

## PERMAGRAPH® L

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



### ● Introduction

The PERMAGRAPH® is the world-wide known standard equipment for the measurement of hysteresis loops of permanent magnets in research, quality control and production.

The PERMAGRAPH® L is the light version of this fully automatic, computer controlled measuring system to determine magnetic characteristics of hard magnetic materials.

Together with the high performance software package PERMA and the required control unit we offer an automatic measuring station which facilitates quick and reliable measurements. Our instruments are known for quality and long lifetime.

The system design conforms to IEC 60404-5, ASTM A977, DIN EN 10332 (formerly DIN 50470). The temperature upgrade conforms to IEC 61807TR, DIN IEC 68/190/CDV.

The equipment has been optimized for years and has been made especially to the requirements of our customers. The following measurements are possible:

- Automatic measurement of the hysteresis curves of permanent magnets
- Determination of magnetic quantities as remanence, coercivity, max. energy product
- Measurement with surrounding coils to determine the magnetic mean values
- Measurements at temperatures up to 200 °C with heating poles and temperature surrounding coil

## ● Measuring Method

Depending on the model of the PERMAGRAPH<sup>®</sup> L and its particular accessories the following measuring methods are possible with our components:

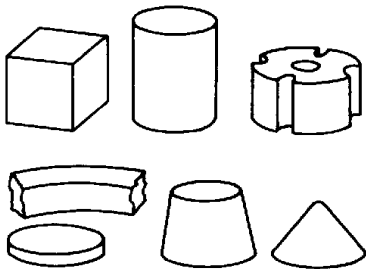
### Measurement of Ferrite magnets

using measuring poles with incorporated pole coils.

**Measurement of Ferrite segment magnets** with segment pole sets with incorporated pole coils, each pole corresponding to the radii of the segment magnet.

### Magnet shapes

which may be measured with pole coils without determination of their cross section in the PERMAGRAPH<sup>®</sup> L.



### Measurement of AlNiCo, Ferrite or Rare Earth magnets (e.g. samarium-cobalt, Sm-Co and neodymium-iron-boron, Nd-Fe-B)

with J-compensated surrounding coils.

### IMPORTANT:

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

### Measurement of AlNiCo, Ferrite or Rare earth magnets at high temperatures (up to 200 °C)

with up to 200 °C heatable measuring poles and temperature resistant JHT surrounding coils.

All important applications and examples for measuring techniques especially regarding the PERMAGRAPH<sup>®</sup> are described in our booklet

#### “MAGNETIC MEASURING TECHNIQUES”

by Dr. E. Steingroever

and

Dr. Gunnar Ross

which we supply free of charge.

## ● Product Family

The PERMAGRAPH<sup>®</sup> L can be composed from a variety of components.

For the measurement of the different magnetic materials we offer Standard packages which can be completed by further accessories according to your application.

On the following pages we list up the components which are included in the packages and give technical details. You will also find a list with all available measuring equipment and accessories.



## • Standard Packages

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### Package 1 Permagraph® L

(for measurements at temperatures up to 200 °C)

- 1 Cabinet PERMAGRAPH® L with power supply for measuring and control electronics and heating poles
- 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 Personal computer
- 1 Software PERMA for Windows
- 1 Training in our works

### Package 2 Permagraph® L

(for measurements at room temperature only)

- 1 Cabinet PERMAGRAPH® L with power supply for measuring and control electronics and heating poles
- 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 Personal Computer
- 1 Software PERMA for Windows
- 1 Training in our works

Package 2 can be upgraded subsequently to package 1 by adding heating poles, thermo couple and a surrounding coil JHT.

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

## • The MAGNET-PHYSIK Measuring Method

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For the measurement of the field strength  $H$  we use either integrated or separate field measuring coils. Therefore a Hall effect gaussmeter is superfluous. If Hall sensors are used to measure  $H$  next to the specimen additional space for the probe and an additional gaussmeter is 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 measuring coil instead of a Hall probe.

