IMKO
MICROMODULTECHNIK GMBH

MANUAL SONO-DIS with SONO-WZ or SONO-M1

Thank you very much for deciding to purchase this IMKO product!

Should you have any questions in regard to this product please contact our local distribution partner or IMKO directly.

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User Manual SONO-WZ with the Hand Measurement Device SONO-DIS

Table of Contents

1 General Notices

Please read the operating instructions carefully.

Should you have any further questions, please contact our service department under the contact data depicted above. In no event should you attempt to open and repair the device yourself. Should you like to file any guarantee claims, please contact the distribution partner where you purchased the device.

Within the scope of product improvements, the device is subject to technical and optical changes.

1.1 Intended Use

This portable measuring instrument was designed to serve as a reading device for various IMKO probes. Only respectively intended probes may be connected to the device. The connection of a probe not intended for connection may lead to the destruction of the device and/or the connected probe.

1.2 The chargeable Accumulator

Never exchange the integrated accumulator yourself.

The stated maximum operating periods refer to ideal conditions. The ambient temperature and the charging cycle can significantly reduce the performance time. In addition, the charging capacity reduces itself for technical reasons within the course of the utilisation of the device or due to storage at very high or low temperatures.

1.3 Charging the SONO-DIS Portable Measuring Instrument

Only deploy the respectively provided charger or a comparable power supply unit to charge the SONO-DIS portable measuring instrument. Any deviation of the charging voltage can lead to damage to the device.

Should the device heat up during the charging process, this is normal and not connected with any hazards.

Should the SONO-DIS only function for a short period or not at all in spite of several attempts to charge it, the integrated accumulator is defective and must be exchanged. In this case, please contact our local distribution partner or us directly.

1.4 Temperatures and Ambient Conditions

The SONO-DIS portable measuring instrument was designed for deployment under rough conditions.

The operation of the device under conditions beyond those depicted may lead to damage to the same.

2 Control Elements of SONO-DIS

With only 4 control keys, SONO-DIS allows an easy handling and well-structured measurement procedure.

„UP“

Back to previous Menu Item or Setting

„Measurement/Activate“

- Shutting ON/OFF- → press 1second
- Perform Measurement → press shortly
- Selection of a Menu Item → press shortly
- Storing a setting → press shortly

„DOWN“

- Go to next Menu Item or Setting
- Deleting the Value Memory

„Settings“

- Conclude Settings by pressing this button longer than 1 second
- Leave Menu Item by short pressing

Attention: For measuring concrete, the standard calibration curve **"Cal. No.4"** is pre-selected inside the SONO-DIS. When switching on the SONO-DIS, the display shows the active calibration curve Cal.No.4. This pre-selection should be changed only if other materials as concrete like ceramic suspension, etc. should be measured.

3 Initial Commissioning

3.1 Safety Instructions

Attention: Before initial commissioning, do not fail to read the General Notices, Item 1 at the front of these operating instructions. Any not intended use may lead to damage to the device.

3.2 Checking the Delivery Scope

- SONO-DIS Portable Measuring Instrument
- Plug-in Power Supply Unit (12V/2A)
- Charging Adapter
- Protective Hood
- Manual

3.3 Charging the Accumulator

The integrated accumulator should be charged before putting the device into operation the first time. For this purpose, plug in the provided charging adapter into the 7-pole socket of the SONO-DIS. Subsequently, connect the plug-in power supply unit to the charging adapter. In the event that the device is already switched on, or if the accumulator is exhaustively discharged, the charging process will commence immediately. If not, switch on the SONO-DIS by pressing the button „Measurement“  for approximately 1 second. An active charging process is signalised in the display by an animated accumulator symbol.

The integrated charging electronics charges the accumulator until the same is completely charged. In case of exhaustive discharge, this will approximately take 2 hours. As soon as the charging process is concluded, all 4 „accumulator bars“ will be permanently presented in the display and the trickle charging will commence.

Attention: **Only charge the accumulator at room temperature (approximately between 10°C and 30°C)! At too low temperatures, it may happen that the charging concluding shut-down does not operate safely and the accumulator is over-charged. Too high ambient temperatures may lead to damage to the SONO-DIS due to the additional heat-up during the charging process.**

3.4 Connecting a Sensor

The SONO-DIS portable measuring instrument can be operated with the IMKO-moisture probe SONO-WZ.

Connect the moisture probe SONO-WZ to the SONO-DIS by plugging in the 7-pole plug into the respectively provided socket at the SONO-DIS and fastening the coupling nut.

4 Operation

Key/Button Designation:

Key/Button	Designation
	**Measurement** • Shutting ON/OFF- → press 1 second • Perform Measurement → press shortly • Selection of a Menu Item → press shortly • Storing a setting → press shortly
	**Settings** • Conclude Settings by pressing longer than 1 second • Leave Menu Item by short pressing
	**UP** • Back to previous Menu Item or Setting • Direct link to “Evaluation”
	**Down** • Go to next Menu Item or Setting • Deleting the Value Memory (Average Value)

Display Symbols:

Symbol	Designation
	Residual Accumulator Capacity
	Active Measurement
	Settings are stored
	Intensity of the Background Illumination
	Remaining time until shut-down (illumination / APO)
	Press button „UP“
	Press button „DOWN“
	Warning symbol: Measurement values lower than 3% are not taken into account. The validity of a measurement value is questioned due to large scattering.

Text Meaning:

Text	Meaning
Density	Raw density of the controlled fresh concrete
Water content	Total water content measurement value
EC_{TRIME}	Electrical conductivity, based on the TDR radar signal. EC_{TRIME} offers an evaluation of the used cement inside the measured concrete sample.
Serial No.:	Serial Number of the probe, respectively of the SONO-DIS
HW:	Hardware Version
FW:	Firmware Version

4.1 Switching ON the SONO-DIS Portable Measuring Instrument

Switch ON the SONO-DIS by pressing the button „Measurement“ for approximately 1 second.

During the starting-up process, the SONO-DIS will attempt to communicate with the connected probe. This will take approximately 4 seconds. If no probe is connected, or the probe is not able to communicate for any reason, an error message will be generated on the display.

If the probe was successfully detected, the accordingly set background of the operation mode will appear on the display and the HD” is ready for deployment.

Notice: Should no connection to the probe be possible in spite of several attempts, check if the probe is connected properly. Should this not deliver a positive result, please contact our service department.

4.2 Switching OFF the SONO-DIS Portable Measuring Instrument

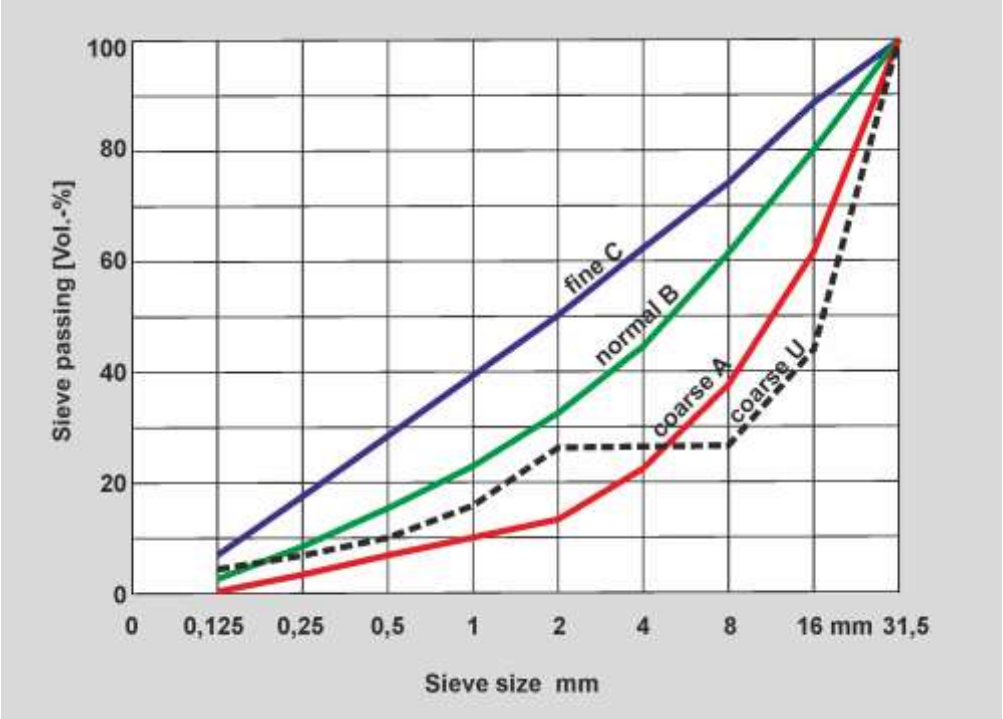
Switch OFF the SONO-DIS by pressing the button „Measurement“ for approximately 1 second.

Notice: It is not possible to shut off the SONO-DIS while it is in a „Setting“ procedure. Please, first leave the menu item „Settings“ by pressing the button „Settings“ until the measurement display appears.

