetizer and a magnetization coil are required.

Measurement of AlNiCo, Ferrite or Rare earth magnets at high temperatures

with up to 200 °C heatable poles and temperature resistant J-compensated surrounding coils.

You can find technical explanations and further topics, e.g. how hard magnetic powders are measured with the PERMAGRAPH[®], in our booklet

MAGNETIC MEASURING TECHNIQUES

by Dr. Erich Steingroever
and
Dr. Gunnar Ross

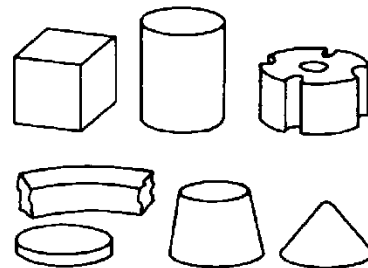
It can be obtained free of charge upon request (also available as a pdf file).

Measurements on Ferrite magnets
using measuring poles with embedded pole coils.

Measurement of Ferrite segment magnets
with segment poles with incorporated pole coils, the poles are shaped corresponding to the radii of the segment magnet.

Magnet shapes

Examples of specimen shapes that can be measured with pole coils in the PERMAGRAPH[®] L without the need of determining their cross section:



• Product Family

The PERMAGRAPH[®] L can be composed from a variety of components and accessories.

For the most common measurement tasks we offer packages which can be completed by further components according to your application.

On the following pages, the components that are included in the packages are listed. You will also find descriptions and technical details of all available accessories.

All components are calibrated in our qualified calibration laboratory. The calibration is traceable to national standards. A proprietary calibration certificate is included in the delivery.

• Specialties of the MAGNET-PHYSIK Measuring Method

For measuring the field strength H we use either integrated or separate field strength measuring coils. Therefore a Hall effect gaussmeter is superfluous. When Hall sensors are used to measure H next to the specimen, additional space for the probe and an additional gaussmeter are required. Hall sensors are very fragile and can easily be damaged. Because of the linearity error and the temperature dependence of the sensitivity of a Hall sensor, corrections are necessary to achieve an acceptable accuracy. Additional errors can arise from the facts that the Hall probe has always to be aligned truly perpendicular to the magnetic field direction and that it is, due to the small active area, more sensitive to local field strength variations. Therefore it is the better solution to use a field strength measuring coil instead of a Hall probe.

If a surrounding coil is used, the field strength and the polarization are measured with only one combined coil system. As no space for the Hall probe is required, specimens of a thickness down to only 1 mm can be measured.

• Packages and Options

<p>Package 1 PERMAGRAPH® L (for measurements at temperatures up to 200 °C)</p> <ul style="list-style-type: none"> 1 Cabinet for PERMAGRAPH® L 1 PERMAGRAPH® power supply SVP 2 1 Measuring and control unit ST-P-L 1 Electromagnet EP 3 2 Poles P 0/0, 92 mm diameter 2 Heating poles PT 200 1 J-compensated surrounding coil JH 26-1 for measurements at room temperature (other coil diameter on request) 1 J-compensated surrounding coil JHT 40-4 for measurements at temperatures up to 200 °C (other coil diameter on request) 1 Thermocouple TH-J 1 Computer 1 Software PERMA for Windows 1 Training in our works 	<p>Package 2 PERMAGRAPH® L (for measurements at room temperature only)</p> <ul style="list-style-type: none"> 1 Cabinet PERMAGRAPH® L 1 PERMAGRAPH® power supply SVP 2 1 Measuring and control unit ST-P-L 1 Electromagnet EP 3 2 Poles P 0/0, 92 mm diameter 1 J-compensated surrounding coil JH 26-1 for measurements at room temperature (other coil diameter on request) 1 Computer 1 Software PERMA for Windows 1 Training in our works
<p>Option PT 200 FeCo Heating poles PT 200 FeCo to be supplied <i>instead</i> of the PT 200 that are included in package 1</p>	<p>Package 2 can be upgraded subsequently to package 1 by adding heating poles, thermocouple and a surrounding coil JHT</p>
<p>Option Electromagnet EP 5 EP 5 to be supplied <i>instead</i> of the electromagnet EP 3 which is included in the packages above</p>	
<p>Detailed information on the individual components is given on the following pages. For further accessories see page 10 and following.</p>	

• Operation

The PERMAGRAPH® can automatically record the demagnetization curves of permanent magnets. The measuring method is standardized and verified by round robin tests.

