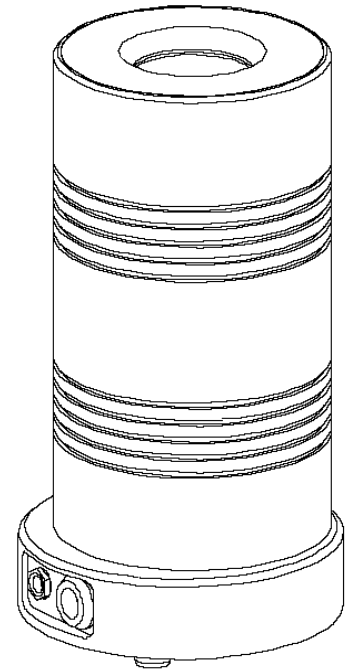


Heritage Group Inc.

Magnetic susceptibility
meter

SM-100

USER'S MANUAL



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1.GENERAL INFORMATION

1.1 Application

Instrument SM-100 is designed to measure magnetic susceptibility of small rock samples. Due to high sensitivity of the instrument, it is possible to measure diamagnetic substances as well. The instrument is ready to measure with the maximum sensitivity within a minute after being set into operation. Advanced method of signal processing distinctively reduces effects of outer electromagnetic disturbances and that of circuit noise . The embedded scale (based on strain-gauge bridge) measures the weight of every sample and the measured value is used for evaluation of mass susceptibility. The measured values can be stored on the hard disk or similar medium for later use. Small size and low weight make it easier to manipulate with the instrument on the working site.

1.2 Specification

SENSITIVITY..... 1×10^{-6} SI Units for sample 11.147 cubic cm at 320 A/m
(cylinder: $d=25.4\text{mm}$, $h=22\text{mm}$)

DIMENSIONS OF THE PICK-UP UNIT.....diameter = 90mm, height = 200mm
WEIGHT:

- pick-up unit.....1.6kg
- accumulator1.1kg
- charger.....0.5kg
- the whole instrument with transport box.....6.1kg

DIMENSIONS OF THE TRANSPORT BOX.....400x250x170 mm

OPERATING FREQUENCIES.....8 kHz, 4 kHz, 2 kHz, 1 kHz, 0.5 kHz

FIELD INTENSITY (effective values).....320 A/m, 160 A/m, 80 A/m, 40 A/m,
20 A/m, 10 A/m

MEASUREMENT TIME..... approx. 15s

CONTROLS.....weighting sensor in the instrument's body and by
computer

PICK-UP COIL CAVITY..... 38 mm in diameter

OPERATING TEMPERATURE..... -20°C to $+50^{\circ}\text{C}$

POWER.....12 VDC / 200 mA, Accumulator and/or charger

TIME BETWEEN CHARGING.....typically 10 hours

COMMUNICATION WITH COMPUTER.....RS232

2. DESCRIPTION OF INSTRUMENT

2.1 General description

The susceptibility Meter SM-100 requires a computer with WINDOWS operation system.

The computer does the processing, displaying and storing of acquired data.

SM-100 is a cylinder-shaped instrument with an opening, through which samples are put inside the pick-up coil. The measuring process is initialized by placing a sample into a pick-up unit.

The sample should be removed after an acoustic signal. There are not any control buttons on the instrument's body. The instrument is switched on automatically after the activation of the computer application. The instrument can be powered either by a 12 V accumulator. The accumulator can be charged while the instrument is in operation.

2.2 Operating principles

The instrument consists of an oscillator, part of which is a pick-up coil. When a rock sample is placed inside the pick-up coil, it results in a change in oscillator frequency.

The variation is proportional to the susceptibility of the sample. To be able to specify the change of the frequency, it is necessary to measure the frequency of

the oscillator in two steps. First measurement takes place while the rock sample is inside. This step is further referred to as "**the pick-up step**". Second measurement takes place after the rock sample is removed from the pick-up coil ("free air measurement"). This step is further referred to as "**the compensation step**". It is the difference in the both frequencies that indicates the value of magnetic susceptibility. The above mentioned method of measurement is illustrated in Fig.1

Figure 1a shows the way the oscillator frequency is affected by the measured sample. It also shows the frequency difference in both the steps. The difference is used as ground for the calculation of magnetic susceptibility. Figure 1b shows also the effect of the thermal drift. Susceptibility with unwanted thermal drift is calculated using the formula

$$\text{susc} + \text{drift} = f_2 - f_1$$

Because of the strong effect of the thermal drift, this mode of measurement can be used only for samples with very high susceptibility.