5 Adjustment and Measurement

In order to display the kiln drying water content, it is necessary to preset the system to three parameters: Firstly to the **Density**, the characteristic of the recipe with **CHAR** and thirdly with **G-Set** to the used type of concrete together with the type of rock. For a required accuracy with +-1 to +-3 liter/m^3 it is necessary to adjust once the SONO-WZ with help of these three parameters **Density, CHAR** and **G-Set**.

5.1 The Recipe-Characteristic Parameter CHAR



SONO-WZ shows small dependencies with its radar field at different recipe characteristics. Therefore the system offers 4 different setting possibilities for the parameter **CHAR** with:

fine
normal,
coarse,
special
(gap graded U)

fine C	**normal B**	**coarse A**	**special (gap graded U)**
SONO-WZ measures a little too less and has to correct the water content upwards.	no correction	SONO-WZ measures a little too high and has to correct the water content downwards.	SONO-WZ measures too high and has to correct the water content downwards.
Concretes with lower coarseness factors Concretes with higher sand contents, more fine particles as well as concretes with very high proportion of cement. Standard admixtures like fly ash, standard additives as well as PCEs.	**Well graded sieve curves** Standard admixtures like fly ash, standard additives as well as PCEs.	1. **Concretes with higher coarseness factors** 2. **Well graded B sieve curves with one peculiarity:** Concretes with a set value of water which is lower than 160 Liter/m^3, plus high-performance concrete plasticizer in higher amounts which takes care for the general flowability.	**Gap graded recipes** A gap of little or no smaller gravel with size 4/8mm. Standard admixtures like fly ash, standard additives as well as PCEs.

5.2 The general G-Set parameter

SONO-WZ measures the free water for the hydration of the cement as well as rather **a part** of the maximum core water inside the aggregates with an increased weighting of the core water of sand.
In other words: SONO-WZ “sees” due to the radar field only parts of the core water!

5.2.1 SONO-WZ measures three types of water

Note: In principle SONO-WZ measures the same water like the kiln drying procedure.

1. **Free water** in the concrete mixture, the water which is count for the water/cement ratio (the desired result).

2. **A part of the core water.** Such water is absorbed by the aggregates. Therefore this water must not count for the water/cement ratio!
   SONO-WZ measures only a part of the core water (approx. 1/3). Dependent on type of rock, the core water content can amount from 5 liter to 50 liter per cubic meter. This correction value depends on recipe and rock type and is represented by the parameter **G-Set** (approx. 2/3 of the core water).
   The value of G-Set for the SONO-DIS lies typically at -10 liter (per cubic meter) and these 10 liters are automatically subtracted during measurement, so that the display of SONO-DIS show the effective water value.

3. **Chemical additives** which behave like water are therefore also measured by SONO-WZ, which must be taken into account.

There are types of rock which absorb only a little core water, but also possible are strong absorbing type of rock like sandstone or lime grit which can absorb up to 50 liter of core water.

Therefore it is recommended to adjust once the SONO-WZ to the used recipe with the type of rock or the location of the rock type. (see also chapter “Core water….”)

The precise value for the parameter G-Set which has to be set once inside the SONO-DIS can be controlled or determined in two ways:

A) With comparative concrete measurements of SONO-WZ with correct and known values of water content (perhaps fresh concrete which is mixed with dried aggregates).
B) With comparative concrete measurements of SONO-WZ with correct values of water content, controlled by several kiln dried values.

The effective water content which is count for the water/cement ratio is set up as follows:

Effective water content = kiln water - core water - “water content” of chemical additives

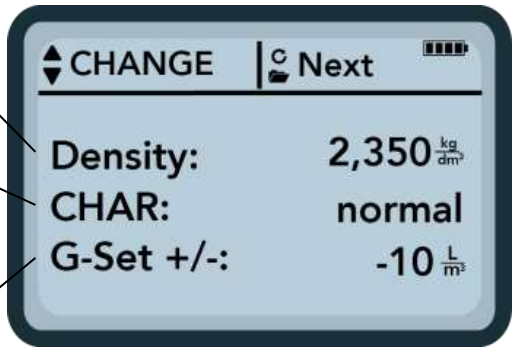
5.3 How to adjust and CHANGE the three base parameters

5.3.1 Adjust the raw density

After entering four parameters, the SONO-DIS can be switched to the measurement mode.

Raw Density, take the value from the vibrating table test, or take the density from the mix computation.

Characteristic of the recipe with **fine** (positive-correction), **coarse** (negative correction), **normal** (no correction) or **special** (gap graded with negative correction).
Note: Primarily the mortar content in the concrete influences the parameter CHAR.



General-Set: Fine adjustment for type of concrete and type of aggregates with different core or core water content. Entering max. +- 50 liter. Typical value is -10 liter/m^3 which is automatically subtracted during measurement, when the effective water content (the active water) is to be measured.

If you want to measure the complete water content (the total kiln drying water content) with SONO-WZ, the G-Set is to be entered with a plus value, with 1/3 of the core water!

As first parameter the raw density can be set in steps of +-0.005. Select the correct density value of the concrete sample with the buttons „+“ or „-“ and confirm it with the button . The SONO-DIS switches back to the CHANGE menu.
Attention: the setting of the correct raw density is important. The raw density influences the measurement of the water content inside the SONO-DIS. The difference of raw density between 2.200 and 2.300 corresponds with 8 liter water. If the raw density of the concrete cannot be determined on site, the input of the set density of the mix computation would be however a possible compromise to achieve acceptable results. A deviation of +-0.02 of the density corresponds with +-1.6 liter water.

5.3.1 Setup of CHAR recipe charasteristic

Select the parameter CHAR with entering parameter **CHAR** with **fine, normal, coarse or special (gap graded U)** with the buttons „+“ or „-“ and confirm it with the button . The SONO-DIS switches back to the CHANGE menu.

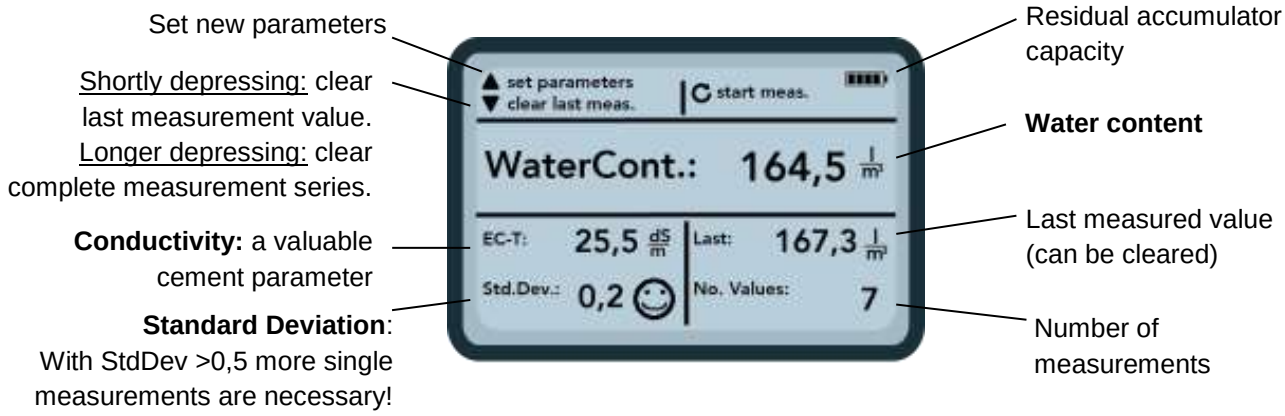
5.4 Setup of general G-Set for type of concrete and rock type with core water

It is necessary to adjust once the SONO-WZ to the used type of concrete and type of rock or the location of the rock type with core or core water.
The indication of the **G-Set** value is made in liter/m^3 and can be entered in steps of +-1 liter. It is recommended to archive founded values for G-Set values for individual rock locations.
Select the parameter “G-Set” and enter the value in + or - liters with the buttons „+“ or „-“ and confirm it with the button . The SONO-DIS switches back to the CHANGE menu.

After adjusting the “Raw density”, the “CHAR” and the “G-Set” and with activating the button you will automatically enter into the measurement mode with the following menu.

5.4.1 Measurement mode „Average“

SONO-DIS generally measures in the „average“ mode and determines the total water content of a fresh concrete sample. The following display will appear in the measurement mode „Average” value after the start screen:



In order to initiate a measurement cycle, shortly press the button “Measurement” . The measurement will commence and a turning -symbol will appear instead of the accumulator-symbol in the upper right hand corner. During this period, no other actions can be performed. The measurement requires approximately 2 to 3 seconds. Once the measurement is concluded, the accumulator-symbol will re-appear and the measured values will be generated on the display. The measured **water content**, calculated via the raw density is displayed. The number of measurements **No. Values** is also displayed.

To achieve a best possible result it is advisable to make several single measurements at different places inside the fresh concrete. With smaller grain sizes, up to 5 single measurements can be enough, **with concrete which tends to bleed, more than 5 single measurements are necessary.** The higher the number of single measurement cycles, the higher the average measurement accuracy!

An information about the quality of the measurement:

The SONO-DIS reflects a statement to the accuracy with displaying the standard deviation **StdDev**. With **StdDev** values of >0.5 the concrete mixture is probably too inhomogeneous, so that it is recommended to make more single measurements. Only after 5 to 6 single measurements and with a standard deviation **StdDev** less than 0.5 the single measurement procedures can be stopped and the final result is correct.