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



Reg. No. 004201 QM

## ● Technical Data

<b>PERMAGRAPH® power supply</b> for the electromagnet, with minimum ripple voltage, electronic remote control	<b>SVP 2</b>	Voltage	:	0 - 120 V
		Current	:	0 - 25 A
		Output power	:	3 kW
		Mains	:	3 x 380 - 415 V 50-60 Hz
		Weight	:	15 kg
<b>Cabinet for PERMAGRAPH® L</b> 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 50-60 Hz
		Weight (without SVP 2)	:	20 kg
<b>Measuring and control unit</b> with two-channel fluxmeter integrator, thermo couple input and control for electromagnet power supply	<b>ST-P-L</b>	AD converter resolution	:	24 bit
		Interface	:	RS232
		Weight	:	0.5 kg
<b>PERMAGRAPH® electromagnet</b> magnetizes hard magnetic samples to record hysteresis curves. The pole distance is manually adjustable.	<b>EP 3</b>	Max. field strength (92 mm standard poles, 2 mm gap)	:	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 128 kg
		Weight	:	
<b>PERMAGRAPH® electromagnet</b> magnetizes hard magnetic samples to record hysteresis curves. The pole distance is manually adjustable.	<b>EP 5</b>	Max. field strength (92 mm standard poles, 2 mm gap)	:	2200 kA/m (27.5 kOe)
		Max. field strength (65 mm FeCo poles, 2 mm gap)	:	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 220 kg
		Weight	:	

\*Other voltage configurations may require an internal or external transformer. Therefore please contact factory.

## ● Description of Hard- and Software

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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
- electromagnet power supply and polarity controller
- thermocouple amplifier for measurement of the pole and specimen temperature
- temperature controller for heating poles

## ● Software Features PERMA – Software for Permagraph® L

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- User friendly, menu driven operation
- Fast access to important functions via function keys
- Context sensitive help
- Automatic detection of coils and measurement type
- Real time display of the curve during the measurement
- Saving of measuring data and parameters
- Automatic saving (e.g. below a test number)
- Calculation of results, data analysis
- Print preview
- Output of measuring results and curves on a printer
- Output of measuring results and curves as graphic files (.gif, .jpeg, .bmp) or via the Windows clipboard
- Output of measuring results in files or data bases allowing statistical treatments in programs like EXCEL
- Various possibilities for customized output design
- Display of demagnetization curve and/or hysteresis loop, for  $J(H)$  and  $B(H)$
- Display of up to 5 curves in one diagram with results
- Language separately selectable for program menus and output (English, German, French, Spanish)
- Microsoft Windows 98/2000/XP compatible

## ● Parameters

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- Default parameters minimize the number of necessary inputs
- Calculation of the cross-sectional area from specimen geometries

## ● Drift correction

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- Automatic drift correction
- Proposal for drift correction by software if required, automatically before measurement or on command (20 s)
- Duration of measurement: adjustable, usually 20 – 120 seconds according to sample type
- Speed enhancement by faster magnetization and sufficiently slow demagnetization

## • Curves

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- Demagnetization curve
- Complete hysteresis loop
- Recoil curves
- Automatic stop at  $H_{cJ}$  possible
- Automatic stop at  $-I_{max}$  possible
- $(BH)_{max}$  area
- $B=0$  line

## • Evaluation

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- Remanence ( $B_r$  or  $J_r$ )
- Coercivity of  $J$  curve  $H_{cJ}$  (intrinsic coercivity)
- Coercivity of  $B$  curve  $H_{cB}$  (normal coercivity)
- Maximum energy product  $(BH)_{max}$
- Maximum field strength
- $H_k$ : Knee shape parameter ( $H$  coordinate of intrinsic curve when  $B = 0.9 \cdot B_r$ )
- $H_x$ :  $H$  coordinate of  $J(H)$  curve when  $B = x \cdot B_r$
- Tables of  $J(H)$ , where  $H$  are user defined field strengths. Tables of  $H$  values can be predefined and stored.
- Output of sample and measurement parameters and calculated results in ASCII files, for import by other programs
- Output of sample and measurement parameters and calculated results in data bases
- Temperature correction: Conversion of results by means of temperature coefficients

## • Units

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- Full support of SI and CGS units in software and output
- Change of unit system possible at any time
- Simultaneous display of SI and CGS units on diagram axis

### CONTROL UNIT

Computer-Hardware for Permagraph<sup>®</sup> L included in standard packages

For the set-up of an automatic measuring system and smooth operation of the before mentioned software the following hardware components are required:

- |   |  |  |
|---|--|--|
| <ul style="list-style-type: none"><li>• Personal computer with<ul style="list-style-type: none"><li>• Hard disk drive</li><li>• CD/DVD drive</li><li>• Network connection</li><li>• LCD flat screen</li><li>• Keyboard, Mouse</li></ul></li></ul> | <ul style="list-style-type: none"><li>• Interfaces (COM, USB)</li><li>• Various connection cables for printer, computer etc.</li></ul> | <ul style="list-style-type: none"><li>• WINDOWS (current version)</li><li>• HP Deskjet (current model)</li></ul> |
|---|--|--|

The computer has to be configured by Magnet-Physik.

We cannot guarantee faultless operation if apart from the programs loaded by us further software is installed.