To suppress the thermal drift the SM-100 employs thermal drift correction mode described in Fig. 2. Figure 2 makes it possible to derive

$$\text{susc} = (f_1 + f_3)/2 - f_2$$

Effect of the drift is eliminated. Note that the above formula is valid only when the pick-up step is in the center of both compensation steps.

2.3 Technical implementation of SM-100

The SM-100 instrument is controlled by computer. The Fig.4 shows „Measuring control“ window, „Document“ window, „Settings“, „Scale calibration“ and „Kappa calibration“ windows. The „Document“ window contains table with measured values and other important data and is placed on the background. This table can be stored to the XML file (for more details see chapter 5). Fig. 3 describes technical implementation of SM-100. During the period of time when the instrument is ready to measure the rock sample, the frequency is continually being measured at very short successive intervals. The results of the measurements are transferred to computer and stored in "barrel shift memory". The oldest measurements are replaced by the latest ones, therefore we have the information about the time period, which is represented in Fig.3 by t_1 . There are a few examples of time samples in Fig.3.

The period of time when the instrument is ready to measure is represented in Fig.3 by *ready to measure*. During this period computer is constantly monitoring the frequency sample's standard deviations in barrel shift memory. The result of this is displayed in the status window under a name *noise*, see Fig.4. Placing of a rock sample into the instrument is recognised by an weighting sensor inside the instrument and the numerical value, which is equivalent to "1'st compensation step", is calculated from the "barrel shift memory" data. The computer

simultaneously beeps and status window changes color and notice, as shown in Fig.3a. "1'st sample movement time" is over and " the pick-up step" is initialized. The end of " the pick-up step" is again signalled by a beep and followed by a change in color and notice in the status window. Now is the moment for an operator to remove a sample from the pick-up coil. This is represented in Fig. 3. by "2'nd sample movement time". After that "2'nd compensation step" follows automatically.

Susceptibility and weight measuring are processed simultaneously. One of susceptibilities is displayed in the „Measuring control“ window after finishing the "2'nd comp. step". The radio buttons are used for changing between Mass and Volume susceptibilities. If the weight of the sample is too low, the value „N/A“ is shown instead of value of mass susceptibility. Both susceptibilities and weight of the sample are stored into the table in „Document“ window on background. Display of the latest acquired data is accompanied by a double beep. When the weight of the sample is measured on accurate laboratory balance, it's value can be used instead of the value measured by built-in scale. This is done by entering this value into the appropriate column in the „Document“ window. The mass susceptibility is automatically corrected when the value of weight is changed.

The variation in oscillator frequency takes effect for a certain time after placement or removal of a sample. Placing and removing must be therefore finished early enough before the beginning of the pick-up step and 2'nd compensation step, respectively. Time period when a sample must stay in its place (either inside the coil or far enough from it) is displayed under a name "settling time" in the status window. For the final result, the data acquired from

the barrel shift memory for 1'st compensation step are as important as data acquired during the pick-up step and 2'nd comp. step. To make sure that the data has not been disturbed (e.g. by movement of metal object within the reach of the sensor) the noise level in the status window should be checked while placing in the sample. If necessary, wait until it settles

2.4 Calibration

The calibration of the instrument is made by manufacturer by means of the coil in the shape of cylindre (d=25.4 mm, h=22 mm). The strength of the field is calibrated according to voltage induced in the coil. The susceptibility is calibrated using the same coil loaded with the known impedancy. Each frequency and strength of the field has its own calibration constant.

The user is allowed to adjust the sensitivity at particular frequencies. It is possible to do it from the „Kappa Calibration“ window. It is very useful mainly when the frequency dependence of the magnetic susceptibility is measured.

The calibration constants are stored in two files called:

- cal_fact_SM100_2005_#.xml
- cal_user_SM100_2005_#.xml

where the sign # means the serial number of the instrument which is read from the instrument. It is not possible to work with the instrument without having the correct calibration files. Every single instrument has its own calibration files.