Smileys in the display show the acceptance of the standard deviation. Good (<0,2), acceptable (0,2 ..0,49) or not acceptable (>0,5).

The SONO-DIS is filtering out automatically water content values which are lower as 100 liter. This could happen e.g. if the start button was activated and the probe was not completely inside the fresh concrete.

Such wrong measurement values with <100 are shown with a warning symbol at the place of the single measurement value and will not be used for calculation of the average value!

After finishing of the measurement procedure it is possible with the button UP and DOWN to delete the measurement values or to set a new raw density value.

5.4.2 EC-TRIME - a valuable cement parameter

Shown on the LCD of the SONO-DIS is the determined radar based **E**lectrical **C**onductivity parameter EC_{TRIME}. SONO-WZ determines cement type and cement quantity by using and detecting the electrical attenuation of the radar pulse. At that time this raw value EC_{TRIME} can be used for a preliminary analysis of the cement and the type of cement and allows higher security when testing a standard concrete type which has to be controlled recurrently.

At standard recipes the cement can be recurrently controlled with EC-TRIME.

The following graphic shows possible EC_{TRIME} values at different concrete and cement types. As user of SONO-WZ and for later controls and better verifications it is to recommend and helpful, to document EC_{TRIME} with the respective concrete type. It is to consider that earth moist concretes show lower values for EC_{TRIME}.

Remark: An evaluation of EC-TRIME only makes sense, when recurrently the same type of concrete is controlled by the SONO-WZ.

5.4.3 General Settings

SONO-DIS provides diverse possibilities for different settings. By pressing of **at least 2 seconds** of the button „Settings“ you reach the menu “Settings”. Select the desired function with the buttons „+“ or „-“ and confirm it with the button . Leave the menu item „Settings“ by pressing the button „Settings“ .

An Overview of the setting options

Settings	Designation
Detect Probe	A new search for a connected probe (if an error has occurred during the activation of the device)
Language	Switching the System Language -German -English
Auto-Power-Off	Setting of the automatic shut-down
Display Illumination	Setting of the Background Illumination - Turn-Off-Time - Intensity
LCD-Contrast	Setting of the ideal contrast
Probe Info	Issues various information regarding the probe
SONO-DIS-Info	Issues various information regarding the SONO-DIS portable measuring instrument
Materialcal.	Calibration curve for different materials

5.4.4 Detecting Sensor/Probe

In the event that communication problems arise with the probe at the activation of the SONO-DIS portable measuring instrument, or if the probe was not connected, or it is intended to exchange the probe during operation, this menu item should be selected. After selection of this menu item, the SONO-DIS will again attempt to establish a connection to the connected probe. If this attempt is successful, the serial number of the probe will appear in the display.

Should a connection not be possible, „No probe detected“ will be generated on the display.

Notice: Should no connection to the probe be possible in spite of several attempts, check if the probe is connected properly. Should this not deliver a positive result, please contact our service department.

5.4.5 Language

In this menu item, the language of the SONO-DIS portable measuring instrument can be selected. Currently, the user has the choice between the languages English and German. You can select the desired language by actuating the buttons „Up“ and „Down“ and activate the same via the button „Measurement“ . After activation of the language, the symbol will appear in the upper right hand corner of the display.

5.4.6 Auto-Power-Off

In the menu item „Auto-Power-Off“, you can select an automatic shut-down offered in various time periods.

Hereby, you can select between the following shut-off times:

- 1 Minute
- 2 Minutes
- 5 Minutes
- 10 Minutes
- 20 Minutes

respectively also deactivate the automatic shut-down function (Display „—min“).

For this purpose, select the desired shut down time by actuating the buttons „Up“ and „Down“ and activate the same via the button „Measurement“. After activation, the symbol will appear in the upper right hand corer of the display.

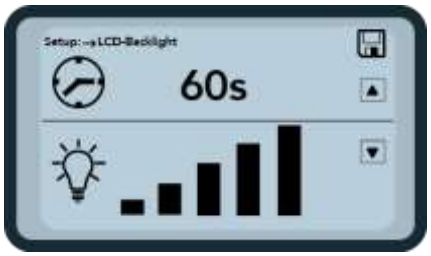
Notice: The SONO-DIS will only automatically shut down, if no further button is actuated. Any actuation of a button will lead to the shut down time to start again.

Attention: For measuring concrete, the standard calibration curve **“Cal. No.4”** is pre-selected inside the SONO-DIS. When switsching on the SONO-DIS, the display shows the active calibration curve Cal.No.4. This pre-selection should be changed only if other materials as concrete should be measured.

5.4.7 Display Illumination

If required, the background illumination of the display can be individually adjusted. Consequently, this enables the option to save power and to prolong the operational period.

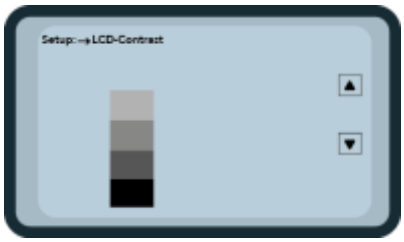
After the selection of the menu entry, the following screen will be presented on the display:



The selection of the background illumination, respectively the time until the automatic shut-down of the same is selected via the button „Up“ by actuating the same several times. Using the button „Down“, you can adjust the intensity of the illumination, respectively turn the same completely off. Activate and store your settings by actuating the button „Measurement“. After activation, the symbol will appear in the upper right hand corner of the display.

5.4.8 Display contrast

At extreme temperatures, it may be necessary to adjust the contrast of the display in order to be able to clearly read the display. For this purpose, select the menu item „Display Contrast“. Change the contrast by actuating the button „Up“ , respectively „Down“ . Activate and store your settings by actuating the button „Measurement“ . After activation, the symbol will appear in the upper right hand corner of the display.



Change the contrast by actuating the button „Up“ , respectively „Down“ . Set the contrast that you can realize the whole grayscale on the diagram. Activate and store your settings by actuating the button „Measurement“ . After activation, the symbol will appear in the upper right hand corner of the display.

5.4.9 Probe Info

By selecting this menu item, after a short moment, you will be issued various information regarding the connected probe. These are:

- Serial Number
- Probe Type
- Hardware Version (HW)
- Firmware Version (FW)

5.4.10 SONO-DIS-Info

By selecting this menu item you will be issued various information regarding your SONO-DIS portable measuring instrument. These are:

- Serial Number
- Hardware Version (HW)
- Firmware Version (FW)
- Accumulator Capacity
- Accumulator Voltage

5.4.11 Material Calibration Curve

By selecting this menu you have the possibility to adjust the probe SONO-WZ to another calibration curve. After switching ON the SONO-DIS, the calibration curve which you have selected in this menu point, is displayed for 3 seconds on the lower section of the screen.

Attention: For measuring concrete, the standard calibration curve **“Cal. No.4”** is pre-selected. This preselection should be changed only if other materials are to be measured. A total of up to 15 different calibration curves can be handled, e.g. for materials like ceramic suspension, sludges and others. Furthermore it is possible to change the sensitivity of the concrete calibration curve **“Cal. No.4”**. For more details please get in contact with IMKO´s service team.

6 Operation with SONO-WZ

SONO-WZ works with state-of-the-art TRIME TDR-method (**T**ime-**D**omain-**R**eflectometry) based on radar technology. Plastic and liquid concretes with slump values >30mm can be easily measured with SONO-WZ. An automatic averaging with 4 to 5 single measurements ensures a procedure with representative material mix on the probes surface. Due to the structured working method with SONO-WZ, precise and reliable results are displayed within few minutes.
By using and detecting the electrical attenuation of the radar pulse it is possible to determine the cement content and allows therefore higher security for testing of a concrete type which must be controlled continually. Guided radar (TDR) technology with very low power of 10mW is also be used in the industrial level measuring.

Please consider: With concretes which do not conform to standards (e.g. tend to bleed), considerable fluctuations of the measuring values can occur. Such concretes are difficult to be measured with SONO-WZ.

6.1 Measured volume of the SONO-WZ probe

The penetration depth of electrical fields ranges theoretically infinite. But the effectively used penetration depth of the SONO-WZ probe amounts about 50mm around the probes surface.

It is to consider that with all dielectric measurement methods like TDR, microwave or capacitive, the electrical field distribution is not linear but exponentially. This means that the intensity of the electromagnetic field is the highest at the probes surface and decreases with more distance. In consequence this means that bigger gravels which lies tightly at the probes surface can influence the measurement field significantly. For that reason a mixer moisture probe inside a mixer has to build enough measurements with filtering procedures to come to an acceptable result.

It has also taken into consideration, like the application in a mixer, that it is necessary with SONO-WZ to build more than one single measurement because one bigger gravel can influence a single measurement. Necessary is a representative material mix at the probes surface with several measurements.

To achieve a best possible result it is advisable to make several single measurements at different places inside the fresh concrete. With smaller grain sizes up to 4 single measurements, with bigger grain sizes more than 4 single measurements are necessary. The higher the number of single measurement cycles, the higher the average measurement accuracy!