## ● Electromagnets

### Electromagnet EP 3



For the use with PERMAGRAPH® L

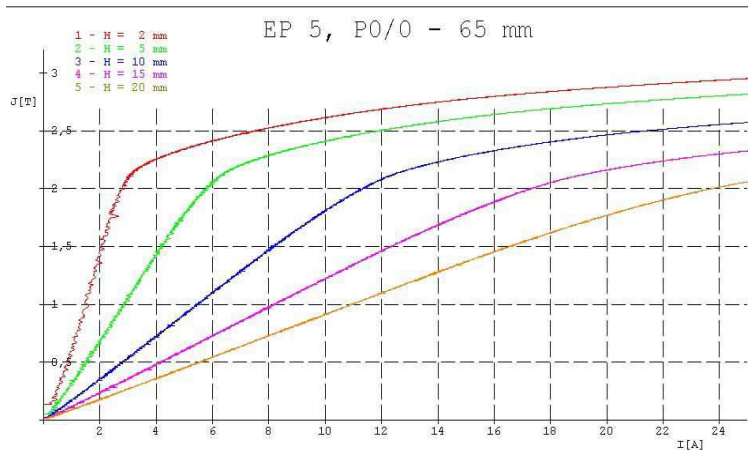
- High field strength in the air gap up to 1700 kA/m (21.5 kOe) with 2 mm air gap and straight poles
- Exchangeable pole caps with following options:
  - made of Fe or FeCo
  - diameter 92 mm straight or tapered
  - with or without pole coils
  - without or with heating (up to 200 °C)
  - air gap plane parallel or with segment profile
- Minor heating of the field coils
- Easy movement of upper poles by handwheel
- 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 like EP 3
- Easy movement of the upper pole by hand wheel on the front side
- No danger of injuries by closed frame of yoke
- Required power supply: 3 kW

Achievable field strength with poles tapered to 65 mm diameter:



With the measuring yoke EP 5 the high field strength in the air gap is achieved by moving the upper field coil together with the upper pole in the frame of electromagnet so that 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® L

### Electromagnet Poles

Exchangeable pole caps for electromagnets EP 3 and EP 5 (usually 2 poles P 0/0 needed). Poles are made of softmagnetic steel or iron cobalt (FeCo) alloy (Vanadium Permendur), which is the material with the highest saturation polarization. Special sizes available on request.

#### Pole P 0/0, 92 mm Ø

standard pole for measurement with surrounding coils or flat pole coil measuring systems. Made of softmagnetic steel.

#### Pole P 0/0, 65 mm Ø

for measurement with surrounding coils. Tapered from 92 mm to 65 mm. Maximum surrounding coil diameter: 40 mm. Made of softmagnetic steel.

#### Pole P 0/0, 65 mm Ø, FeCo

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

#### Pole P 0/0, 80 mm Ø

for measurement with surrounding coils or as counterpart to a pole coil measuring system with 80 mm Ø. (Regarding use in EP 3 contact factory)



Pole P 0/0, 92 mm Ø



Pole P 0/0, 65 mm Ø FeCo

### Measuring Poles

with pole coils, for insertion in the electromagnets for measurement at room temperatures.

#### ▪ Flat Pole Coil Measuring Systems

Recommended for ferrite magnets. The measuring system can be positioned on standard poles 92 mm Ø. The poles are made of FeCo.

##### Flat Pole P 3/3, 92 mm Ø

with 2 incorporated pole coils 3 mm Ø

##### Flat Pole P 6/6, 92 mm Ø

with 2 incorporated pole coils 6 mm Ø

#### ▪ Pole Coil Measuring Systems

for measurement of the polarization  $J = B - \mu_0 \cdot H$  with two incorporated pole coils (suitable for ferrite magnets). The poles are fixed in the electromagnet. As counterpart a pole P 0/0 Ø 80 mm is required. The poles are made of soft magnetic steel. (Regarding use in EP 3 contact factory)

##### Pole P 3/3, 80 mm Ø

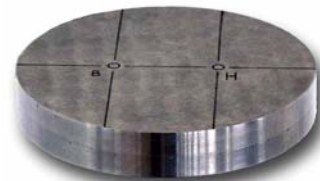
with 2 incorporated pole coils 3 mm Ø

##### Pole P 6/6, 80 mm Ø

with 2 incorporated pole coils 6 mm Ø

##### Pole P 9/9, 80 mm Ø

with 2 incorporated pole coils 9 mm Ø



Flat Pole P 3/3



Pole P 6/6, 80 mm Ø



## • 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  $H$  measurement when pole coil measuring systems are used.

Thickness: 2 mm, area turns: approx. 100 cm<sup>2</sup>.



