MAGNET-PHYSIK
Dr. Steingroever GmbH
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Germany

Operating Instructions

Moment Measuring Coils

Preserve for future application!

BA-no.: 1480040102

Introduction

Dear customer,

You have decided on a product of high technical standard from MAGNET-PHYSIK. We are convinced that our product will be a valuable help in your daily work. Condition is that the operating instructions are read carefully and observed. We will not take over any warranty or liability in case of deliberate faulty operation or disregard of our safety notes.

If you face any problems while working with the equipment or the operating instructions or if you have any proposals for improvements please do not hesitate to contact us.

Purpose

The operating instructions give an overview about the application and functioning of the coils of the MS series (Helmholtz-type).

Target group

In the following chapters the user and owner of the measuring coil(s) will find all necessary information about the handling of the product and its peripheral components.

Manufacturer

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Notes

- This instruction cannot cover every possible aspect of installation, operation and maintenance, or every error that might occur.

- If you would like more information, or if you encounter particular problems that are not discussed in sufficient detail in the instructions, please contact MAGNET-PHYSIK.

- We also state that the content of these Instructions is not part of a previous or existing agreement, undertaking, or legal relationship, and is not intended to amend the same. All obligations of MAGNET-PHYSIK result from the applicable warranty: These contractual warranty provisions are neither extended nor limited by statements in these instructions.

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1 General Information

This document gives an insight into the possible fields of applications of the coils of the MS series, which are produced and offered by the Magnet-Physik Dr. Steingroever GmbH, Cologne, Germany. In combination with an electronic fluxmeter, acting as an integrator, these coils can be used for the measurement of the magnetic dipole moment of permanent magnet samples. On the other hand some of the coils of the MS series are – in combination with suitable current sources − predestinated for producing easy accessible and very homogeneous magnetic fields.

1.1 Safety Information and Hints

Special warning signals, whose non-observance may lead to injuries and/or property damage, as well as important hints are indicated in these operating instructions as follows:

Danger!

Means that serious bodily injury resulting in death or considerable material damage may occur if the appropriate safety measures are not taken.

Caution!

Means that light bodily injury or material damage may occur if the appropriate safety measures are not taken.

Important!

Indicates important information which is to be paid particular attention.

1.2 Intended Purpose

Important!

It must be expressly stated that the moment measuring coil(s) must only be used for the intended purpose.

The intended purpose of the moment measuring coil(s) is the measurement of permanent magnets or the generation of very homogeneous magnetic fields.

Danger!

During handling with permanent magnets persons with heart pace makers may be in mortal danger caused by the magnetic fields of the permanent magnets.

Important!

Any other application than those of intended purpose is absolutely prohibited and implies intentional misuse with incalculable risks for both the operator and the coil system.

Unauthorized reconstruction and/or changes to the moment measuring coil(s) are absolutely prohibited for reasons of safety!

The instructions as stipulated in this operating manual for operation and maintenance are to be strictly followed!

Caution!

Under no circumstances should liquid media such as water, oil, etc. come in contact with the moment measuring coil(s).

Never clean the moment measuring coil(s) fixture with water! To clean use dry cloths only!

2 The Helmholtz Coils of the MS Series

Figure 1 shows as an example of the coils of the series MS the Helmholtz coil MS 150.

Fig. 1 : A coil of the type MS 150

For the application as a Helmholtz coil the upper and lower coil of this pair of coils must be connected in series: For instance the red banana jack of the lower coil has to be connected with the black banana jack of the upper coil. Between booth coils you can see an adjustable support, which can as well be moved in direction of the axis of the coil system. This part will act as a sample holder for measurements of the magnetic moment of permanent magnets. It guarantees an orientation of the sample base plane perpendicular to the coil axis.

Characteristic for coils of the Helmholtz-type is its set-up of two identical coaxial coil sections with the distance *a* between booth coils identical to the radius *r* of booth coils.
By connecting booth coils in series, on one hand a large region with very good homogeneity results in the case where the whole coil is connected to a current source.
On the other hand, for the application of these coils as moment measurement coils (moment coils), as well a large region with a low sensitivity deviation exists. It can be shown, that this region with low relative sensitivity deviation is exactly as large as the region of very good relative homogeneity, when the coil is connected to a current source (cf. Figure 2). Typical data of the coils of the MS series are compiled in Table 1.