Important: Around the probe head of SONO-WZ there should be no metal parts during the measurement procedure, because metal can influence the electrical field. Best and easiest way is to use a plastic bucket filled with fresh concrete. To avoid air gaps the concrete should be compressed by several stamps of the bucket on the ground.

The probes surface must be clean and free of concrete crusts and if necessary the probes surface must be cleaned with a wire brush.

The probe head of the SONO-WZ must be completely immersed inside the fresh concrete during the measurement.

During a measurement cycle it is important that the probe is fully immersed in the fresh concrete without air gaps

Not correctly!	**So it is correctly!**
The measurement field of the probe is **not completely inside the material**	The measurement field is **completely inside the material**

When inserting the probe several times at the same place, there is the danger of segregation effects at this place. By removing the probe out of the fresh concrete, the space will be filled with fine and liquid particles which could lead to higher measurement values.

So it is important not to prick in the probe at the same place for several measurements.

6.2 Measurements of fresh concrete samples in a plastic bucket

It is necessary to perform a measurement of a fresh concrete sample in a plastic bucket because metal parts can influence an electrical field. The bucket should be not too small, minimum should be 5 liters and the height should be large enough.

To avoid segregation, the fresh concrete inside the bucket should be not shakened. After insertion of the probe, the concrete can be compacted only a little by knocking three times to the bucket, so that the concrete lies closed to the probe´s surface at the dark ceramic plate.

We recommend to carry out at least 4 to 5 measurements and take care to prick in the probe at different places at the edge of the bucket, shifted by 70 to 90 deg.

Please note:

1. The probes surface must be clean and free of concrete crusts and if necessary the probes surface must be cleaned with a wire brush.

2. The bucket should be filled minimum 30mm higher with fresh concrete than the probe length (180mm).

3. **The probe head should be placed inside the concrete with a slight angle, at the edge of the bucket.**

6.3 Measurement procedure for concretes with lower or mean slump values (F2, F3, F4)

The probe head should be placed inside the concrete with a slight angle, at the edge of the bucket in position1. Compress the concrete by several knockings at the bucket with the foot, so that there are no air-gaps at the probe´s surface. Start the measurement by pressing the start button. For every new measurement cycle: Remove the SONO-WZ probe, prick in the probe at a different place around the edge of the bucket, shifted by 70 to 90 deg. and perform a further single measurement after compressing by several knockings at the bucket.

Use a standard 10-12 liter plastic bucket. Do not use metal buckets or larger containers, due to correctly compaction!

Never prick twice at the same place in the bucket !

Before starting a series of measurements, it is recommended to make an initial test measurement and thereafter to delete this initial measurement result.

The higher the number of single measurement cycles, the higher the measurement accuracy!

Delete a single measurement value if the deviation is too high from the mean value!

6.4 Measurement procedure for very liquid concretes (F5, F6) with high slump values

1) Fill the bucket with only two third of the volume.

2) Insert the SONO-WZ probe inside the concrete with a slight angle and with the **covered plastic shovel**, at the edge of the bucket in position1. The plastic shovel ensures that larger gravel didn´t “drift away” from the WZ-probe head during measuring.

3) Press the probe tip with the black ceramic window in front side, slowly and diagonally to the opposite side of the bottom of the bucket, so that the handle of the probe lies on the edge of the bucket. This ensures that a representative concrete mixture lies on the probe´s surface. Carry out this procedure several times, whereby the insertion of the probe at the edge of the bucket should be shifted by 70 to 90 degree.

Please consider: Concretes which do not comply with standards can tend to bleed. Such concretes are difficult to measure with SONO-WZ but also with kiln drying test. In such cases it can come to measurement deviations.

Note: When taking such liquid concrete samples for kiln drying, considerable deviations can be occur. There is the danger of segregation effects if the concrete was left in the bucket for a while. When taking samples at the bucket surface, the dried sample could have a considerable too high water content.

After completion of 4-5 measurements:

If, after 4 to 5 cycles the standard deviation **StdDev** value is >0.5, the concrete mixture is probably too inhomogenous. So it is recommended to make more single measurements. Therefore **mix the concrete with a professional stirrer inside the bucket** and place the probe again inside the bucket for performing more measurements. Please consider: If the concrete will be not mixed correctly, there is the danger of segregation and measurement deviations**. But it is also to consider, that the mixing time is not too high**, because water can escape (evaporate) out of an open bucket during mixing.

Non-ideal concrete mixtures have stronger effects concerning measurement deviations. A concrete which does tend to bleed, separates out. The question can then be asked, if it is a problem if SONO-WZ interprets such a concrete with a higher measurement value.

7 First Start-Up with step1 to step5

Important: There should be no metal parts around the probe head of SONO-WZ during the measurement procedure, because metal can influence the electrical field. Best and easiest way is to use a plastic bucket filled with fresh concrete. To avoid air gaps the concrete should be compressed by several stamps of the bucket on the ground. The probes surface must be clean and free of concrete crusts and if necessary the probes surface must be cleaned with a wire brush. During measurement the probe head of the SONO-WZ must be completely immersed inside the fresh concrete.

To achieve a best possible result it is advisable to make several single measurements at different places inside the fresh concrete, because smaller and bigger gravels are influencing a single measurement physically near the probes surface. With smaller grain sizes up to 5 single measurements, with bigger grain sizes more than 5 single measurements are necessary. **The higher the number of single measurement cycles, the higher is the measurement accuracy!**

The SONO-DIS reflects a statement to the accuracy with a precise determination of the standard deviation **StdDev**. With **StdDev** values of >0.5 the concrete mixture is probably too inhomogenous, so that it is recommended to make more single measurements. Only after 5 to 6 single measurements and with a standard deviation **StdDev** smaller than 0.5 the single measurement procedures can be stopped and the values can be adopted into the result. The operation with the SONO-DIS with single buttons, probe connection, charger, etc. is described in detail in the manual. In the following Step1 to Step6 only particular actions are illustrated with the associated LCD display contents and the SONO-DIS keyboard.

Preliminary remark**: In order to display the total water content, it is necessary to preset the system with two parameters: Firstly to the characteristic of the recipe with CHAR and secondly to the used type of rock with G-Set. For a required accuracy with +-1 to +-3 liter/m^3 it is necessary to adjust once the SONO-WZ with help of the parameters Density, CHAR and G-Set.**

SONO-WZ shows small dependencies with its radar field at different recipe characteristics. Therefore the system offers 4 different setting possibilities for the parameter **CHAR** with “fine, coarse, normal special”. The parameter **CHAR** have to be entered into the hand measurement device SONO-DIS:

SONO-WZ measures the “free” water inside the fresh concrete as well as rather a part of the core water inside the aggregates with an increased weighting of the core water of sand. There are types of rock which absorb only little core water, but also strong absorbing type of rock like sandstone or lime grit which can absorb up to 50 liter of core water. **Therefore it is necessary to adjust once the SONO-WZ to the used recipe with the type of rock or the location of the rock type.**

In order for the SONO-DIS to display the total water content, it is necessary to find once a value for the parameter “G-Set” “General Offset” (see also chapter “Core moisture”).

The precise value for the parameter G-Set which has to be set inside the SONO-DIS can be controlled or determined in two ways:

A) With comparative concrete measurements of SONO-WZ with correct values of water content (e.g. fresh concrete which is mixed with dried aggregates).

B) With comparative concrete measurements of SONO-WZ with correct values of water content, controlled by several kiln dried values.

Step1: Switch-On the SONO-DIS

By activating the button for longer than one second, the SONO-DIS starts with the measure mode.

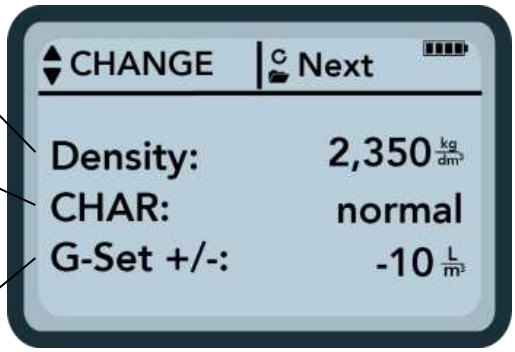
Note: By repeated longer activating of this button in the measure mode, the SONO-DIS is switched off. After 10 minutes (can be configured!) without activity, the SONO-DIS switches off automatically.

Step2: Adjust the Raw Density, CHAR-parameter and G-Set

After entering the three parameters, the SONO-DIS can be switched to the measurement mode.

Raw Density, take the value from the vibrating table test, or take the density from the mix computation.

Characteristic of the recipe with **fine** (positive-correction), **coarse** (negative correction), **normal** (no correction) or **special** (gap graded with negative correction).
Note: Primarily the mortar content in the concrete influences the parameter CHAR.



General-Set: Fine adjustment for type of concrete and type of aggregates with different core or core water content. Entering max. +- 50 liter. Typical value is -10 liter/m^3 which is automatically subtracted during measurement, when the effective water content (the active water) is to be measured.

If you want to measure the complete water content (the total kiln drying water content) with SONO-WZ, the G-Set is to be entered with a plus value, with 1/3 of the core water!