Central component of the measuring instrument is an electromagnet that is used to magnetize and demagnetize the magnet specimen in order to cycle through the hysteresis loop. The magnetic field strength H and the magnetic polarization J are measured simultaneously with special measuring coils. Two integrators are required to process the output signals of the coils. The PERMAGRAPH® L uses a two-channel analog precision fluxmeter integrator with 24 bits analog-to-digital converters. The integrator is included in the measuring and control unit.

This control unit is operated from a computer. The measured data are received via a digital interface and shown on the computer display in real-time. This allows checking the results already while the measuring procedure is in progress.

The computer also allows an evaluation and output of the measuring data, so that the measuring results are directly available.

Usually only the second quadrant of a hysteresis loop, the demagnetization curve, is of interest for the application of permanent magnets. Therefore the measurements can be automatically stopped after the coercivity H_{cJ} is reached.

The measurement is carried out quasi-statically, that means that the demagnetization curve is recorded rather slowly, avoiding eddy current problems. If the magnet material is electrically conductive, the measuring speed must be chosen so slow, that the polarization of the magnet is not influenced by magnetic fields caused by eddy currents.

The specimen and measuring parameters can be stored. Thus in the case of new measurements only a few new inputs must be made.

• Technical Data

Cabinet for PERMAGRAPH® L Houses the power supply and contains the electrical distribution and power supply for measuring and control electronics and heating poles	Width	:	520 mm	
	Depth	:	500 mm	
	Height	:	300 mm	
	Mains*	:	3 x 380 - 415 V, (L1, L2, L3, PE), 50 - 60 Hz	
	Weight (without SVP 2)	:	20 kg	
Measuring and Control Unit With two-channel fluxmeter integrator, thermocouple input and control for electromagnet power supply	ST-P-L	AD converter resolution for integrators	:	24 bits
		AD converter resolution for temperature measurement	:	16 bits
		Interface	:	RS232
		Weight	:	0.5 kg
PERMAGRAPH® Power Supply Power supply for the electromagnet, with minimum ripple voltage, electronic remote control	SVP 2	Output voltage	:	0 - 120 V
		Output current	:	0 - 25 A
		Output power	:	3 kW
		Mains*	:	3 x 380 - 415 V 50 - 60 Hz
		Weight	:	15 kg
PERMAGRAPH® Electromagnet For magnetic field excitation to record magnetization curves of hard magnetic materials. The pole distance is manually adjustable.	EP 3	Max. field strength	:	
		92 mm standard poles, 2 mm air gap	:	approx. 1700 kA/m (21.5 kOe)
		Bottom pole size	:	100 mm x 100 mm
		Standard pole diameter	:	92 mm
		Air gap (without poles)	:	73 - 102 mm
		Air gap (with standard poles)	:	0 - 63 mm
		Nominal short-time electrical load	:	3 kW
		Depth x width x height	:	(310 x 500 x 600) mm ³
		Weight	:	128 kg
PERMAGRAPH® Electromagnet For magnetic field excitation to record magnetization curves of hard magnetic materials. The pole distance is manually adjustable.	EP 5	Max. field strength	:	
		92 mm standard poles, 2 mm air gap	:	approx. 2200 kA/m (27.5 kOe)
		65 mm FeCo poles, 2 mm air gap	:	approx. 2500 kA/m (32 kOe)
		Max. pole diameter	:	92 mm
		Air gap, without poles	:	0 - 130 mm
		Air gap, with standard poles	:	0 - 110 mm
		Nominal short-time electrical load	:	3 kW
		Depth x width x height	:	(430 x 480 x 830) mm ³
		Weight	:	220 kg

*Other line voltage configurations may require an internal or external transformer. Please contact us.