3 Operation

3.1 Switching the instrument ON and OFF

1. Plug the instrument in the accumulator or charger. Connect the instrument with a computer by the communication cable.

2. Open SM100W application. The instrument switches on automatically. Choose the number of the communication channel. The table that unfolds itself provides the information about application versions in both the instrument and computer. This table disappears after a while.

In case the application versions are not compatible or the connection has not been established, the table does not disappear.

3. When SM100W application is closed, the instrument is switched off. Disconnecting of one of the cables switches the instrument off as well.

3.2 Weighting scale calibration

The „Scale calibration“ window can be displayed via menu „Measuring->Scale calibration“. This window is shown on the Fig. 4. The calibration steps are as follows:

- insert empty pot into instrument
- press button „Zero“
- remove pot from the instrument

The weight of the pot with minus sign is displayed.

- The 50g or 100g weight standard is put into the pot. Used value must be written into the „Calibration value“ edit field.
- Place the pot into the instrument and press „Adjust“ button. The value behind the label „Scale“ in „measuring control“ window is changed.
- Remove the pot from the instrument and check whether the value behind
- the label „Scale“ is apx. $\pm 0.1\text{g}$.

Note: The calibration can be repeated if needed.

3.3 Kappa calibration

The SM-100 instrument is calibrated in factory. Nevertheless the user can change the sensitivity. After opening the window „Kappa calibration“ via menu „Measuring->Kappa calibration“ we may change the const. for each measuring frequency. The measured susceptibility is multiplied by this value. The calibration const. is also inserted into table in „Document“ window.

3.4 Pot susceptibility compensation

During measuring of samples with very low susceptibility it is recommended to measure the susceptibility of the empty pot and automatically subtract it from the susceptibility of the measured sample. It is recommended to measure the susceptibility of the empty pot several times (at least 20times) and calculate the average value. Then the calculated average value should be inserted into the column „Pot. Susc.“ of the table in the „Document“ window. Do not forget to put

the value with the sign. (The susceptibility of the pot is usually very low and negative value.) The subtraction is done automatically by the programme.

3.5 Measuring susceptibility of the rock

1. Switch the instrument on.
2. Chose the measuring frequency and strength of the field in the window „Settings“, which can be displayed via menu „Measuring->Settings“.
3. The noise level in the status window should be checked before placing in a sample. If necessary, wait until it settles.
4. Press button „Tara“ in the „Measuring control“ window. Insert the empty pot and press „Tara“ again. It is not necessary to perform this step during each measurement. It is sufficient to do it from time to time for suppressing the thermal drift of the scale. After that the weight of the pot will be automatically subtracted. Remove the pot. The weight of the empty pot is displayed as a negative value.
5. Insert the pot with sample. The instrument produces a beep. Status window changes color and notice, as shown in Fig.3. The threshold value of the weight of the sample for inicalization of this step is 3g. Concerning the sample with the weight <3g; The information about insertion and removal of the sample can be supplied to the instrument by pressing hotkeys F5 (insertion) and F6 (removal).These hotkeys must be enabled in the menu „Measuring“ by deselecting the first menu item „Use weight as a start pulse“. If the weight of the sample is very small (very near to 0g), the evaluation of the mass

- susceptibility is not done and the table column „Mass Susc.“ in the „Document“ window is filled with the text „N/A“.
6. When the second beep is produced after a short while, the sample should be removed and placed in a reasonable distance from the coil. Status window changes color and notice, as shown in Fig.3.
 7. Wait until the result is displayed.
 8. If you want to use a different (more accurate) value of the weight, you may enter it into the table manually and the new mass susceptibility is evaluated.
 9. The name and note can be added into appropriate column if needed.
 10. The table in the „Document“ window consists of 12 columns. The white columns are editable, the grey ones are not. If the value in the column „Vol“ is changed the „Vol. Susc.“ value is automatically changed as well. If the value in the column „Weight“ is changed, the „Mass susc.“ value is automatically changed as well. Default value 11148 mm³ is a volume of the cylinder with dimensions (d=25.4 mm, h=22 mm).
 11. It is possible to evaluate the mean value and standard deviation of the group of measured values. It is simply done by selecting the several values in the column. The process of selecting values is the same as selecting in usual in MS Windows. It means that values are selected by left mouse button when the key „shift“ or „ctrl“ are pressed. The result is shown in the right corner of the status bar.
 12. It is also possible to select one or more rows to be deleted.