As first parameter the raw density can be set in steps of +-0.005. Select the correct density value of the concrete sample with the buttons „+“ or „-“ and confirm it with the button . The SONO-DIS switches back to the CHANGE menu.

Attention: the setting of the correct raw density is important. The raw density influences the measurement of the water content inside the SONO-DIS. The difference of a raw density between 2,200 and 2,300 corresponds with 8 liter water.

If the raw density of the concrete cannot be determined on site, the input of the set density of the mix computation would be however a possible compromise to achieve acceptable results. A difference of the density of +-0.02 corresponds with +-1.6 liter water.

After adjusting the **Raw density**, the **CHAR** parameter and the **G-Set** and with activating the button , you will automatically enter into the measurement mode with the following menu.

Step3: Insert the probe SONO-WZ in the fresh concrete and start the measurement

Please consider the two different procedures for the SONO-WZ for placing the probe inside the bucket, as described in the “Instruction Sheet”.

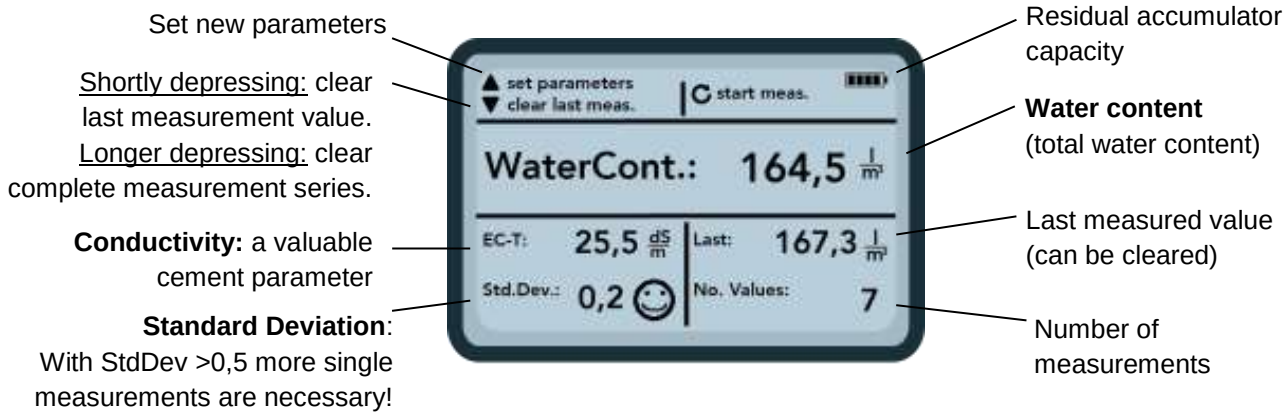
The probe head should be placed inside the concrete with a slight angle, at the edge of the bucket.

For stiffer concretes: Compress the concrete by several knockings at the bucket with the foot. Start the measurement by pressing the start button.

For very liquid concretes: Use the **covered plastic shovel.** Press the probe tip with the black ceramic window in front side, slowly and diagonally to the opposite side of the bottom of the bucket, so that the probe lies diagonally in the bucket with the handle of the probe on the edge of the bucket. This ensures that a representative concrete mixture lies on the probes surface. Start the measurement by pressing the start button.

In order to initiate a measurement cycle, shortly press the button “Measurement” .

SONO-DIS generally measures in the „average“ mode and determines the water content of a fresh concrete sample. The following display will appear in the measurement mode „Average” value after the start screen:



The measurement will commence and a turning -symbol will appear instead of the accumulator-symbol in the upper right hand corner. During this period, no other actions can be performed. The measurement requires approximately 2 to 3 seconds. Once the measurement is concluded, the accumulator-symbol will reappear and the measured values will be generated on the display. The measured **total water content**, calculated via the raw density is displayed. The number of measured values is also displayed.

To achieve a best possible result it is advisable to make several single measurements at different places inside the fresh concrete. With smaller grain sizes, up to 5 single measurements can be enough, **with concrete which tends to bleed, more than 5 single measurements are necessary.** The higher the number of single measurement cycles, the higher the average measurement accuracy!

An information about the quality of the measurement:

The SONO-DIS reflects a statement to the accuracy with displaying the standard deviation **StdDev**. With **StdDev** values of >0.5 the concrete mixture is probably too inhomogeneous, so that it is recommended to make more single measurements. Only after 5 to 6 single measurements and with a standard deviation **StdDev** less than 0.5 the single measurement procedures can be stopped and the final result is correct.

Smileys in the display show the acceptance of the standard deviation. Good (<0,2), acceptable (0,2 ..0,49) or not acceptable (>0,5).

The SONO-DIS is filtering out automatically water content values which are lower as 100 liter. This could happen e.g. if the start button was activated and the probe was not completely inside the fresh concrete.

Such wrong measurement values with <100 are shown with a warning symbol at the place of the single measurement value and will not be used for calculation of the average value!

After finishing of the measurement procedure it is possible with the button Up and DOWN to deleted the measurement values or to set a new raw density value.

Step4: Start next single measurement cycle

Place the lance probe SONO-WZ again inside the fresh concrete, at another place shifted by 70 to 90 deg. It is necessary to come to a good material mix around the probes surface (similar to a mixer probe inside a mixer) because smaller or bigger grain sizes are influencing the measurement field. By pressing again the button the next single measurement cycle starts which needs again 2 to 3 seconds. The new measurement value is displayed above the former value and is stored in the SONO-DIS. An average value of first and second value is done and the average value is displayed on the LCD.

Step5: Start further single measurement cycles (back to Step4)

Re-process as described under Step4. Particular mention should be made that a higher number of measurements leads to a higher representativity and accuracy. With smaller grain sizes, up to 5 single measurement cycles can be enough, **with concrete which tends to bleed, more than 5 single measurements are necessary.** If the standard deviation **StdDev** value is >0.5 after 4 to 5 cycles, the concrete mixture is probably too inhomogenous. So it is recommended to make more single measurements. Therefore **mix the concrete with a professional stirrer inside the bucket** and place the probe again inside the bucket for performing more measurements. Please consider: If the concrete will be not mixed, there is the danger of segregation and measurement deviations.

7.1 To the topic "core water"

SONO-WZ measures the free water content inside the fresh concrete as well as rather **parts of the core water** (approx. 1/3) inside the aggregates with an increased weighting of the core water of sand. In other words: SONO-WZ sees only parts of the core water inside the rock. There are types of rock which absorb little core water, but also strong absorbing types of rock like sandstone or lime grit is possible which can absorb core water up to 50 liter per m^3.

Therefore it is recommended to adjust once the SONO-WZ to the used recipe with the type of rock or the location of the rock type.

If SONO-WZ is to measure the effective (active) water content:

If a rock has e.g. 15 liters of core water, then SONO-WZ sees only 1/3 of it. That is, the **G-Set** must then be entered with the remaining 2/3 **as a negative value** in order to measure the effective (active) water content, here G-Set = -10 liters/m^3 if the core water is typically 15 liters/m^3.

If SONO-WZ is to measure the complete water content (the total kiln drying water content):

In this case, then the G-Set must be entered with a third **of the positive value** of the core water.
Here G-Set = +5 liters/m^3 if the core water is typically 15 liters/m^3.

The precise value for the parameter G-Set which has to be set inside the SONO-DIS can be controlled or determined in two ways:

A) With comparative concrete measurements of SONO-WZ with correct and known values of water content (perhaps fresh concrete which is mixed with dried aggregates).
B) With comparative concrete measurements of SONO-WZ with correct values of water content, controlled by several kiln dried values.

The kiln dried water content is set up as follows:

Kiln water content = effective water + core water + "water content" of chemical additives

Relevant core water value for the kiln drying calculation:

An example: A porouse lime grit with 2% core moisture can absorb 34 liter core water at 1m^3 aggregate fraction. With a bulk density for the lime grit of 1700kg/m^3 the basis for the calculation is:

2% * 1700kg/100 = 34 liter core water per cubic meter concrete

Relevant core water value for setting the G-Set inside the SONO-DIS:

With a maximum core water content of e.g. 34 liter for a porous lime grit, a value for the **G-Set** of about -23 liter can be calculated for entering into the SONO-DIS if you want to measure the effective (active) water content. The precise value for the parameter G-Set which has to be set once inside the SONO-DIS should be controlled or determined with some reliable comparative measurement values.

7.2 To the topic “kiln drying” as comparative value

First it is to mention that correct kiln drying is expert work. A kiln moisture measurement result by weighing of a sample would be falsified if free water would be bonded in cement due to a too long kiln drying time. Therefore kiln drying of fresh concrete must be performed very quickly, in order to prevent that free water in the mixture can be bonded to the cement.

