PERMAGRAPH® C

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

Introduction

The PERMAGRAPH® C is an automatic computer controlled measuring system to determine the magnetic characteristics of permanent magnets.

With the precision fluxmeters EF 5 and the high performance software package PERMA we offer an automatic measuring station which facilitates quick and reliable measurements.

The PERMAGRAPH® C is a measuring system which will meet your present and future requirements. Our instruments are known for quality and long lifetime.

The system design conforms to the standards IEC 60404-5, ASTM A977, DIN IEC 60404-5 (replacement for DIN 50470, DIN EN 10332). 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. Among others, the following measurements are possible:

- Automatic measurement of the hysteresis curves of permanent magnets
- Determination of magnetic quantities like remanence, coercivity, max. energy product
- Measurements with surrounding coils to determine the magnetic mean values
- Measurements at temperatures up to 200 ℃ with heat ing poles and temperature surrounding coils

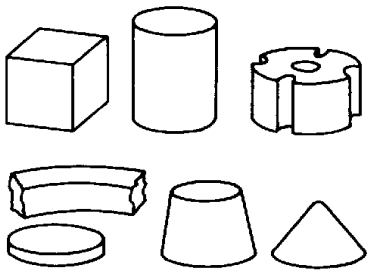
Measuring Method

Depending on the model of the PERMAGRAPH® C and its particular accessories the following measurements are possible using 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® C:



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

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

“Magnetic Measuring Techniques”
by Dr. Erich Steingroever
and Dr. Gunnar Ross

which we supply free of charge (also as pdf file)**.**

Product Family

A PERMAGRAPH® C can be composed from a variety of components and accessories.

For the measurement of the different magnetic materials we offer standard packages which can be completed by further components 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

Universal package Permagraph® C – 300

1 PERMAGRAPH® power supply SVP 2
2 Electronic Fluxmeters EF 5
1 Cabinet for PERMAGRAPH® C
1 Electromagnet EP 3
2 Poles P 0/0, 92 mm Ø, without pole coils
1 Flat pole coil measuring system P 6/6
(or optionally P 3/3)
1 Field measuring coil FS 100/2
1 J-compensated surrounding coil JH 26-1
(other diameter on request)
1 PERMAGRAPH® control unit consisting of:
1 PERMAGRAPH-control board ST-P/R2
1 Computer Hardware PC-PERM
1 Software PERMA for Windows
1 Training in our works

**Basic package "Rare Earth"
Permagraph® C – 300**

1 PERMAGRAPH power supply SVP 2
2 Electronic Fluxmeters EF 5
1 Cabinet for PERMAGRAPH® C
1 Electromagnet EP 3
2 Poles P 0/0, 92 mm Ø, without pole coils
1 J-compensated surrounding coil JH 26-1
(other diameter on request)
1 PERMAGRAPH-control unit consisting of:
1 PERMAGRAPH® control board ST-P/R2
1 Computer Hardware PC-PERM
1 Software PERMA for Windows
1 Training in our works

**Basic package "Ferrite"
Permagraph® C – 300**

1 PERMAGRAPH power supply SVP 2
2 Electronic Fluxmeters EF 5
1 Cabinet for PERMAGRAPH® C
1 Electromagnet EP 3
2 Poles P 0/0, 92 mm Ø, without pole coils
1 Flat pole coil measuring system P 6/6
(or optionally P 3/3)
1 Field measuring coil FS 100/2
1 PERMAGRAPH-control unit consisting of :
1 PERMAGRAPH® control board ST-P/R2
1 Computer Hardware PC-PERM
1 Software PERMA for Windows
1 Training in our works

**Upgrade package PERMAGRAPH® C
for measurements at temperatures up to 200 °C**

1 Temperature control unit TC 3
1 Thermocouple Type J
2 Heating poles PT 200
1 Temperature surrounding coil JHT 40-4
(other diameter on request)

Option Electromagnet EP 5

Electromagnet EP 5
To be supplied instead of the electromagnet EP 3
which is included in the standard packages

The MAGNET-PHYSIK Measuring Method

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, specimens of a thickness down to only 1 mm can be measured.