3.6 Weighting plate

The pick-up coil has homogenous magnetic field in its centre. It means that the measured value changes very little when the sample is moved. Nevertheless it is better to place the sample into the centre of the pick-up coil. There are two types of weighting plates supplied with instrument, see Fig. 5. One plate is for small samples the second one for bigger samples. The changing of the weighting plates is very simple. The protective tube is unscrewed from the top of the instrument and the plate is changed by means of tweezers.

4 Figures

4.1 Figure 1

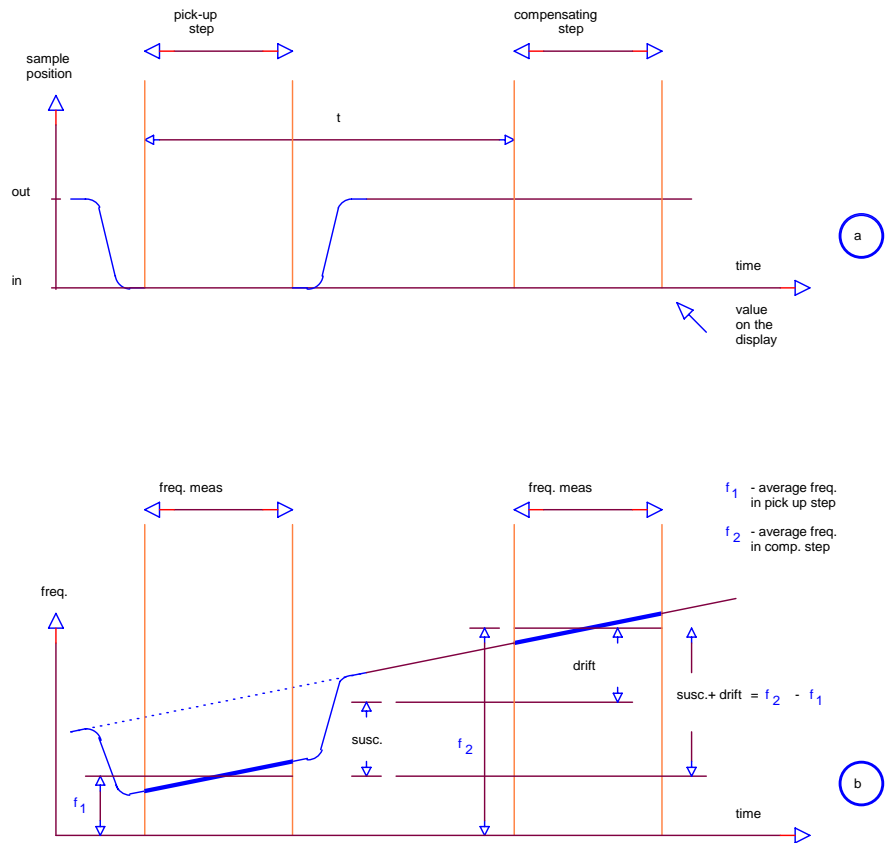


Fig.1

4.2 Figure 2

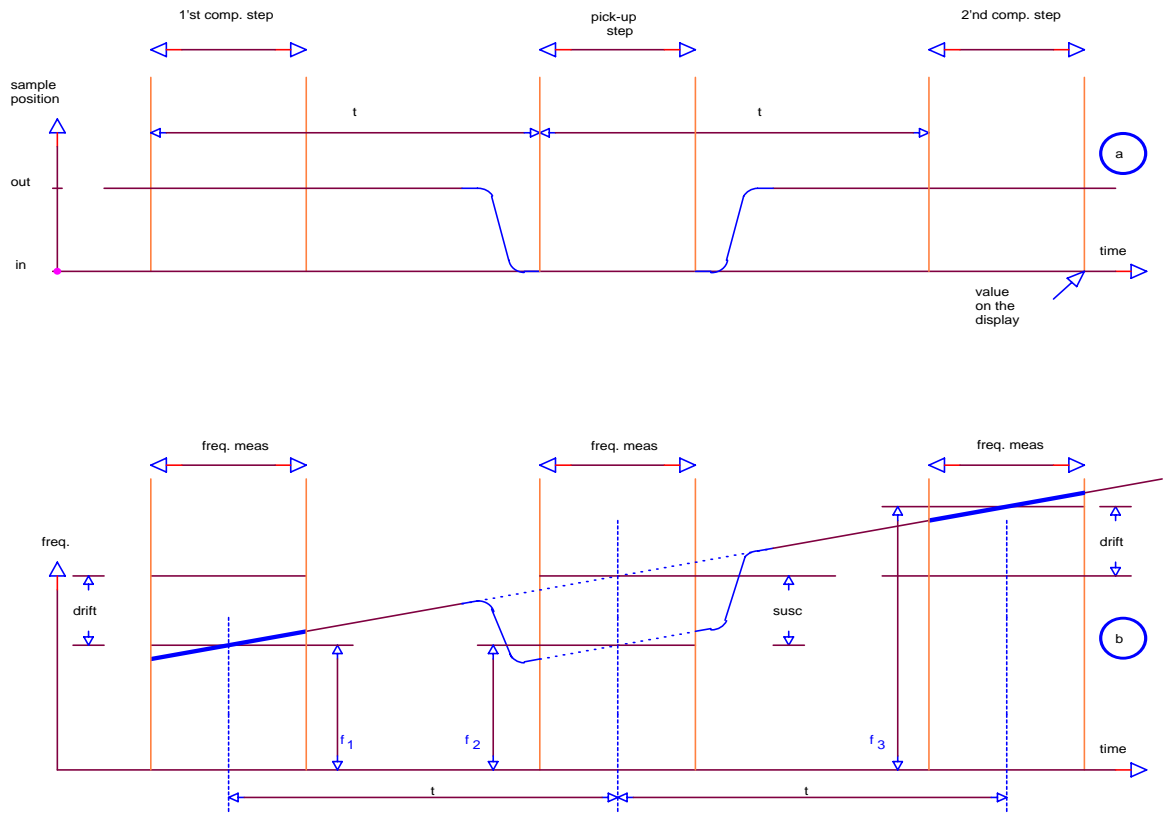


Fig.2

4.3 Figure 3

Color and text of the status window:

green: insert the sample

blue: remove the sample

light red: settling

red: measurement

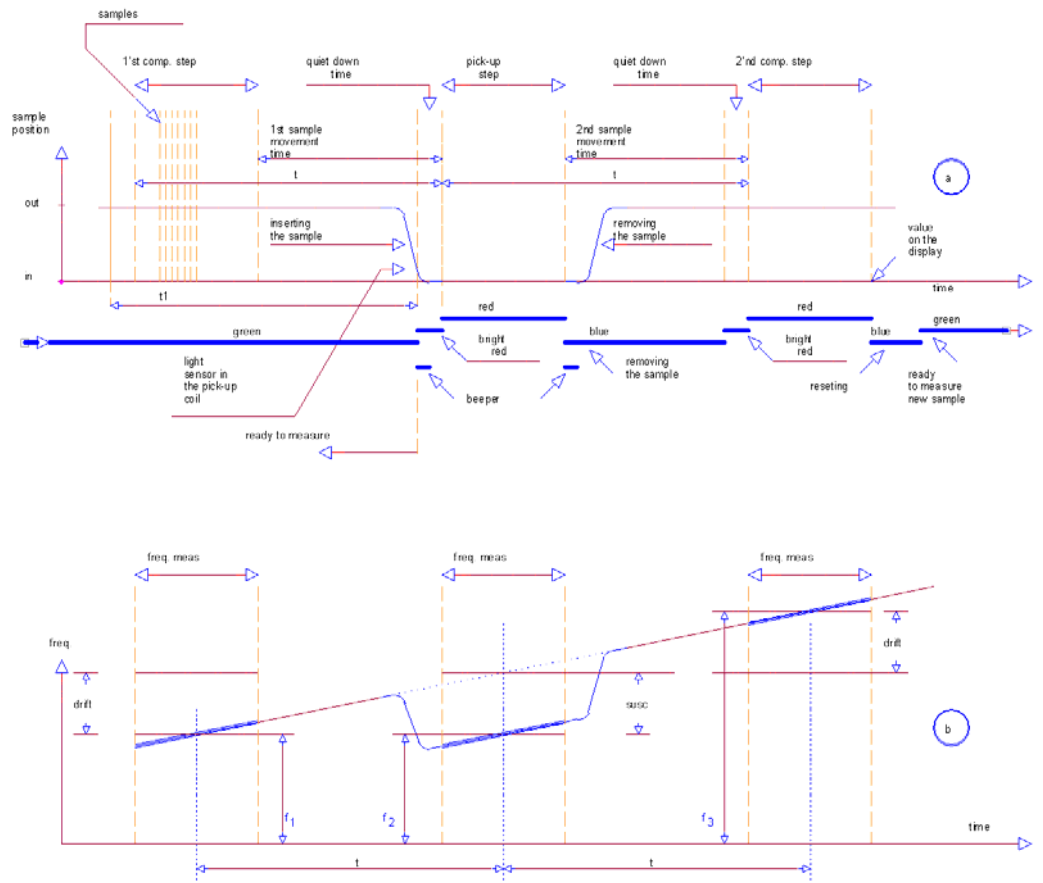


Fig.3

4.4 Figure 4

The screenshot displays the 'Test_for_manual - 5M-100' software interface. At the top, a menu bar includes 'File', 'Edit', 'View', 'Measuring', and 'Help'. Below the menu is a toolbar with various icons. The main area features a data table with the following columns: No., Name, Volume [mm3], Vol. susc [1e-3S], Weight [g], Mass susc. [1e-6 m3/kg], Pot. susc. [1e-3S], User cal., Freq [Hz], Field [A/m], Noise, and Comment.

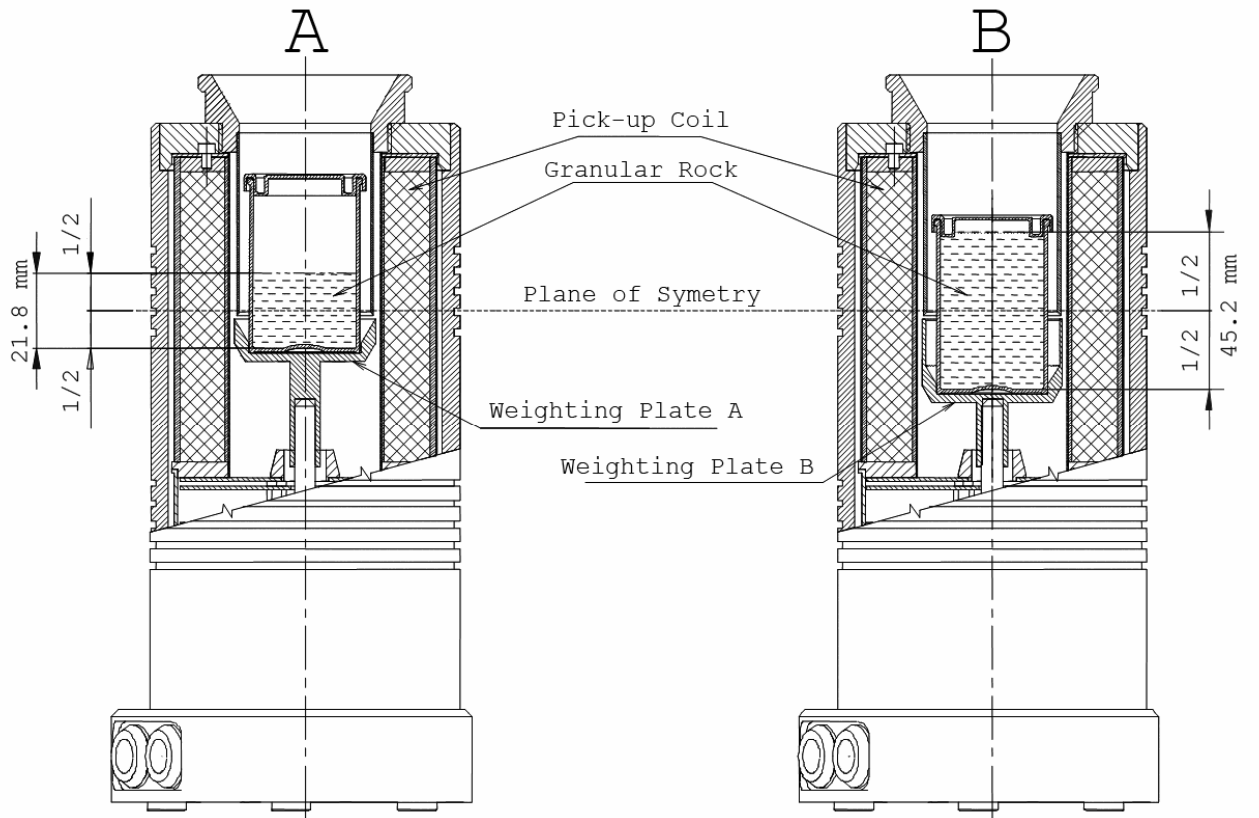
No.	Name	Volume [mm3]	Vol. susc [1e-3S]	Weight [g]	Mass susc. [1e-6 m3/kg]	Pot. susc. [1e-3S]	User cal.	Freq [Hz]	Field [A/m]	Noise	Comment
1	Sample 1	11148	2.114	14.2	1.660		1.0001	8006	320	4.9	Gd203
2	Sample 2	11148	2.110	14.3	1.645		1.0001	8006	320	5.5	Gd203
3	Sample 3	11148	2.111	14.3	1.646		1.0001	8006	320	4.9	Gd203
4	Sample 4	11148	2.111	14.3	1.646		1.0001	8006	320	6.2	Gd203
5	Sample 5	11148	2.112	14.3	1.646		1.0001	8006	320	6.5	Gd203
6	Sample 6	11148	2.110	14.3	1.645		1.0001	8006	320	6.8	Gd203
7	Sample 7	11148	2.111	14.3	1.646		1.0001	8006	320	7.2	Gd203
8	Sample 8	11148	2.114	14.3	1.648		1.0001	8006	320	7.8	Gd203
9	Sample 9	11148	2.110	14.3	1.645		1.0001	8006	320	4.3	Gd203