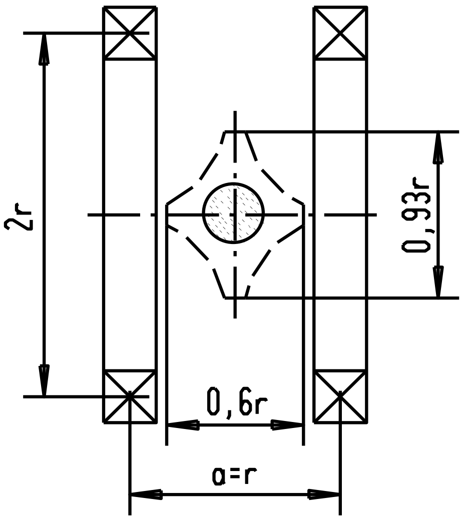

Fig. 2 : Drawing of the coil geometry

Explanations concerning Fig. 2.:
Coil according to Helmholtz with the Helmholtz condition ($a = r$). Indicated here is the region with 1% deviation of the relative sensitivity (dashed line with at maximum 0.6 r in axial direction and at maximum 0.93 r in diametric direction for an idealized Helmholtz-coil). Keep in mind that within the same area one has a relative deviation of 1% of the field homogeneity if the coil is connected to a current source and used as a field generating coil.

Table 1 : Characteristic data of the coils of the series MS

Coil of the MS-series	Measuring constant k_M	Resistance R	Free pass-through	Region with 1% deviation in sensitivity (diameter × height)
MS 20	0.00022 cm	6650 Ω	18 mm	10 mm ⌀ × 5 mm
MS 75	0.0078 cm	77 Ω	65 mm	31 mm ⌀ × 30 mm
MS 150	0.015 cm	37 Ω	140 mm	70 mm ⌀ × 50 mm
MS 210	0.014 cm	75 Ω	200 mm	94 mm ⌀ × 70 mm
MS 534	0.42 cm	6.5 Ω	275 mm	260 mm ⌀ × 150 mm
MS 990 × 990	1.5 cm	13 Ω	984 mm	160 mm ⌀ × 220 mm

Important!

Please note:
The data of the measuring constant k_M and of the resistance R in the table above are only typical data and can't substitute calibration data. Calibration data are determined for every coil individually by MAGNET-PHYSIK before shipping and are printed on a label on top of the coil.

3 Use of the Coils of the MS Series as Moment Coils

The use of Helmholtz coils connected to a fluxmeter facilitates the measurement of the magnetic moment, the dipole moment and the polarization of permanent magnetic samples, which have been magnetized dipolar. The measurement of these magnetic quantities with moment coils is a very fast method, which is frequently used in quality control.

Distinction is made between the so called withdrawal procedure und the rotation method. Booth methods are defined by the international standard IEC 60404-14. For booth methods coils of the MS series can be used as measurement coils.

Important for booth methods is the choice of the appropriate measurement coil. Under ideal conditions, the tested permanent magnet sample has dimensions smaller than the 1% region of sensitivity deviation (cf. Fig. 2).
On the other hand, the sensitivity of the coil (i.e. the inverse of the Measurement constant k_M) should fit to the magnetic dipole moment of the tested permanent magnet sample. Samples with small magnetic moments should be measured with high sensitivity coils.

3.1 The Withdrawal Method

In a first step the permanent magnet sample to be measured is positioned in the center of the moment coil. Then the connected fluxmeter is set to zero (Reset). By the following withdrawal of the sample from the coil a change of the magnetic flux $\Delta\phi$ (in units of Weber i.e. in units of Vs) will be provoked in the coil:
The voltage U_{ind} which is induced in the moment coil by this withdrawal is integrated by the fluxmeter between the instant of time t_0 (the sample is at rest inside the coil) and the time t_1 (the sample is far outside the coil) according to

$$\phi = \Delta\phi + \phi_0 = -\int_{t_0}^{t_1} U_{ind}(t)\,dt + \phi_0 . \quad (1)$$

(Due to the reset of the fluxmeter before withdrawal, ϕ_0 in Equ. (1) is set to zero and therefore $\Delta\phi$ is equal to ϕ). The magnetic flux ϕ which is measured this way is proportional to the magnetic dipole moment j (the unit Weber times cm, i.e. Vs · cm, is used here) of the permanent magnetic sample.

$$j = k_M\,\phi. \quad (2)$$

The measuring constant k_M is a characteristic quantity (in units of cm) for the different coils of the MS series. It is for every individual coil different to a lesser extent. Therefore it is determined by MAGNET-PHYSIK before shipping and printed on a label on top of the coil together with the resistance value of the coil.