Hereinafter a list of possible problems and influences when kiln-drying:

1. By use of gas oven kilns, care must be taken that no amounts of solids are blown away in the air during drying, because this could result in a too high moisture value. Sometimes the fresh concrete sample will be stired during drying, sometimes it lies still and accordingly it comes to different results. When not-stiring there is the danger that the water will be bounded chemically inside the cement, due to a too long drying time. Such bounded water cannot escape, even at highest temperatures.
2. By drying with microwave ovens the drying time should be noted depending on the electrical power of the microwave oven (e.g. 700Watt to 1000Watt). Furthermore care must be taken that the quantity of the fresh concrete sample (e.g. 2 to 3kg) is not too less or too high. With the same fresh concrete sample, deviations in ranges of +-3 to +-10 liters/m^3 are not unusual when drying with gas ovens or microwave ovens.
3. When taking concrete samples for kiln drying, considerable deviations can be occur. There is the danger of segregation effects if the concrete was left in the bucket for a while. When taking samples of very liquid concretes at the bucket surface, the dried sample could have a considerably too high water content.
4. When weighing very hot dried samples, the weighing result could be influenced considerably due to lift forces of vertical hot air streams. When weighing a 4kg weight, dependent on weighing cell, the difference could be 30 grams forced by the hot air stream. These 30 grams at 4kg weight corresponds to a moisture error of 0.75%. In worst case, the 0.75% moisture in turn corresponds to **an error of +17 liter water per cubic meter** !
5. Most chemical additives have the same behavior as water (equivalent to the kiln drying procedure). The amount of chemical additives have to be subtracted from the measured value by the SONO-DIS for coming to the correct water content for the cement paste matrix and to the correct water/cement ratio.
6. Chemical additives can bound water so quickly, that it is possible that the water doesn´t completely get out during the kiln drying.

More certainty is given when mixing a reference concrete by using absolute dry sand and dry gravel with the precise knowledge of the addition of mixing water. Nevertheless care must be taken, that a too long mixing time of small samples could lead to an escape of water. E.g.: one minute mixing time of small samples can lead to an error (loss) of up to 5 liter water/m^3.

A 32mm gravel shows how important it is to take representative samples for kiln drying. This gravel represents a water content of 5.3 Liter/m^3 with a small sample quantity of 1,5kg for microwave oven drying. With a higher sample quantity of 5kg for gas oven drying, this gravel still represents still a water content of 1.5 Liter/m^3. Dependent on drying method, one gravel more or less can lead to significant errors.

For comparative kiln drying tests we recommend to use the **“Form Construction Site Test”** in the Annex.

7.3 Measurement of earth-moist concrete

Stiff concretes with slump values <30mm **cannot** be measured with the SONO-WZ by hand. They have air gaps and it is not possible to compress such concretes precise by hand.

In Preparation:

For this application IMKO is planning a measurement procedure with a subsequent addition of water into the earth moist concrete inside a 10 liter bucket. The subsequent addition of water is used to get from a stiff concrete to concrete with a fluid consistency. After measuring the water content of the concrete with fluid consistency, the water content of the earth-moist concrete can be recalculated by mathematics. More information on request!

7.4 Pittfalls in the Laboratory

7.4.1 Pittfall1: Problems with subsequent adding of water into the concrete

IMKO has been pointed out frequently to a diverging laboratory test which runs as follows:

1. About 8 Liter fresh concrete were measured in a bucket with SONO-WZ with a measurement result of e.g. 178 Liter/m^3 water.
2. Later +50 gram water was added to the fresh concrete inside the bucket, which sould have been an increasing of the water content from 178 Liter/m^3 to 184.25 Liter/m^3. After mixing during one minute of the concrete in a small mixer, the concrete was tested for slump and raw density. The tested concrete was than refilled in the bucket for measuring the water content with SONO-WZ.
3. The measurement result with SONO-WZ shows only 181 Liter/m^3 instead of the expected 184.25 Liter/m^3.

So what happened?

During mixing concrete in a small and open mixer, water escapes because the water adheres on extensive surfaces and evaporates quickly. With further test of slump and raw density, there are additional extensive surfaces where water and fine particles adheres.
It is possible to control this error-effect with a simple test: After a first SONO-WZ measurement of e.g. 178 Liter/m^3 water, the concrete can be mixed for about a further minute. Afterwards a measurement with SONO-WZ shows a decreasing of the water content (a deviation) with about 3 Liter/m^3 water. This decreasing is an indicator for this evaporation effect.

An afterward mixing of concrete will result in significant measurement deviations!

7.4.2 Pitfall2: Problems with completely dried aggregates

When using dry aggregates in the lab, it is necessary, to wait a certain delay before controlling the water content with SONO-WZ. A dry rock needs time for saturating. The time for saturation of the rock is dependent on the type of rock. Perhaps 5 to 10 minutes delay time can be necessary dependent on type of rock. E.g. the measured water content of SONO-WZ can start with 185 liter/m^3 and can be reduced to 180 liter/m^3 with a delay time of 10 minutes after mixing of the concrete with absorbent aggregates.

When using dry aggregates in the lab, it is necessary to wait a certain delay before controlling the water content of the fresh concrete with SONO-WZ.

7.4.3 Pittfall3: Sampling in the concrete plant

Due to a short mixing time in a twin-shaft mixer and before filling and further mixing in a truck mixer, a concrete sample was drawn directly from the twin-shaft mixer into a bucket. The concrete sample with a normally distributed sieve line and a water nominal value of 170 liters/m^3 was measured using the SONO-WZ and the result was 170 liters/m^3. Then a concrete sample quantity of 5 kg was dried in a kiln dryer. Here the calculated value was 149 liters, that is, there was a difference of -21 liters to the SONO-WZ measured value with 170 liters/m^3.

What happened here?

Mixing in the twin-shaft mixer without repeated continuous mixing in the mixing machine resulted in a large number of large gravels in the first sampling. These large gravels have led to a considerable error in the sampling, there were simply too many large gravels in the sample, which pulled the value downwards to 149 liters/m^3 (gravels have no water content). The cement paste, which was therefore high, led to the deviation from the SONO-WZ to the dried value. It is, of course, a question of whether this was a disadvantage, since in this case the cement paste had a too high water content (this would not have been a good concrete).

The following table will again illustrate the influence of large garvels during sampling:

	Influence of the water content of the gravels during sampling	**Recipe A with relatively high fine content and little 16/32mm gravel content**	**Recipe B with a gap grading recipe, little 4/8mm and high 16/32mm gravel content**
 **Concrete sample of 1,5 kg**	**+-2 große Kiesel verursachen einen Fehler von +-9 Liter/m^3**	 **approx. 5 pieces 16/32mm gravels**	 **approx. 15 pieces 16/32mm gravels**
 **Concrete sample of 5,0 kg**	**+-2 große Kiesel verursachen einen Fehler von +-3 Liter/m^3**	 **approx. 16 pieces 16/32mm gravels**	 **approx. 100 pieces 16/32mm gravels**

One must take into account that a single 16/32mm gravel weighs between 10 to 50g. If one assumes an average of 20 g per gravel, the procedure of sampling is much more important than it seems at the first moment!

8 Recipe Handling and Archiving

With the adjustment of the parameters **Density**, **CHAR** (fine, coarse, normal, special), as well as the **G-Set**, it can probably be guaranteed to come to a good conformity with actual values concerning the water content in fresh concrete.

With repeated use of different concrete recipes and for obtaining the best possible result in accuracy, we recommend to archive the required settings **of Density**, **CHAR,** and **G-Set** together with the type or variety of concrete.

Following example table shows the possibility with the archiving of **CHAR, Largest Gravel Size** and **G-Set**:

Type or Variety of Concrete	Nominal Raw Density (in kg/dm^3)	Parameter CHAR	Parameter G-Set
F600TL	2.422	coarse	-10
AAV2	2.441	normal	-5
163802	2.330	normal	-7
3716CL	2.367	fine	-12

9 Form “Construction Site Test”

Date:	**Construction Site:**	**Concrete type: (C20/25…):**
Nominal raw density according recipe:	**Nominal water content according recipe:**	
Cement type and quantity in kg: **e.g. CEMI, CEMII, CEMIII,** **CEM IV etc. 32,5 350kg**	**Admixtures like fly ash in kg:**	**Chemical additives in liter:**
Amount of aggregates in kg or %: **Sand Gravel 1 Gravel 2 Gravel 3**		**Core moisture (water in liter/m^3):**

Kiln drying water content and further information:

Kiln drying method (micro-wave, gas oven):	**Kiln water content by oven drying in l/m^3 inclusive core moisture:**	**Kiln quantity in kg:**	**Kiln drying time:**

Setted values inside the SONO-DIS:

Raw densitiy in kg/dm^3:	**CHAR-Parameter (fine, coarse, normal or special):**	**G-Set, fine adjustment for type of concrete and rock type with core water:**

Determined values of the SONO-DIS:

Total Water content in l/m^3	**StdDev Standard deviation:**
EC-TRIME in dS/m:	**Number of values:**
Radar time tp (with longer pressing of the button ▲, the radar time in Picoseconds is displayed.	**Please fill out completely!**

