Stefan Mayer Instruments

FERROMASTER

Permeability Meter

Instruction Manual

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1 Safety Precautions

The instrument must not be operated in explosive atmosphere.

The operation of the instrument is left at user's risk.

Keep away the probe from magnets or strongly magnetic material. Using the instrument to test magnets or highly magnetic material can damage the instrument.

Before putting the instrument into operation the complete instruction manual should be read. The instrument and this manual may be subject to alterations without prior notice.

2 General Description

The permeability meter FERROMASTER has been designed to measure the relative magnetic permeability μ_r of feebly magnetic material and workpieces with μ_r between 1.001 und 1.999. The relative magnetic permeability μ_r is a pure number independent of the system of units. The relation between the magnetic field B, the magnetic permeability, and the magnetizing field H is given by

$$B = \mu_r \mu_0 H,$$

where μ_0 is the vacuum permeability with

$$\mu_0 = 4\pi \times 10^{-7} \frac{\mathrm{m\ kg}}{\mathrm{A^2 s^2}}.$$

The FERROMASTER is used for material selection in applications where totally non-magnetic material must be used. Examples are: electron microscopes, electron/ion spectroscopy, NMR systems, and compass navigation. Apart from quality control of stainless steel and other alloys the instrument can also be used for the detection of material defects induced by stress.

The permeability is measured by touching the workpiece with the tip of the permeability probe and reading the result from the LC display.

The permeability probe contains a small permanent magnet which magnetizes the sample to be investigated in the vicinity of the probe tip. Two sensitive magnetic field sensors in difference connection measure the distortion of the magnetic field introduced by the magnetized sample. The instrument is calibrated to precise reference standards manufactured by the National Physical Laboratory (NPL, Teddington, UK). The calibration can be easily readjusted. A calibration standard is supplied with each instrument.

As a special feature the FERROMASTER is provided with a robust waterproof case (protection IP65) and is therefore well suited to applications in harsh industrial environments. The built-in battery serves for $\sim$50 hours operation.

3 Operation

Before the instrument is switched on the protective cap must be removed from the permeability probe. **The probe and its metal tip which is now visible must not be exposed to a strong magnetic field because the magnetic properties of the built-in permanent magnet may then change, and the instrument can be damaged. The magnetic field in the vicinity of the probe should never be much larger then the Earth's magnetic field, even when the instrument is switched off. Do not use the instrument for testing of magnets or highly magnetic material!**

The function of the instrument controls is as follows:

Push button ON / ZERO:
Pressing the ON /ZERO button switches on the instrument and starts an automatic zeroing procedure. During automatic zeroing several dots are displayed between the digits on the LC display. The duration of the automatic zeroing procedure depends on the actual offset error and usually takes a few seconds. In extreme cases the zeroing procedure can take up to 2 minutes. After successful zeroing the display shows 1.000. The instrument is now ready for operation.

The zeroing can be repeated any time by pressing the ON / ZERO button. During automatic zeroing the probe tip must not touch any material and the probe must not be moved.

The instrument automatically shuts down 15 minutes after the ON / ZERO button has been pressed the last time.

Push button OFF:
The instrument is switched off by pressing the OFF button. The display goes blank.

Calibration trimmer:
The trimmer is located at the instrument's top near the cable grommet. The calibration factor can be changed by turning

the calibration trimmer with a suitable screw driver. The instrument is factory calibrated. A change of calibration is not recommended. Further details concerning the calibration of the instrument are described in the next section.

4 Measurement of Permeability

In order to measure the magnetic permeability of a workpiece or sample of material the permeability probe is placed perpendicularly on the surface of the sample. The tip of the probe should slightly touch the sample but any mechanical load of the tip should be avoided. The measured permeability value is shown on the LC display.

The FERROMASTER is calibrated to precise permeability standards which have been manufactured and calibrated by the National Physical Laboratory (NPL, Teddington, UK). For easy check of the calibration a calibration standard is supplied with each instrument. In order to check the calibration the permeability probe is placed perpendicularly on the top of the standard so that the tip touches its center. The measured value should correspond with the number printed on the standard. The calibration can be readjusted by turning the trimmer CAL on top of the instrument with a screw driver. The calibration standard should be protected against mechanical load and exposure to strong magnetic fields.

The magnetic permeability and the result of a permeability measurement depend on a number of factors which must be taken into account if a precise measurement is to be made. In particular, the following points should be considered:

4.1 Dependence on the magnetic field strength

The magnetic permeability of a material depends on the strength and frequency of magnetizing field. The permeability probe of

the FERROMASTER contains a permanent magnet which produces a constant magnetizing field of ∼35 kA/m.