Technical Data

PERMAGRAPH® power supply for the electromagnet, with minimum ripple voltage, electronic remote control	**SVP 2**	Voltage Current Output power Mains* Weight	: : : :	0 - 120 V 0 - 25 A 3 kW 3 x 380 - 415 V 50-60 Hz 15 kg
Electronic Fluxmeter to measure the polarization *J* as well as the field strength *H* (2 instruments needed**)**	**EF 5**	Detailed technical data and an exact description of the properties of these instruments can be found on one of the next pages.		
Temperature control unit Allows temperature measurement and computer control of the temperature of heating poles PT 200	**TC 3**	Mains Weight	: :	380 - 415 V, 250 VA, 50-60 Hz 12 kg
Cabinet for PERMAGRAPH® C houses above mentioned components, a controller for the electromagnet power supply and polarity and the electrical wiring		Length Width Height Weight	: : : :	520 mm 600 mm 800 mm 25 kg
Control board Computer board with inputs and outputs to control the power supply and the measuring procedures	**ST-P/R2**	Weight	:	0.3 kg
PERMAGRAPH® electromagnet magnetizes hard magnetic samples to record hysteresis curves. The pole distance is manually adjustable**.**	**EP 3**	Max. field strength - 92 mm standard poles, 2 mm air gap Bottom pole size Standard pole diameter Air gap (without poles) Air gap (with standard poles) Nominal short-time electrical load Weight	: : : : : : :	 1700 kA/m (21.5 kOe) 100 mm x 100 mm 92 mm 73 – 102 mm 0 – 63 mm 3 kW 128 kg
PERMAGRAPH® electromagnet magnetizes hard magnetic samples to record hysteresis curves. The pole distance is manually adjustable**.**	**EP 5**	Max. field strength - 92 mm standard poles, 2 mm air gap - 65 mm FeCo poles, 2 mm air gap Max. pole diameter Air gap, without poles Air gap, with standard poles Nominal short-time electrical load Weight	: : : : : :	 approx. 2200 kA/m (27.5 kOe) approx. 2500 kA/m (32 kOe) 92 mm 0 – 130 mm 0 – 110 mm 3 kW 220 kg

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

Description of Hard- and Software

The two fluxmeters are synchronously triggered. They are controlled by the computer. The measured data are received from the two fluxmeters via the interfaces and displayed on the computer display in real-time. This allows the results already to be checked while the measuring procedure is in progress. The measuring process is controlled via the computer board ST-P/R-2.

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

Software Features *PERMA* – Software for Permagraph® C

- 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 Microsoft Excel
- Various possibilities for customer specific 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, Russian, Czech, Slovak, simplified Chinese)
- Microsoft Windows 2000/XP/Vista compatible

Parameters

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

Drift Correction

- Automatic drift correction during warm-up (max. 1 minute)
- Proposal for drift correction by software if required, automatically before measurement or on command (20 s).
- Automatic calibration during warm-up or before drift correction (10 s)
- Duration of measurement: adjustable, usually 20 – 120 seconds according to specimen type
- Speed enhancement by faster magnetization and sufficiently slow demagnetization.

Curves

- 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

- 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 $J(H)$ and B(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

- 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® C 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:

- Personal computer with
  - Hard disk drive
  - CD/DVD drive
  - Network connection
  - LCD flat screen
  - Keyboard, Mouse
- Interfaces (2 x COM, USB)
- Various connection cables for printer, computer etc.
- WINDOWS (current version)
- HP Deskjet (current model, printer not supplied to China)

It is recommended to have the computer configured by Magnet-Physik. We cannot guarantee faultless operation if apart from the programs loaded by us further software is installed.

Electronic Fluxmeter EF 5

Description

The Electronic Fluxmeter EF 5 is designed to measure the magnetic flux using measuring coils. It comprises a precision electronic DC integrator of high sensitivity and extremely low drift.