• Measuring and Control Unit

The microcontroller driven measuring and control unit ST-P-L forms the interface between the PC and all other hardware components. It contains

- a 2-channel fluxmeter integrator with automatic coil detection and instrument configuration according to coil type
- an electromagnet power supply and polarity controller
- a thermocouple amplifier for measurement of the pole and specimen temperature
- a temperature controller for heating poles

• Features of *PERMA* – Software for *PERMAGRAPH*®

- Flexible, user friendly operation using menus, function keys and shortcut keys or icons
- Extensive help files, context-sensitive help
- Convenient input of measuring parameters
- Saving and opening of parameters and measuring data
- Multiple measurements can be simultaneously opened for easy comparison
- Existing measurements can serve as templates for new measurements
- Automatic calculation of measured results
- Automatic saving of measured data, parameters and results (e.g. under a test name or number)
- Saving of a group of associate measurements into a single file
- Export of measuring data, parameters and results to text files or to Microsoft Excel® files
- Export of parameters and results to text databases or SQL databases, a database viewer is integrated in the software
- Print preview for measurement diagrams with curves, parameters and results
- Output of measurement diagrams to a printer or pdf writer (printer and pdf writer not included)
- Copying of measuring diagrams and result lists via the Windows® clipboard
- Saving measuring diagrams as pictures (bmp, gif, jpeg, png) for easy distribution
- Various possibilities for customer specific output design as selection of curves, calculated results, units, measuring parameters, user-definable information texts, company logo, etc.
- User-definable limit classifiers for all results (out of range results are shown in red or boldface)
- Display of multiple curves in one diagram including results
- Optional display of averaged results of multiple measurements
- Different output diagram layouts can be saved for easy switching between different outputs
- Selectable units for magnetic quantities, temperatures, specimen dimensions and other parameters
- Full support of SI and CGS units in software and output, changing units is possible at any time
- Simultaneous display of results in mixed SI and CGS units can be configured by the user
- The number of significant digits to be displayed for results can be selected by the user
- Creating of result lists for multiple measurements incl. the possibility of saving, copying and printing
- Program menu access can be restricted for selected users (password protection)
- Language separately selectable for program menus and output (English, German, French, Spanish, Polish, Czech, Slovak, Russian, Chinese (simplified))
- Microsoft Windows® Vista / 7 / 8 / 10 compatible

• Parameters

- Default parameters minimize the number of necessary inputs
- Automatic measuring coil type and coil data identification
- Calculation of the cross-sectional area from specimen geometries
- Input of measurement and specimen identification data to predefined or user-definable text lines
- Input of room and specimen temperatures in °C, °F or K
- Automatic room temperature recording with optional room temperature sensor
- Extensive parameter verification to avoid illegal or inconsistent parameter settings

• Measurement

- Magnetization and demagnetization curve or demagnetization curve only
- Drift correction: automatic or on command, reminder for drift correction by software if required
- Automatic polarity detection and adjustment of field direction for magnetized rare earth magnets
- Adjustable duration of measurement, usually 20 - 120 seconds depending on specimen type
- Speed enhancement by faster magnetization and sufficiently slow demagnetization
- Measuring speed: constant dI/dt or dJ/dt controlled
- Excitation to preset values of field current I , field strength H or polarization J
- Automatic stop at H_{cJ} possible
- Automatic stop at $-I_{max}$ possible

• Curves

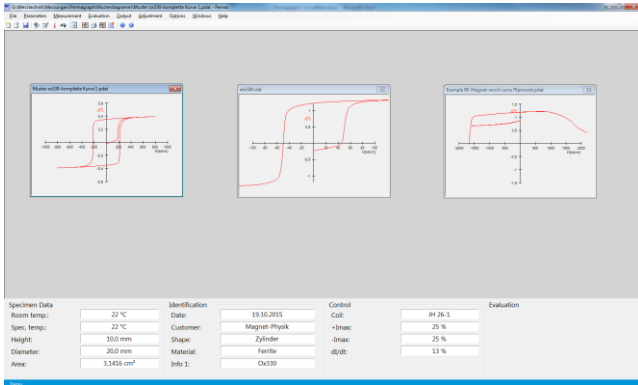
- Demagnetization curve
- 2- or 4-quadrant hysteresis loop
- Recoil curves or inner (minor) loops, automatically or manual
- $(BH)_{\max}$ area
- $BH = \text{const.}$ hyperbolas
- $B = 0$ line