Using the fluxmeter EF 5 or EF 14 of MAGNET-PHYSIK in connection with coils of the MS series, that have a coil data memory (EEPROM), the user has the benefit that when connecting the MS coil with the fluxmeter EF 5 or EF 14 the resistance R and the measuring constant k_M, are transferred automatically from the coil data memory to the fluxmeter.
Therefore a manual input of these data, which may be possibly flawed, is not necessary. (These parameters can be manually overridden by the dialog DEVICE of the fluxmeter EF 5 or EF 14. However, these changes will be kept only up to switching off the fluxmeter or peeling off and again connecting of the coil.).
After transmission or manual input of all necessary settings, the fluxmeter is now prepared to measure the magnetic dipole moment j and to output the measurement results directly in units of Vs · cm. (For further information, please have a look into the operation manual of your fluxmeter.).

At older fluxmeters or fluxmeters of other manufacturers the displayed quantity is the magnetic flux ϕ. In these cases the value of the magnetic dipolar moment j has to be calculated according to Equ. (2) manually. (*Please note*: For a possibly necessary correction of the input resistance of the used fluxmeter and the resistance of the moment coil see section 3.3).

Important!

Please note:
In the case of the withdrawal method, the permanent magnet sample has to be withdrawn so far from the moment coil that the connected fluxmeter doesn't show any further significant change in the display.

Important!

Please note:
By touching the permanent magnet sample by hand the sample will be heated. In the case of some magnetic materials – as for instance hard ferrite, which shows a strong dependence of its remanent magnetization on temperature – heating may cause significant deviations of the measuring results. Therefore, the permanent magnet samples should be touched only for a short moment. If necessary a glove should be used. This is in particular important, if, to obtain a better statistics, repeated measurements of one and the same sample were made in quick succession.
While measuring with the MS coils no magnetic material (watches, keys, coins, belt buckles) should be placed or moved close to the MS coil, since this may result in erroneous measurements.

If the volume *V* of the permanent is known the magnetic polarization *J* can be calculated according to

$$J = \frac{j}{V} \quad . \tag{3}$$

Generally, for the magnetic polarization the IS-unit Tesla is used (1 Tesla = 1 T = 1 Vs/m^2).

Together with the inner magnetic field strength *H*, that can be measured by a potential coil connected to a fluxmeter, the magnetic flux density can be calculated according to

$$B = J + \mu_0 H \quad . \tag{4}$$

By *J* and *H* the working point in the *J*(*H*)-diagram is defined. By *B* and *H* the working point in the *B*(*H*)-diagram is defined.

3.2 The Rotation Method

As already mentioned above, in the case of the withdrawal method the permanent magnet sample has to be withdrawn so far from the moment coil that the connected fluxmeter doesn't show any further significant change in the display. Sometimes this is due to limitations of the required space around the moment coil impossible to realize.
In these cases the so called rotation method can be applied:
In a first step the permanent magnet sample is positioned in the center of the moment coil. Then the connected fluxmeter is set to zero (Reset). In the following, the sample will be slightly lifted, rotated by 180 degree, so that north and south pole of the sample are interchanged, and again positioned in the center of the coil.
By this procedure a change of the magnetic flux ϕ in the moment coil is caused, which is *twice as high* as the change of the magnetic flux in the case of the withdrawal method.
Therefore, for the measured change of the flux ϕ, which is still proportional to the magnetic dipole moment *j* of the permanent magnet sample, we obtain for the rotation method the equation.

$$j = k_M \, \phi \, / \, 2. \tag{5}$$

Again here the measuring constant k_M enters into the calculation.

Important!