10 Technical Data

10.1 Technical Data SONO-DIS

Height			36mm
Width			64mm
Length			150mm
Power Consumption	Power Down		ca. 35µA
	Idle - Background Illum. OFF - Background Illum. Max	ca. 26mA ca. 56mA	Idle - Background Illum. OFF - Background Illum. Max
	Probe turned ON		a. 100mA
	Measurement		ca. 350mA
Measurement per Charge	20°C / Background Illum. Max Mode – Continuous Measurement		ca. 5000
Connectable Sensors			SONO-WZ
Storage Temperature			-30°C up to 80°C
Operating Temperature			-20°C up to 70°C
Charging Temperature			10°C up to 30°C
Charging Voltage			Nom. 12V, Max. 15V, Min. 12V
Charging Current			ca. 1A
Charging Time			At exhaustively discharged accumulator. 2h
Accumulator			Ni-MH (4 x 1.2V) (AA), 2000mAh, >1000 Measurements
Physical BUS			RS485
Bus-Protocol			IMP-BUS-Protocol II
IMP-Bus Port Settings			8 Data Bits, 2 Stop Bits, Odd Parity

10.2 Technical data SONO-WZ probe

Power supply:	7V..24V-DC
Power consumption:	100mA @ 12V/DC during 2..3sec. of measuring
Water content measuring range:	Up to 0..100% moisture content
Repeated accuracy:	±2 liter /m^3
Absolute accuracy:	±3% from the total quantity of water
Conductivity range:	0..50dS/m
Range for water/cement ratio	from 0.4 to >1
Measuring volume:	0,5 Liter
Operating temperature:	0°C...50°C
Calibration:	Universal calibration for fresh concrete
Probe body:	Stainless steel and ceramic, sealed to IP68
Size:	155 x 60mm
Interface:	1,5m cable with 7-pin female connector

11 Sand Moisture Probe SONO-M1

Manual SONO-DIS with SONO-M1

Please note: the SONO-DIS has the same function as the handheld measuring device HD2 from IMKO for measuring sand moisture. The word **"HD2"** can be shown in the display of the SONO-DIS as well as in this manual, but the word “HD2” is valid here for the SONO-DIS.

11.1 Putting SONO-M1 into Operation

Connect the moisture probe SONO-M1 to the SONO-DIS by plugging in the 7-pole plug into the respectively provided socket at the SONO-DIS and fastening the coupling nut. SONO-DIS automatically detects that the sand moisture probe SONO-M1 is connected.

Text Meaning:

Text	Meaning
Cal.:	Number of the active calibration in the probe
Moist.:	Moisture Measurement Value Notice: Depending on the set calibration, the measurement value may refer to %vol, %grav, ε or tp
Temp.:	Temperature
EC-Trime:	Electrical Conductivity based on the TDR signal
Serialno.:	Serial Number of the probe, respectively of the SONO-DIS
HW:	Hardware Version
FW:	Firmware Version

11.2 Measurement

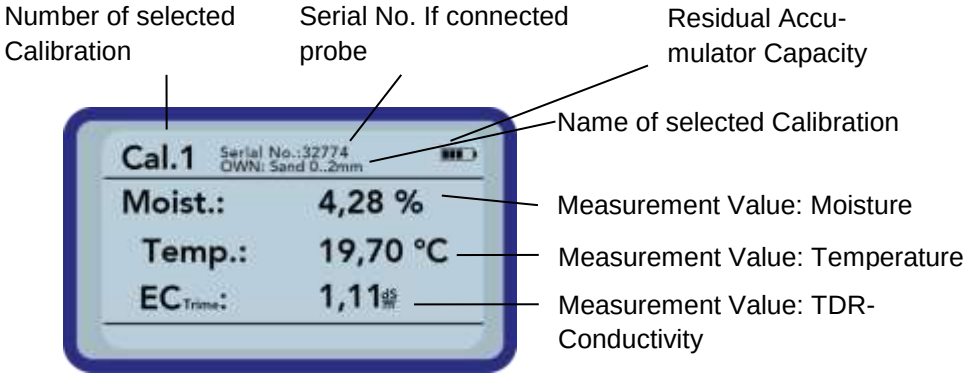
The SONO-DIS portable measuring instrument disposes of three operating modes:

1. Normal → Individual Value Display – presents the measurement variables Moisture, Temperature and the EC-Trime
2. Average Value → presents the average value of the moisture of up to 6 individual measurements
3. Water calculation → determine the content of water in l/m³

Notice: During a measurement, no further actions are possible. It is necessary to wait until the measurement is concluded.

11.2.1 Operating Mode „Normal“

After switching on the SONO-DIS portable measuring instrument, the following display will appear in the operating mode „Normal“ after the start screen:

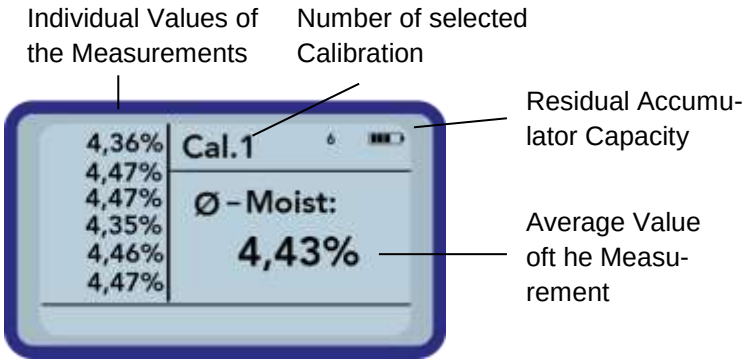


In order to initiate a measurement, shortly press the button “Measurement” . The measurement will commence and a turning -symbol will appear instead of the accumulator-symbol in the upper right hand corner. During this period, no other actions can be performed. The measurement requires approximately 4 to 5 seconds. Once the measurement is concluded, the accumulator-symbol will reappear and the measured values will be generated on the display. The display of the values will be maintained until a new measurement is conducted.

11.2.2 Operating Mode „Average Value“

In this operating mode, only the moisture is measured and an average value of up to 6 individual values is evaluated. Depending on the set calibration, either the volumetric or the gravimetric moisture is presented.

After switching on the SONO-DIS portable measuring instrument, the following display will appear in the operating mode „Average value“ after the start screen:

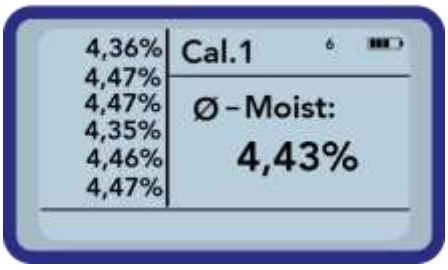


In order to initiate a measurement, shortly press the button “Measurement” . The measurement will commence and a turning -symbol will appear instead of the accumulator-symbol in the upper right hand corner. During this period, no other actions can be performed. The measurement requires approximately 4 to 5 seconds. Once the measurement is concluded, the accumulator-symbol will reappear. On the left hand side of the display, the individual values of the measurements will be presented. The currently measured value is presented at Position 1 and old values will be shifted one position onwards. The arithmetic average value is displayed on the right hand side. The average value is calculated out of the existing individual values up to a number of 6 values.

Notice: Only a maximum of 6 values can be stored in the list. Older values are removed from the list and are no longer involved in the formation of the average value.

In order to delete the measurement series, actuate the button „Down“ .

TIPP:

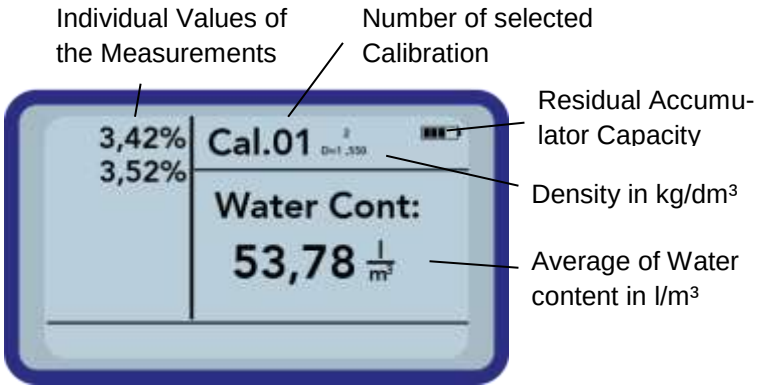


Within the operating mode “Average Value”, the HD2 will deliver a representative measurement result of all measured locations that represents significant volume of the material.

11.2.3 Operating Mode „Water Calculation“

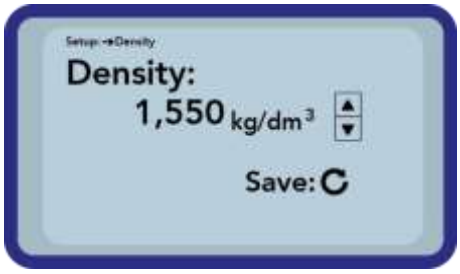
In this operating mode, only the variable Moisture is measured. There will be up to six single values stored and concluded to an average value. Out of this the water content per m³ is calculated. To get the correct water contend it is necessary to set up the density of the measured material.

The continuous measurement is initiated by actuating the button „Measurement“. The same is concluded by actuating the button „Measurement“ once more. The currently pending measurement is performed completely once more and the sequence is concluded.



In order to delete the measurement series, actuate the button „Down“.