• Evaluation

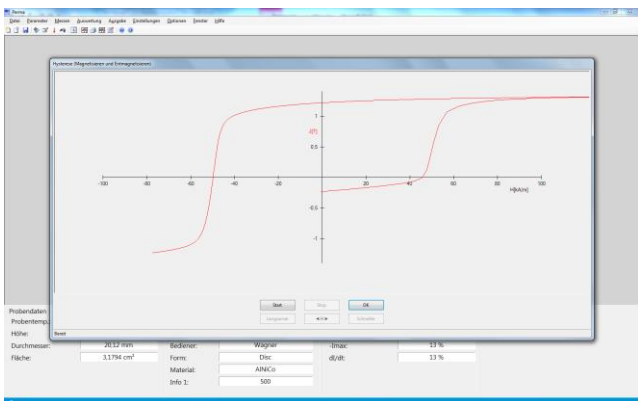
- Remanence (B_r or J_r)
- Coercivity of $J(H)$ curve H_{cJ} (intrinsic coercivity)
- Coercivity of $B(H)$ curve H_{cB} (normal coercivity)
- Maximum energy product $(BH)_{\max}$
- Maximum field strength H_{\max}
- Maximum polarization J_{\max} and B_r/J_{\max} ratio
- H_k : knee shape parameter (H coordinate of $J(H)$ curve for $J = 0.9 \cdot B_r$)
- H_x : H coordinate of $J(H)$ curve for $J = x \cdot B_r$
- H_{D5} and H_{D2} results
- Tables of $J(H)$ and $B(H)$, where H are user defined field strengths
- Tables of $H(J)$ and $B(J)$, where J are user defined polarizations
- Tables of $H(B)$ and $J(B)$, where B are user defined flux densities (inductions)
- User values for tables can be predefined and stored. The corresponding functional values are automatically interpolated.
- Output of specimen and measurement parameters and calculated results to ASCII text files, Microsoft Excel[®] worksheets (xlsx) or Microsoft Excel[®] xml spreadsheets
- Output of sample and measurement parameters and calculated results to databases
- Temperature correction: conversion of results by means of temperature coefficients of B_r or H_{cJ}

Microsoft Excel[®], a SQL server and a PDF writer are not included.