Please note:
By touching the permanent magnet sample by hand the sample will be heated. In the case of some magnetic materials – as for instance hard ferrite, which shows a strong dependence of its remanent magnetization on temperature – heating may cause significant deviations of the measuring results. Therefore, the permanent magnet samples should be touched only for a short moment. If necessary a glove should be used. This is in particular important, if, to obtain a better statistics, repeated measurements of one and the same sample were made in quick succession.
While measuring with the MS coils no magnetic material (watches, keys, coins, belt buckles) should be placed or moved close to the MS coil, since this may result in erroneous measurements.
Using the MAGNET-PHYSIK fluxmeter EF 5 or EF 14 the operator has the opportunity to perform a division by 2 of the measurement result under the menu item **VAR**. Then the fluxmeter displays automatically the right value of the magnetic dipole moment *j* according to Equ. (5).
The settings of the **VAR**-menu remains stored even after switch off of the fluxmeter EF 5 or EF 14. If the division of the measurement result by 2 is no longer desired, it should be reset in the **VAR**-menu. For further information, please have a look into the operation manual of your fluxmeter.

3.3 Correction Rule for the Fluxmeter Measurement Reading

If a moment coil is connected to a fluxmeter, the dc resistance of the moment coil R is in series to the input resistance of the fluxmeter R_F. Herefrom the following correction rule for the flux ϕ registrated by the fluxmeter results

$$\phi_{\mathrm{corr}} = \phi \cdot \frac{R_{\mathrm{F}} + R}{R_{\mathrm{F}}} . \qquad (6)$$

Here ϕ_{corr} is the corrected value of the measured magnetic flux.

Using the fluxmeter EF 5 or EF 14 of MAGNET-PHYSIK in connection with coils of the MS-series, that have a coil data memory (EEPROM), the user has the benefit that when connecting the MS-Coil with the fluxmeter EF 5 or EF 14 all important parameters, like for instance the resistance *R*, are transferred automatically from the coil data memory to the fluxmeter. The fluxmeter EF 5 or EF 14 then automatically calculate the corrected value of the measurement result according to Equ. (6).

Important!

Please note:

If the analog output of the fluxmeter EF 5 or EF 14 is used, the correction according to Equ. (6) has to be applied to the analog signals. This has as well to be done for fluxmeters from other manufacturers.

In former times simple fluxmeters had an input resistances of the order of some hundred or thousand ohms, which even differed from measurement range to measurement range. For these fluxmeters it was always necessary to consider the coil resistance. For every moment coil and every measurement range its own correction factor according to Equ. (6) had to be calculated and applied.

In contrast, modern fluxmeters have input resistances of 10 kΩ or 100 kΩ, which is independent from the used measurement range. For instance the EF 14 fluxmeter has an input resistance of 100 kΩ. If the resistance of the moment coil is only of the order of some ohms, the corresponding correction factor can be neglected. If the resistance of the coil is larger than 0.1 % of the input resistance of the fluxmeter (i.e. 100 Ω in the case of the EF 14) the correction factor should be considered.

In the case of the fluxmeter EF 5 the user can choose between an input with an input resistance of 0 Ω and an input with an input resistance of 10 kΩ. In the case of measurements with connected moment coils of the MS series the 10 kΩ input is normally used. (For further information, please have a look into the operation manual of your fluxmeter.)

3.4 Determination of the Direction of Anisotropy of Permanent Magnets

The coils of the MS series connected to a fluxmeter can be used to determine the direction of anisotropy of permanent magnets. Therefore, in a first step, the magnetic fluxes ϕ_i or respectively, the magnetic dipole moments j_i have to be measured consecutively in a direction parallel to a geometric axis of symmetry and in two axis that are perpendicular to this and to each other. The angle α of the magnetic axis with regard to the axis of symmetry of the permanent magnet sample can be calculated according to

$$\alpha = \arccos \frac{\phi_1}{\sqrt{\phi_1^2 + \phi_2^2 + \phi_3^2}}$$

or

$$\alpha = \arccos \frac{j_1}{\sqrt{j_1^2 + j_2^2 + j_3^2}} \quad .$$

Example: A neodymium-iron-boron block magnet has a height of 3 mm and a base area of 42 mm². The measured flux values are

$$\phi_1 = 361 \cdot 10^{-6}\ \text{Vs}, \quad \phi_2 = 20 \cdot 10^{-6}\ \text{Vs}, \quad \phi_3 = 12 \cdot 10^{-6}\ \text{Vs} \quad .$$

ϕ_1 is the flux perpendicular to the base plane.
From these flux values the angle between the easy axis and the vertical on the base plane can be calculated according to

$$\alpha = \arccos \frac{361}{\sqrt{361^2 + 20^2 + 12^2}} = 3.7° \quad .$$

In these measurements one has to take care that the orientation of the axes of the permanent magnet is parallel with regard to the axis of the moment coil. In the case of the Helmholtz-coils MS 75, MS 150 and MS 210 an adjustable support will act as a sample holder (cf. Figure 1). It guarantees that the orientation of the sample base plane is perpendicular to the coil axis.