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 cm<sup>2</sup>.



Field Coil FS 100/1

### J-compensated surrounding coils

with integrated fields coil for measurements at room temperature. Coil thickness: 1 mm

#### J-compensated surrounding coil JH 10-1

Diameter 10 mm, sample diameter 3 ... 10 mm

#### J-compensated surrounding coil JH 15-1

Diameter 15 mm, sample diameter 10 ... 15 mm

#### J-compensated surrounding coil JH 26-1

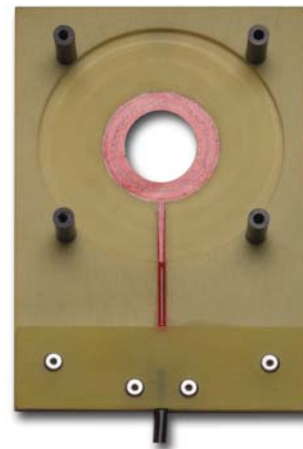
Diameter 26 mm, sample diameter 15 ... 26 mm

#### J-compensated surrounding coil JH 40-1

Diameter 40 mm, sample diameter 26 ... 40 mm

#### J-compensated surrounding coil JH 60-1

Diameter 60 mm, sample diameter 40 ... 60 mm



J-compensated surrounding coil JH 26-1

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

## ● Accessories for Measurements at Elevated Temperatures

### Heating poles PT 200

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 and EP 5. Two poles are needed.



Heating pole PT 200

### Thermocouple TH-J

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



Thermocouple TH-J

### Temperature surrounding coils

with integrated field coil, for measurements at temperatures up to 200 °C. Coil thickness: 4 mm.

#### Temperature surrounding coil JHT 10-4

Diameter 10 mm, sample diameter 5 ... 10 mm

#### Temperature surrounding coil JHT 15-4

Diameter 15 mm, sample diameter 10 ... 15 mm

#### Temperature surrounding coil JHT 26-4

Diameter 26 mm, sample diameter 15 ... 26 mm

#### Temperature surrounding coil JHT 40-4

Diameter 40 mm, sample diameter 26 ... 40 mm



Temperature surrounding coil JHT 40-4

### Thin temperature surrounding coils

with integrated field coil, for measurements at temperatures up to 200 °C. Coil thickness: 2 mm.

#### Temperature surrounding coil JHT 10-2

Diameter 10 mm, sample diameter 5 ... 10 mm

#### Temperature surrounding coil JHT 15-2

Diameter 15 mm, sample diameter 10 ... 15 mm

#### Temperature surrounding coil JHT 26-2

Diameter 26 mm, sample diameter 15 ... 26 mm



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 coil systems. Thus the polarization can be measured either on the lower or the upper side of the segment magnet or both pole coil systems 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

Fe quality

#### Set of segment poles

FeCo quality



**Segment Poles with pole coils**

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

Optionally available:

#### Spring loaded holding device TP 2

(not suitable for EP 3)

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

### Segment Poles MC-BLW

for the measurement of ferrite segment magnets according to a BOSCH in-house standard. The set of poles is constructed corresponding to the radii and size 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 require furthermore: one field measuring coil FS 100/2.



**Segment Pole MC-BLW**

An extension of the PERMA software allows the evaluation of the measurements according to the test directions of BOSCH.



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## ● Further Accessories

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### **Nickel samples**

with calibration diagram

for testing and calibrating the PERMAGRAPH®

Cylinders with a length 10 mm and with cross-sectional areas of:

0.5 cm<sup>2</sup>, 1.0 cm<sup>2</sup>, 2.0 cm<sup>2</sup> or 5.0 cm<sup>2</sup>

Saturation polarization: 0.6 T ± 1.5 %

### **Reference Magnet**

Isotropic ferrite magnet embedded in brass frame, diameter 24 mm.,  
for testing and calibrating the PERMAGRAPH®, with calibration diagram

### **Computer accessories available on request**

Laser printer, CD/DVD Writer, etc.

## ● Services

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### **Taking into operation and training – in Magnet-Physik's premises**

in the operation of the computer controlled PERMAGRAPH® L and its software.

The training will take 1 day and is included in the standard packages.

The customer has to bear all costs in connection with the journey, the stay in Germany,  
accommodation, food, etc.

### **Taking into operation and training – in the customer's premises**

in the operation of the computer controlled PERMAGRAPH® L and its software.

The training takes 1 day and is at customer's expenses.

Additionally the customer has to bear the costs for our engineer in connection with the journey (incl.  
expenses for travelling hours), the stay, accommodation, food, etc.

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