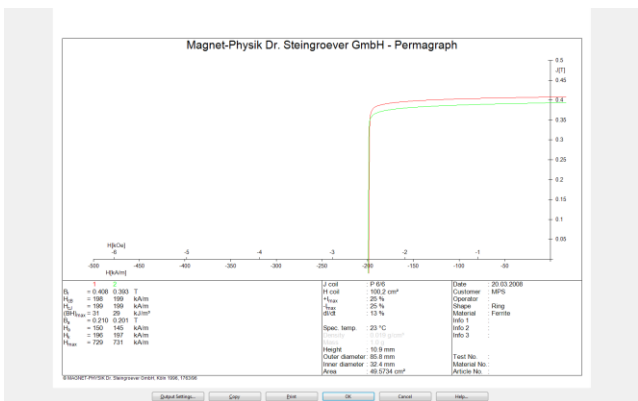
• Screenshots



Main window with different measurements



Measurement of a demagnetization curve



Print preview for multiple curves

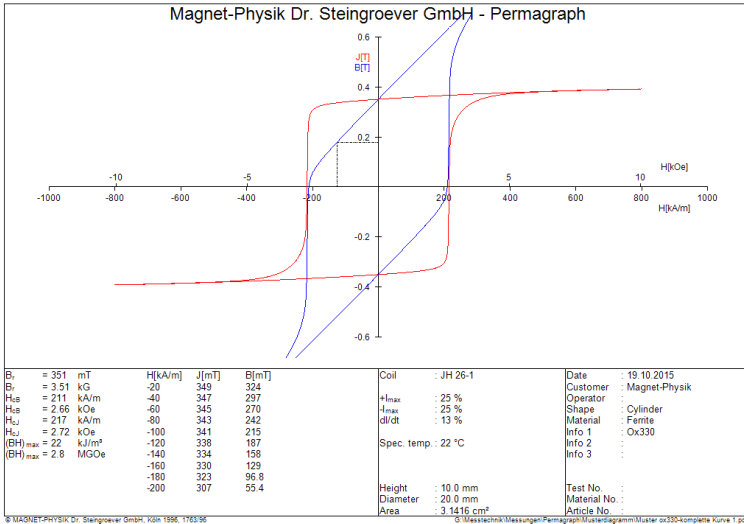
• Control

Operation of the PERMAGRAPH[®] requires a computer. The computer that is included in the standard packages has the following minimum configuration:

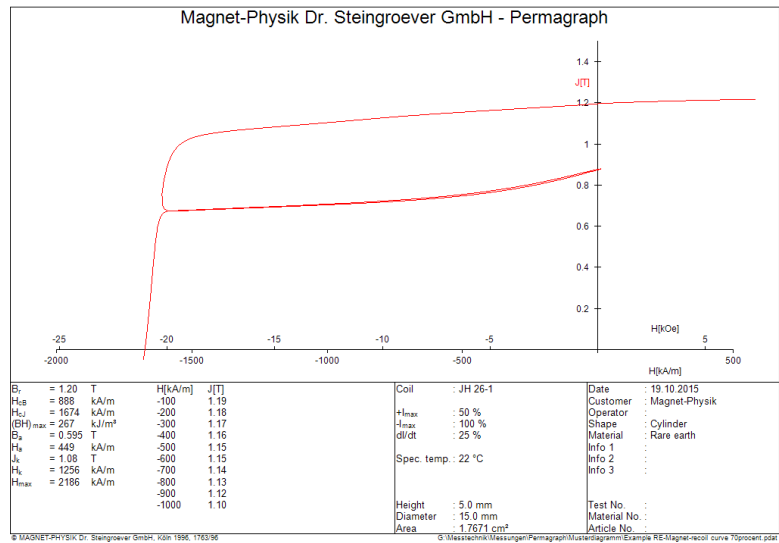
- LCD display
- Keyboard, mouse
- Hard disk drive
- CD/DVD drive
- Network interface
- Interfaces (COM, USB as required)
- Microsoft Windows[®] operating system (current version)

It is recommended to have the computer configured by Magnet-Physik. We can only guarantee faultless operation if apart from the programs installed by us or standard office programs, no further software is installed.

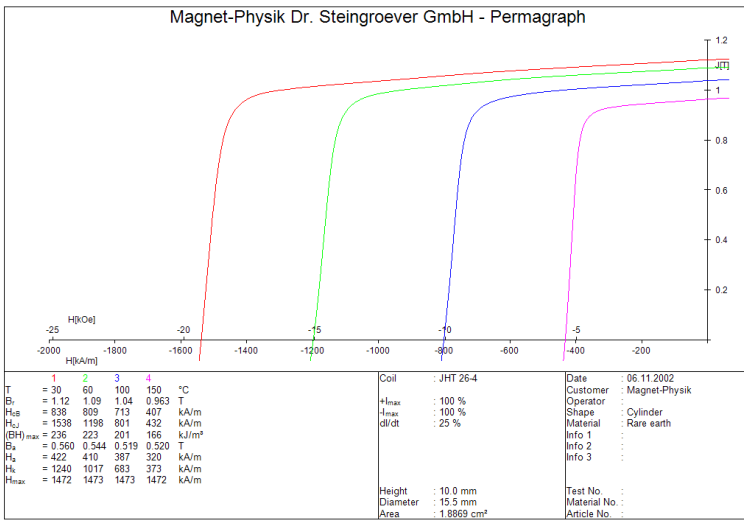
• Example Diagrams



$J(H)$ and $B(H)$ hysteresis loops of a ferrite magnet with $(BH)_{max}$ area. The results and information areas of the diagram are user-configurable.