3.5 Determination of the Working Point of Segment Magnets

The working point of a magnet is the point on the demagnetization curve $B(H)$ or $J(H)$ that is defined by the inner field strength H_m and the flux density B_m or polarization J_m. Is the magnet open, i.e. not assembled in a system, the working point is determined by its shape. The working point changes when the magnet is installed into a system.

A magnet has a uniform working point if it is homogeneously magnetized. For open magnets this is only the case for a rotational ellipsoid. For practical magnet shapes the working point varies for different regions of the magnet resulting in a working zone instead of a working point on the demagnetization curve.

If the demagnetization curve of the magnet material is known, a mean working point can be determined by measuring the polarization J_m with a moment coil. The value of H_m for J_m is obtained from the demagnetization curve.

Alternatively H_m can be measured using a potential coil and J_m can be taken from the demagnetization curve. Both methods have advantages and disadvantages.

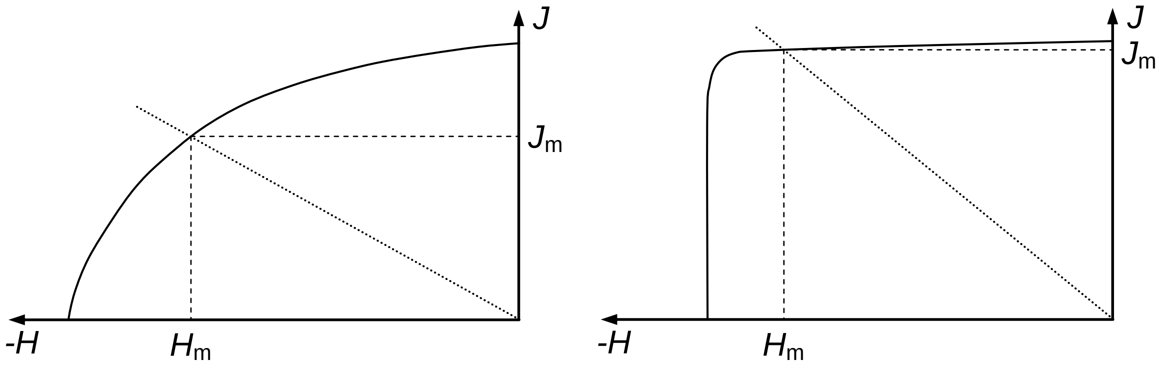

Fig. 3 : Working points of isotropic (left) and anisotropic magnets (right)

The moment coil provides an average for the whole magnet volume. The measuring result of H_m from the potential coil depends for a not homogeneously magnetized magnet on the measuring position. It is, for example, different for the edge and the center of the magnet.

Within this limitation both methods are in principle equivalent for an isotropic magnet. In practice the moment coil provides a better repeatability and smaller uncertainty of measurement.

The situation is different for an anisotropic magnet. Due to the nearly horizontal demagnetization curve a small uncertainty in the determination of the polarization J_m causes a large uncertainty for the position of the working point. In this case the potential coil is preferably used to determine the working point.

Nevertheless the measurement of the dipole moment and the determination of the polarization of anisotropic magnets is a main application of the moment coil. The target here is not the determination of the working point. It is rather made use of the fact that the polarization in the working point J_m is only a little below the remanence B_r. Therefore the determination of J_m is a fast and accurate method to obtain an approximate value or lower limit for B_r. The direct measurement of B_r requires by contrast a hysteresigraph, i.e. a much more demanding measuring instrument for recording the demagnetization curve.

Moment coil and potential coil can also be used for measurements on segment magnets with radial direction of anisotropy. In this case it must be taken into account that the moment coil only captures the component *j´* of the magnetic dipole moment that is parallel to the coil axis.