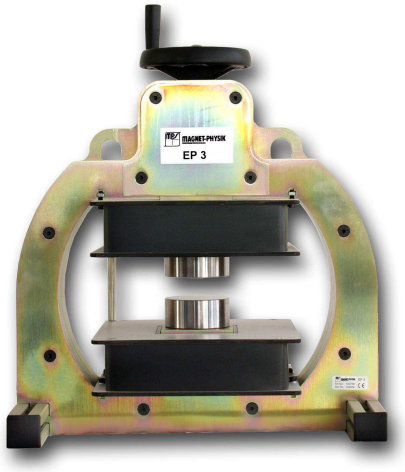
Key features:

- Microprocessor controlled, easy operation
- Automatic drift correction
- Unique continuously working integrator: measuring range limits must not be observed
- Self-adjustment by built-in voltage-time reference
- Complete menu control, the most important functions can directly be accessed by function keys
- Automatic calculation of measuring results taking into account the coil parameters
- Directly reading in Volt-Seconds, Weber, Tesla, Gauss or other units
- Automatic coil recognition and instrument configuration for measuring coils with data memories
- 4 limit comparators with relay outputs for process control
- Modern, compact design
- Directly installable to 19" racks

Technical Data

Display	backlight LCD, 122 x 41 mm²
Reading	max. 6 digits plus 2 digits for exponent
Resolution	10^{-4} / 10^{-5} / 10^{-6} / 10^{-7} Vs
Upper range limits	none due to continuously working integrator
Drift per minute	< 10^{-6} Vs (R_i + R_s ≥ 10 kΩ, R_s = meas. coil resistance)
Units (depending on coil type)	Vs, Wb, T, G, Vs/cm², A/m, Oe, Vs cm, A, Vs/n (per turn)
Basic accuracy	0.1 % of reading ± 10^{-7} Vs
Input resistances R_i	0 Ω, 10 kΩ
Maximum input voltage	60 V
Measurements per second	25
Trigger	internal, external
Extreme values	Max., Min., Max.-Min.
Analog output	±10 V, adjustable scaling
Interfaces	RS232, adjustable baud rate 4800 to 38400 24 V I/O for PLC (reset, drift control, hold reading, trigger, ready) IEEE 488 (optional)
Limit comparator	4 trip points, relay outputs (alternators)

Electromagnets



Electromagnet EP 3

For the use with PERMAGRAPH® C

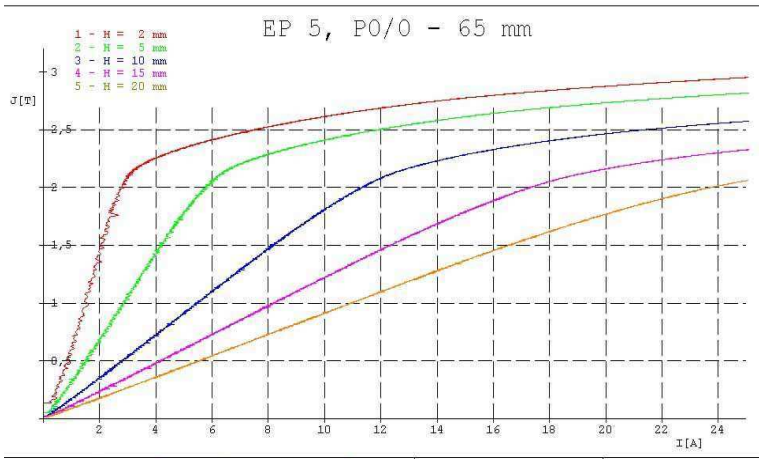
- High field strength in the air gap: up to 1700 kA/m (21.5 kOe) with 2 mm air gap and straight poles
- Exchangeable pole caps with following options:
  - made of soft magnetic steel or FeCo
  - diameter 92 mm straight or tapered
  - with or without pole coils
  - without or with heating (up to 200 °C)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

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, 92 mm Ø

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.