$J(H)$ demagnetization curve of a rare earth magnet with recoil loop.



$J(H)$ demagnetization curves of a NdFeB magnet at different temperatures

• Electromagnets

Electromagnet EP 3



High field strength in the air gap: up to 1700 kA/m (21.5 kOe) with 2 mm air gap and straight poles

Exchangeable pole caps with following options:

- Made of soft magnetic steel or FeCo
- Diameter 92 mm straight or tapered
- Without or with pole coils
- Without or with heating (up to 200 °C)
- Air gap plane parallel or with segment profile

Minor heating of the field coils

Easy movement of upper poles by hand wheel

No danger of injuries by skewed yoke frame

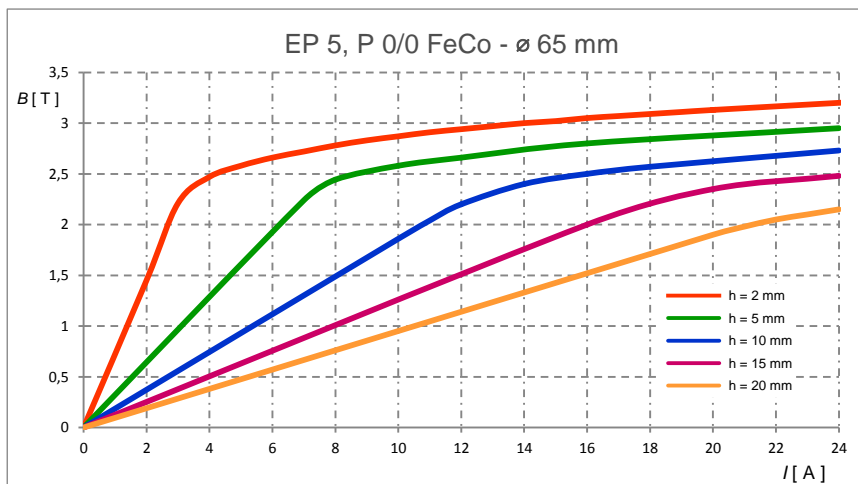
Required power supply: 3 kW

Electromagnet EP 5

The measurement of hysteresis curves of permanent magnets in a measuring yoke requires very high field strengths for the demagnetization of the modern, high coercive materials (Samarium-Cobalt and Neodymium-Iron-Boron).

- Exchangeable pole caps with options as for EP 3
- Easy movement of the upper pole by hand wheel on the front side
- No danger of injuries due to the closed yoke frame
- Required power supply: 3 kW

Achievable flux density in the air gap with iron-cobalt (FeCo) poles tapered to 65 mm diameter for different air gap heights h :



With the electromagnet EP 5, the high field strength in the air gap is achieved by moving the upper field generating coil together with the upper pole in the frame of electromagnet. In this way the magnetic field of the two coils has an optimum effect.

In addition the pole shape and the winding cross sections are of optimum design.

• Accessories for PERMAGRAPH®

Electromagnet Poles

Exchangeable pole caps for electromagnets EP 3 and EP 5. Two poles P 0/0 are usually needed. The poles are made of low carbon soft magnetic steel or a (rather expensive) iron cobalt (FeCo, Vanadium Permendur) alloy, which is the material with the highest saturation polarization. Special sizes are available on request.

P 0/0 - ø 92 mm

Standard pole for measurement with surrounding coils or flat measuring poles. Made of soft magnetic steel.

P 0/0 - ø 65 mm

For measurement with surrounding coils. Tapered from 92 mm to 65 mm. Maximum surrounding coil diameter: 40 mm. Made of soft magnetic steel.

P 0/0 FeCo - ø 65 mm

For measurement with surrounding coils. Tapered from 92 mm to 65 mm. Maximum surrounding coil diameter: 40 mm. Made of FeCo.

P 0/0 - ø 80 mm

For measurement with surrounding coils or as counterpart to a tapered measuring pole with 80 mm diameter. (Regarding use in an EP 3 please contact Magnet-Physik.)