4.2 Remanence

Many materials, like some sorts of stainless steel, can be permanently magnetized in a strong magnetizing field. The magnetization which remains when the magnetizing field is switched off (remanence) influences the permeability measurement because the sensors in the probe are sensitive for any inhomogenous field which emerges from the sample. It is therefore recommended to demagnetize permanently magnetized samples in an alternating magnetic field with decaying amplitude before starting a permeability measurement.

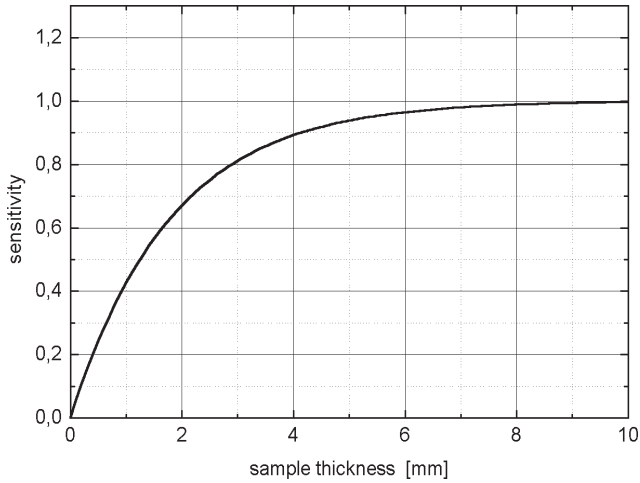
It should be also taken into consideration that a permanent magnetization of the sample may be introduced by the permeability measurement itself since the sample is magnetized by the permanent magnet of the probe.

4.3 Sample surface

For accurate measurements it is important that the probe is placed perpendicularly on the surface of the sample. A tilt may slightly shift the measured values. The instrument is calibrated to reference standards with flat surface. The measurement may be distorted if the sample to be measured has a non-flat surface. If very small pieces or parts with complicated shape should be investigated it may be useful to make reference samples of a material with known permeability.

4.4 Dimensions of the sample

For small samples the result of the permeability measurement depends on the dimensions of the sample. For example, the sensitivity of the instrument increases with increasing sample thickness. The sensitivity is independent of the dimensions for samples which are more than ∼5 mm thick and have a lateral diameter of more than 2 cm. The sensitivity as a function of the sample thickness is shown in the following diagram. The sensitivity is defined as $(\mu_{r\ \mathrm{measured}} - 1)/(\mu_{r\mathrm{true}} - 1)$.



4.5 Earth's magnetic field

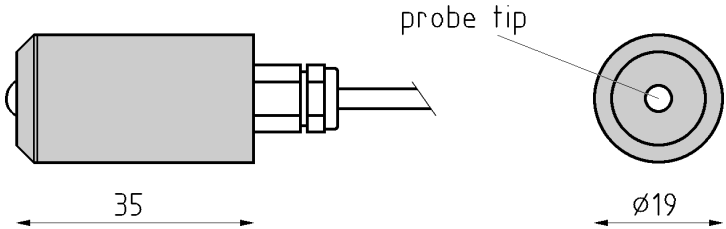
The permeability probe contains two magnetic field sensors which are connected differentially. Therefore, the influence of any homogenous magnetic field (Earth's field) is almost suppressed. Nevertheless, inhomogenities introduced by ferrous objects and a residual mismatching of the sensors may cause offset errors if the probe is turned around. It is therefore recommended to fix the probe in space and to move the sample instead if the expected permeability is much below 1.01.

5 Power Supply

The FERROMASTER is powered by a 9 V battery which serves for ∼50 hours operation. If the capacity of the battery is exhausted "LOBAT" is shown in the upper right corner of the digital display. The battery should then be replaced. In order to open the battery compartment the two lower screws on the back of the instrument must be removed. It is also possible to use rechargeable NiCd or NiMH batteries of the same type. Used batteries are toxic waste and should be properly disposed of!

6 Specifications

Measurement range	$\mu = 1.001$ to 1.999
Resolution	0.001
Calibration accuracy at 20 °C	$(\mu - 1) \times 5\%$, ref. to NPL calibration standards, can be readjusted
Operating temperature	0 to 50 °C
Field strength at probe tip	∼35 kA/m
Battery	9 V (PP3, Alkaline)
Continuous operation with 1 battery	∼50 h
Dimensions of electronics unit	151×82×33 mm^3
Environmental protection	IP65
Length of connection cable	1.5 m
Weight of complete instrument	280 g



Dimensions of the permeability probe in mm

Subject to alterations.

7 Warranty

All components of the permeability meter FERROMASTER are warranted to be free from defects in material and workmanship for a period of two years from the date of delivery to purchaser. The guarantee will apply only if the instrument is operated in accordance with this instruction manual and if the instrument is not changed by the purchaser. In the case of any defect please contact Stefan Mayer Instruments.

Serial number:

Begin of warranty:

End of warranty:

Date, signature:

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