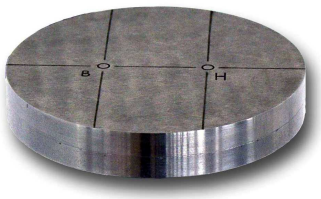

Pole P 0/0, 65 mm Ø FeCo

Pole P 0/0, 80 mm Ø
for measurement with surrounding coils or as counterpart to a pole coil measuring system with 80 mm dia. (Regarding use in EP 3 contact factory)

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 diameter. The poles are made of FeCo.



Flat Pole P 3/3-15

Flat Pole P 3/3-15, 92 mm Ø
with 2 incorporated pole coils 3 mm Ø

Flat Pole P 6/6-15, 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 ∅ 80 mm is required. The poles are made of soft magnetic steel. (Regarding use in EP 3 contact factory)


Pole P 6/6, 80 mm ∅

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

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

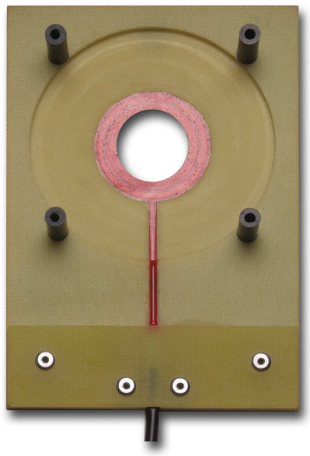
J-compensated surrounding coil JH 10-1
Diameter 10 mm, sample diameter 3 ... 10 mm

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 heat ing 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 3 … 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 3 … 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 electro-magnets 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 DIN 50472 or respectively 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.

Variants

PERMAGRAPH® – REMAGRAPH® – COMBINATION C – 750

For the measurement of the static hysteresis loops of soft and hard magnetic materials.

The PERMAGRAPH®-REMAGRAPH®-COMBINATION C – 750 combines the measuring possibilities of PERMAGRAPH® C and REMAGRAPH® C in one instrument. As some components are only required once, the combination offers a reasonable alternative to separate devices.

Components of the standard package:

- Cabinet for PERMAGRAPH®- REMAGRAPH®-COMBINATION C – 750
- Electronic Fluxmeters EF 5 (2 instruments)
- REMAGRAPH® power supply SVR 4
- PERMAGRAPH® power supply SVP 2
- REMAGRAPH® measuring yoke MJR 5 with exchangeable pole pieces
- J-compensated surrounding coil, round JRR
- J-compensated surrounding coil, flat JRF
- Potential coil PS-R-40/58
- Connection box for ring specimens CB-R
- PERMAGRAPH® electromagnet EP 3
- Pole caps P 0/0 92 mm (2 pieces)
- J-compensated surrounding coil JH 26-1 (other diameter on request)
- Flat pole coil system P 6/6-15 FeCo
- Field measuring coil FS 100/2
- Computer Hardware
- Control board ST-P/R2
- Software PERMA and REMA
- Introduction and training in our works

Cabinet of PERMAGRAPH® – REMAGRAPH® –COMBINATION C – 750 (with optional Temperature control TC 3)

All accessories of the PERMAGRAPH® C and REMAGRAPH® C can also be used with the combination.

You can find a detailed description of all features of the REMAGRAPH® C and of the optional accessories in the specification of this instrument.

Further Accessories

Nickel samples

With proprietary calibration certificate for testing and calibrating the PERMAGRAPH®. Cylinder with a length 10 mm and a cross-sectional area of 0.5 cm², 1.0 cm², 2.0 cm² or 5.0 cm².
Saturation polarization: 0.6 T ± 1.5 %.

Nickel Sample

Reference Magnet

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

Reference Magnet

TS-USB

Room temperature sensor (NTC) for USB connection. With this sensor the room temperature can be shown on the computer display and be saved with the measurement.

Computer accessories

Computer accessories like laser printer, CD/DVD writer, etc. are available on request.

Services

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

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

The training takes 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® C 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.

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

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