P 0/0 - ø 92 mm



P 0/0 FeCo - ø 65 mm
(EP 5 version)

Measuring Poles with Pole Coils

With two embedded pole coils for measuring the polarization $J = B - \mu_0 \cdot H$ at room temperature (suitable for ferrite magnets). Normally pole coils with 6 mm diameter are used. Coils with 3 mm diameter are used to compare the polarization at different locations on the magnet surface.

Flat Measuring Poles

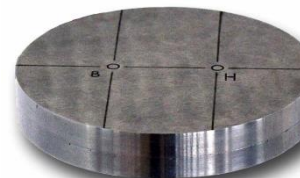
These measuring poles can be positioned on standard poles P 0/0 - ø 92 mm.

P 3/3-15, 92 mm diameter

With two incorporated pole coils of 3 mm diameter

P 6/6-15, 92 mm diameter

With two incorporated pole coils of 6 mm diameter



P 3/3-15

Tapered Measuring Poles

These poles are screwed to the electromagnet. They are tapered from 92 mm to 80 mm. As counterpart a pole P 0/0 - ø 80 mm is required. The poles are made of soft magnetic steel. (Regarding use in an EP 3 please contact Magnet-Physik.)

P 3/3

With two incorporated pole coils of 3 mm diameter

P 6/6

With two incorporated pole coils of 6 mm diameter

P 9/9

With two incorporated pole coils of 9 mm diameter



P 6/6

• Accessories for PERMAGRAPH®

Field Coil FS 100/2

For the measurement of the magnetic field strength or flux density on permanent magnets or in magnet systems. Required for the measurement of the field strength H when measuring poles with pole coils are used.

Thickness: 2 mm, area turns: approx. 100 cm².



Field Coil FS 100/2

Field Coil FS 100/1

For the measurement of the magnetic field strength or flux density on permanent magnets or in magnet systems. Especially suitable if thin magnet sheets are measured using pole coils.

Thickness: 1 mm, area turns: approx. 100 cm².



Field Coil FS 100/1

J-compensated Surrounding Coils

With integrated fields strength measuring coil, for measurements at room temperature.

Coil thickness: 1 mm

J-compensated surrounding coil JH 10-1

Diameter 10 mm,
Specimen diameter 5 ... 10 mm

J-compensated surrounding coil JH 15-1

Diameter 15 mm,
Specimen diameter 10 ... 15 mm

J-compensated surrounding coil JH 26-1

Diameter 26 mm,
Specimen diameter 15 ... 26 mm

J-compensated surrounding coil JH 40-1

Diameter 40 mm,
Specimen diameter 26 ... 40 mm

J-compensated surrounding coil JH 60-1

Diameter 60 mm,
Specimen diameter 40 ... 60 mm



J-compensated surrounding coil JH 26-1

Other J-compensated surrounding coils, also of rectangular shape, can be supplied on request.

J-compensated surrounding coils from Magnet-Physik follow an elaborate design of the windings resulting in separate measuring and compensation coils. This design ensures a real, countable number of turns of the measuring coil. A simpler design approach, which is not used by Magnet-Physik, requires that an effective number of turns must be determined by measurements on reference specimens, resulting in inferior reproducibility.

• Accessories for Measurements at Elevated Temperatures

Heating Poles

For hysteresis measurements at specimen temperatures up to 200 °C. The poles contain a heating element and are tapered from 92 mm diameter to 60 mm diameter. They can be inserted into the electromagnets EP 3 or EP 5. Two poles are needed.

Heating Poles PT 200

The pole caps are made of low carbon soft magnetic steel.

Heating Poles PT 200 FeCo

The pole caps are made of a high saturation iron-cobalt alloy. This material provides better measuring accuracy especially in the vicinity of the knee of the demagnetization curve at field strengths above 1000 kA/m.

Thermocouple TH-J

Temperature sensor for the measurement of the specimen temperature, for insertion into heating poles PT 200 or PT 200 FeCo.

Temperature Surrounding Coils

With integrated field strength measuring coils, for measurements at temperatures up to 200 °C.

Coil thickness: 4 mm.