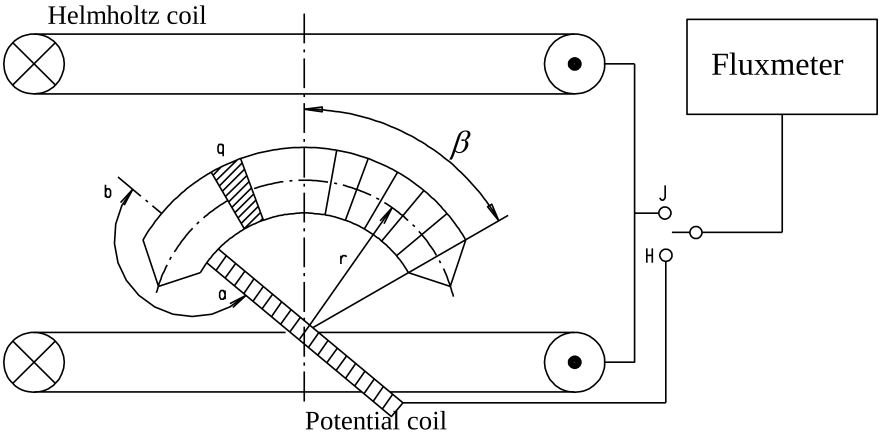

Fig. 4 : Measurement of the dipole moment and potential on a segment magnet

The dipole moment dj' of a volume element dV in direction of the coil axis is

$$dj' = J \cdot dV \cdot \cos\beta = J \cdot A \cdot r \cdot d\beta \cdot \cos\beta.$$

Here J is the polarization, A the cross-section area, r the mean radius and β the half opening angle of the segment.
By integrating over the angle one obtains for the dipole moment

$$j' = 2 \cdot J \cdot A \cdot r \cdot \int_0^\beta \cos\beta \, d\beta \quad .$$

From the magnet volume

$$V = 2 \cdot A \cdot r \cdot \beta$$

follows

$$j' = J \cdot \frac{V}{\beta} \cdot \sin\beta$$

and

$$J = \frac{j'}{V} \cdot \frac{\beta}{\sin\beta}$$

Example**:** The fluxmeter shows a dipole moment j' of 1.39 mVs · cm. The volume V of the magnet is 47.6 cm³. The angle $\beta = 65°$ corresponds to a radian measure of 1.135.

Then the polarization is

$$J = \frac{1.39\ \text{mVs}\cdot\text{cm}}{47.6\ \text{cm}^3}\cdot\frac{1.135}{0.906} = 36.6\cdot 10^{-6}\ \frac{\text{Vs}}{\text{cm}^2} = 0.366\ \text{T}$$

The inner field strength H_m can be measured using the potential coil. Different results are obtained for the center and the edge of the magnet:

in the center: $$H_m = \frac{P_{ab}}{s} = \frac{2300\ \text{A}}{9.2\ \text{mm}} = 250\ \text{kA/m}$$

on the edge: $$H_m = \frac{P_{ab}}{s} = \frac{1886\ \text{A}}{9.2\ \text{mm}} = 205\ \text{kA/m}$$

Here s is the thickness of the magnet.

4 The Use of MS Coils for the Generation of very homogeneous magnetic Fields

As already mentioned above, some of the MS coils can be used – in connection with an appropriate current source – for the generation of easy accessible and very homogeneous magnetic fields. Theses homogeneous magnetic fields can be used for instance for various calibration services. Of the MS coils listed above in Table 1 the coil sytems MS 150, MS 210, MS 534 and MS 990 × 990 are suitable for field generation (cf. Table 2 below).

Danger!

Persons with a heart pace maker may be in mortal danger caused by the field generating coils.

It can be shown, that the field constant of a coil

$$k_H = H / I \tag{7}$$

can be calculated if its measurement constant k_M is known according to

$$k_H = 1 / k_M \quad . \tag{8}$$

Table 2 : Characteristic data of the coils of the series MS which can be used for the generation of very homogeneous magnetic fields

Coil of the MS-series	Field constant k_H	Resistance R	Curent rating (Voltage) at 10 Watts dissipated power P	Field amplitude H (Flux density B) in the center of the coil at 10 Watts dissipated power P
MS 150	6,67 10^3 m^{-1}	37 Ω	0,52 A (19,2 V)	3,5 kA/m (4,36 mT)
MS 210	7,14 10^3 m^{-1}	75 Ω	0,37A (27,4 V)	2,6 kA/ m (3,28 mT)
MS 534	0,238 10^3 m^{-1}	6,5 Ω	1,24 A (8,1 V)	295 A/m (0,37 mT)
MS 990 × 990	0,0667 10^3 m^{-1}	13 Ω	0,88 A (11,4 V)	59 A/m (73 µT)

Important!