Below the table, a large window titled 'Measuring control, mass susceptibility * 1e-9 m3/kg' displays the value '1.64'. Below this display are buttons for 'insert the sample', 'Show result as' (with radio buttons for 'mass susceptibility' and 'volume susc.'), and 'Scale: 0.00g | Tara | Sample is out'. It also shows 'Working frequency: 8006.0Hz; Field strength : 320A/m Noise: 15'.

Three smaller dialog boxes are open: 'Scale calibration' (Scale: 0.00g, Calibration value: 50, Cal.koef: 0.99717), 'Kappa calibration' (Working frequency [Hz] - Cal. coef. table), and 'Settings' (Field strength [A/m] and Working frequency [Hz] selection).

At the bottom left, the status is 'Ready'. At the bottom right, it shows 'Mean=2.112; std=0.0021; n=4 | Online'.

4.5 Figure 5



5.APPENDIX

5.2 SM-100 programme for Windows 9x/NT/2000/XP

- Copy the files:
 - sm100w.exe
 - sport.dll
 - cal_fact_SM100-2005-#.xml
 - cal_user_SM100-2005-#.xmlto your hard drive (# means the serial number of the instrument).
- Connect the communication cable to a serial port and power cable.
- Run SM100W.EXE
- Choose serial port where the SM-100 is connected to (COM1, COM2, COM3 or COM4).
- Device information window will appear. If there is everything OK, the window disappears on the other hand, in case of some error, the window stays as is.
- The window named „Measuring control“ is displayed. All important information about actual measuring are displayed in this window.

- note.: If the window is closed it can be displayed again using the menu item: "View->Show meas. window"

- In the table (document window) there are columns named: „No“, „Name“, „Volume“, „Vol. susc.“, „Weight“, „Mass. Susc.“, „Pot susc“, „User cal.“, „Freq“, „Field“, „noise“ and „Comment“. The white columns are editable. The grey columns are for information purpose only.
 - Measured values can be stored into XML file using menu item „File->Save“ or „File->Save As“.
 - Measured values may be loaded back lately by using menu item „File->Open“ or processed by third party applications, e.g. MS Excel.
-
- In the table (document window) there are columns named: „No“, „Name“, „Vol. susc.“, „Weight“, „Mass. Susc.“ and „Comment“. Columns „Name“, „Weight“ and „Comment“ are editable. The columns „Name“ and „Comment“ are for information purpose only.
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