Temperature Surrounding Coil JHT 10-4

Diameter 10 mm,
Specimen diameter 5 ... 10 mm

Temperature Surrounding Coil JHT 15-4

Diameter 15 mm,
Specimen diameter 10 ... 15 mm

Temperature Surrounding Coil JHT 26-4

Diameter 26 mm,
Specimen diameter 15 ... 26 mm

Temperature Surrounding Coil JHT 40-4

Diameter 40 mm,
Specimen diameter 26 ... 40 mm

Thin Temperature Surrounding Coils

With integrated field strength measuring coils, for measurements at temperatures up to 200 °C.

Coil thickness: 2 mm.

Temperature Surrounding Coil JHT 10-2

Diameter 10 mm,
Specimen diameter 5 ... 10 mm

Temperature Surrounding Coil JHT 15-2

Diameter 15 mm,
Specimen diameter 10 ... 15 mm

Temperature Surrounding Coil JHT 26-2

Diameter 26 mm,
Specimen diameter 15 ... 26 mm



Heating Pole PT 200 or PT 200 FeCo



Thermocouple TH-J



Temperature Surrounding Coil JHT 40-4



Temperature Surrounding Coil JHT 26-2

• Special Applications

Segment Poles with Pole Coils

For the measurement of segment magnets. Both the upper and the lower pole contain pole coils. Thus the polarization can be measured either on the lower or the upper side of the segment magnet, or both pairs of pole coils can be connected together to obtain the average.

The set of poles is constructed corresponding to the radii of the segment magnet. Magnets with different sizes and thicknesses but the same radii can be measured with the same pole set.

Set of segment poles

Material: soft magnetic steel

Set of segment poles

Material: iron-cobalt (FeCo)

The poles are suitable for use in the electromagnets EP 3 and EP 5. For the measurement you also need one field measuring coil FS 100/2.

Optionally available:

Spring Loaded Holding Device TP 2

(not suitable for electromagnets EP 3)

This device makes the mounting of a set of segment poles to the electromagnet faster and easier.

Segment Poles MC-BLW

For the measurement of flux curves of ferrite segment magnets according to the standard DIN 50472. The set of poles is constructed corresponding to the dimensions of the segment magnet.

A coil in one of the poles senses the total magnetic flux penetrating the magnet. The pole distance is fixed and the measurement is carried out with a well-defined air gap. A sheared hysteresis loop is obtained.

The poles are suitable for the use in the electromagnets EP 3 or EP 5. For the measurement you also need one field coil FS 100/2.



Segment Poles with Pole Coils



Segment Pole MC-BLW

• Further Accessories

Nickel Samples

Cylinders with a height of 10 mm and cross-sectional areas of 0.5 cm², 1.0 cm², 2.0 cm² or 5.0 cm² are available. A proprietary calibration certificate is included. Saturation polarization: 0.6 T ± 2 %.

Nickel samples are traditional references for calibrating the measurement of J but they are not necessary for operation of the PERMAGRAPH[®].



Nickel Sample

Reference Magnet

Isotropic ferrite magnet embedded in a brass frame, diameter 24 mm, for testing and calibrating the PERMAGRAPH[®], with proprietary calibration certificate and measuring diagram.



Reference Magnet

Room Temperature Sensor TS-USB

Temperature sensor for USB connection. Using this sensor the room temperature can be shown on the computer display and automatically be saved with the measurement.



TS-USB

Computer Accessories

Computer accessories like a printer, etc. are available on request.

• Services

Taking into Operation and Training – at the Premises of Magnet-Physik

Training in the operation and software of the computer controlled PERMAGRAPH[®].

The training takes 1 day and is included in the standard packages. The customer bears all costs in connection with the journey, stay, accommodation, etc.

Taking into Operation and Training – at the Premises of the Customer

Training in the operation and software of the computer controlled PERMAGRAPH[®].

The training takes 1 day and is at the customer's expenses. Additionally the customer bears the costs for our employee in connection with the journey (incl. expenses for travel time, stay, accommodation, etc.).

Due to continuous product improvements, specifications are subject to change without notice.