Please note:
The data of the field constant k_H and of the resistance R in the table above are only typical data and can't substitute calibration data. Calibration data are determined for every coil individually by MAGNET-PHYSIK before shipping and are printed on a label on top of the coil.

Between the dissipated power P of a coil and the therefore necessary current flow I in the coil wire of resistance R the following relationship exists.

$$P = R \cdot I^2 \tag{9}$$

Caution!

By connecting the MS coils to a current source the dissipated power of the coil P should be so small that the temperature of the coil does not exceed 40 °C (i.e. 104 °F). The maximum permissible current strength of the coil depends on the ambient temperature. The values of the current rating in table 2 above are therefore only typical data for the save working of the coils. In the case of the coils MS 150 and MS 210 the amperage should neither exceed 1 A even for a short time!

***Example*:** A Helmholtz-coil of the type MS 150 has a field constant of approximately $k_H = 6.67 \cdot 10^3\ \mathrm{m^{-1}}$. At a current strength of $I = 0.5$ A a magnetic field amplitude of

$$H = k_H \cdot I = 6.67 \cdot 10^3 \mathrm{m^{-1}} \cdot 0.5\,\mathrm{A} = 33.4 \cdot \frac{\mathrm{A}}{\mathrm{cm}} \tag{10}$$

can be obtained. The corresponds to a flux density B of (here μ_0 is the vacuum permeability with $\mu_0 = 4\pi \cdot 10^{-7}$ Vs/Am)

$$B = \mu_0 \cdot H = 4\pi \cdot 10^{-7} \frac{\mathrm{Vs}}{\mathrm{Am}} \cdot 3.34 \cdot 10^3 \frac{\mathrm{A}}{\mathrm{m}} \tag{11}$$

Hence we obtain

$$B \cong 4.2 \cdot 10^{-3} \frac{\mathrm{Vs}}{\mathrm{m}^2} = 4.2\,\mathrm{mT} \tag{12}$$

Please note therefore the “Important”-note on the next page.

Important!

Please note:

The resistance of a copper coil increases with increasing temperature. In order to obtain never the less a time constant magnetic field, usually constant current sources instead of constant voltage sources are used.

On the other hand the use of a constant current source according to Equ. (9) causes an increase of the dissipated power *P* with increasing coil resistance *R* if the coil current *I* is kept constant. This again enlarges the coil resistance and again increases the dissipated power.

In order to interrupt this vicious circle, a thermodynamically stationary state for the coil has to be approached. In general a cooling of the coil by a moderate room temperature at moderate current values is sufficient.

The data which are compiled in Table 2 are based on a power dissipation of the coil of 10 Watt respectively. These data are a good starting point, in order to obtain stable thermodynamic working conditions for the considered coils.

5 Maintenance

5.1 Maintenance Plan

WHAT?	WHEN?	WHO?
Checking for signs of damage	monthly	operator
Carrying out calibration	e.g. once a year or every two years	Manufacturer or authorized calibration laboratory

The checks should be carried out regularly.

5.2 Checking for Damage

The coils of MS series have to be checked for damage monthly. If damages at the connectors or at the cables become visible the respective parts have to be replaced or the coil has to be sent to the manufacturer (MAGNET-PHYSIK) for repair. If other signs of damage are recognized during these checks, operation of the respective coil only may be continued if approved by an authorized person.

5.3 Calibration

Accurate and repeatable measurements can only be ensured if regular calibrations are carried out.

The respective coil should be calibrated with appropriate standards once a year or every two years. We recommend to have these calibrations carried out by the manufacturer (MAGNET-PHYSIK).

5.4 Shutdown

Store the coil under suitable conditions to enable operation at a later time. It is advisable to register the date of the last operation.

To avoid possible environmental pollution, disposal should be carried out by an authorized specialist company.