To set up the density of your material, actuate the button „Up“. Then you will get the following screen in the display:



Adjust the density of your material by actuating the buttons „Up“ and „Down“. Confirm your setting by pressing the button “Measurement”. You will then automatic get back to the measurement screen. Leave the setting without changing the density by pressing the button „Settings“.

11.3 Settings

There are various options to modify and align the settings of the SONO-DIS portable measuring instrument. You will reach the following menu configuration by actuating the button „Settings“:

By actuating the buttons „Up“ and „Down“, the entry intended for processing can be marked and subsequently be selected with the button “Measurement”. You can exit the current menu item, and also the menu “Settings”, with the button “Settings”.

An Overview of the Setting Options:

Settings (German/English)	**Designation**
SONO-DIS-Mode (is the same as HD2 Mode)	Switching the Operating Mode - „Normal“ → measurement of the variables Moisture, Temperature, and EC-Trime - „Average Value“ → determination of the average value of up 6 individual moisture measurement values - „Water Calculation“ → Calculates the content of water of the material in l/m³
Material calibration	Choosing or change the needed Material Calibration
Detect Probe	A new search for a connected probe (if an error has occurred during the activation of the device)
Language	Switching the System Language -German -English
Auto-Power-Off	Setting of the automatic shut-down
Display Illumination	Setting of the Background Illumination - Turn-Off-Time - Intensity
LCD-Contrast	Setting of the ideal contrast
Probe Info	Issues various information regarding the probe
SONO-DIS-Info	Issues various information regarding the SONO-DIS portable measuring instrument

11.3.1 SONO-DIS-Mode

In this menu item, the operating mode of the SONO-DIS portable measuring instrument can be changed.

With the selection „Normal“, an individual measurement of the three probe parameters Moisture, Temperature and the EC-Trime is selected.

The parameter Moisture, depending on the selected calibration, the moisture in volumetric or gravimetric percentages or can state the running period of the TDR pulse. In case of the display of the running period, the percent-symbol must be understood as „ns“.

When selecting “Average Value”, depending on the selected calibration, only the moisture in %vol or %grav, respectively the running period in ns, is determined. The measured value is stored in a list of up to 6 measurement values. The arithmetic average is formed out of this list.

Notice: Only a maximum of 6 values can be stored in the list. Older values are removed from the list and are no longer involved in the formation of the average value.

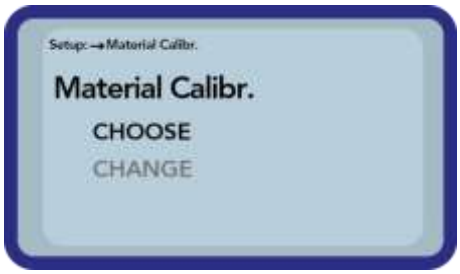
The selection “Water Calculation” will switch on the mode getting the contend of water in l/m³ of the measured material. To get the measurement value of a bigger volume, you can probe on different places of your material. The single values will summed up in one average value.

By actuating the buttons „Up“  and „Down“  , the entry intended for processing can be marked and subsequently be selected with the button “Measurement”  . After the selection, the symbol  will appear in the upper right hand display corner which indicates that the selection is activated and has been stored.

11.3.2 Material Calibration

Depending on the task of the deployment, various calibrations are deposited in the probe. These can be volumetric calibrations for grounds of various densities, gravimetric calibrations for the measurement of sand moisture contents, or also running period calibrations.

You can select the calibration required for your application within the menu item „Material Calibration“. This enables to cover a multitude of deployment options with merely one probe. Also it is possible to setup your own calibration, to get the possibility to measure special materials.



After the selection of the menu item „Material Calibration“, you have to choose between “CHOOSE”, to save one out of fifteen calibration as default calibration, or “CHANGE”, to setup a new calibration in one of the fifteen calibration storages

Menu item: “CHOOSE”:

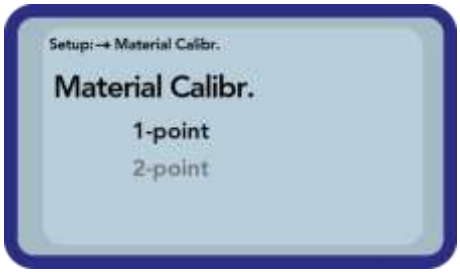
The 15 calibration options are called up by name which requires a short moment of time. Subsequently a display in a similar form as follows will be generated:

The list can be scrolled and the wanted calibration be selected by actuating the buttons „Up“ and „Down“. The “!“ in front of a calibration indicates the currently active one. You can set the selected calibration to become the active one by actuating the button „Measurement“. After a short moment, the symbol will appear in the upper right hand display corner to indicate that the selection has been activated. In addition, the „!“ will be placed in front of the now active calibration.

HINT: Get to this menu item directly out of the measurement screen, by actuating the button „Up“ .

Menu item: “CHANGE”:

Here you’ve got the possibility to setup your own material calibration or to change an existing one to your requirement. Therefor two options are available:



1-point calibration:

- Shifts a calibration curve to a choosen moisture point.
- The gradient isn’t changed.
- Only one measurement is necessary.

2-point calibration

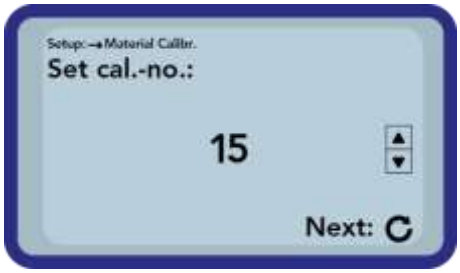
- Creates a linear calibration between two measured moisture points
- Two material samples with differnet moisture values are nedded.

<u>1-point Calibration:</u>

In this material calibration option only an offset of the appointed calibration is done. As there is no changing of the gradient proceeded, it is necessary to choose a calibration curve that fits to the material.

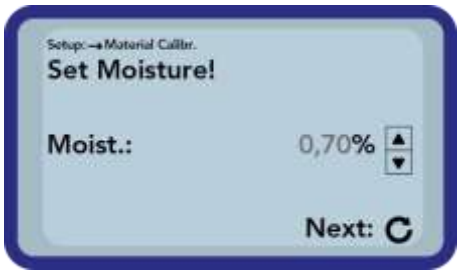
Notice: To perform a 1-point material calibration you need a sample of the material to be measured. You have to determine the moisture of this material with another process before starting the calibration.

Procedure:



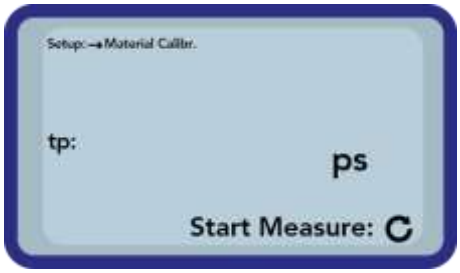
First you have to set the calibration curve to be changed (01 – 15) by pressing the buttons „Up“ ▲ and „Down“ ▼.

Apply your setting by actuating the button „Measurement“ C.



Next set the moisture oft the material by pressing the buttons „Up“ ▲ and „Down“ ▼.

Apply your setting by actuating the button „Measurement“ C.



To start the measurement push the button „Measurement“ C. To increase the accuracy four measurements take place. The whole time of measurement is about 20 seconds. Afterwards the measured average impulse duration is shown for a short moment.

Notice: Ensure that the probe rods are totaly covered with the material the whole time of measuring.

Attention: If you choose “SAVE” at the end of calibration, the stored calibration inside the probe is overwritten! The only possibility to get back the original calibrations is to connect the probe with a RS485 adapter (for example SM-USB) to the PC. Also you need the software PICO-Config.

Finally you can store the calibration into the choosen calibration storage inside the probe. Choose „SAVE“ an confirm by pressing the button „Measurement“ C. If you choose “DISCARD” everything is left untouched.

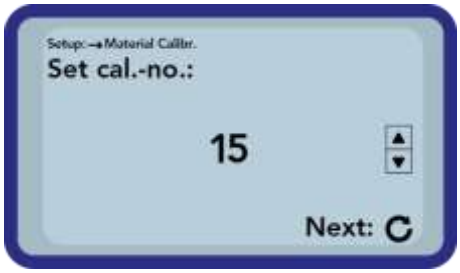
To track the changed calibration, ist name is left untouched, but a „OWN:“ is prefixed.

2-point Calibration:

At the 2-point material calibration, two material samples with different moisture values are measured. Out of this a linear equation (f(x) = mx + b) is calculated. Also a higher polynomial would give a higher accuracy, the linear equation produces very good results especially in lower moisture values.

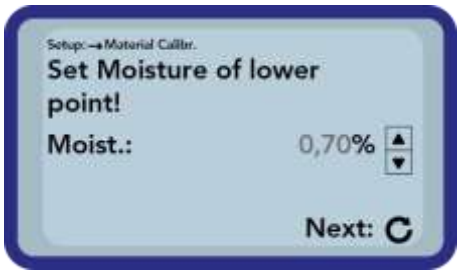
Notice: To perform a 2-point material calibration you need two material samples with different moisture values. You have to determine the moisture of these materials with another process before starting the calibration. The sequence, first the lower moisture point and second the higher moisture point must be strictly adhered.

Procedure:



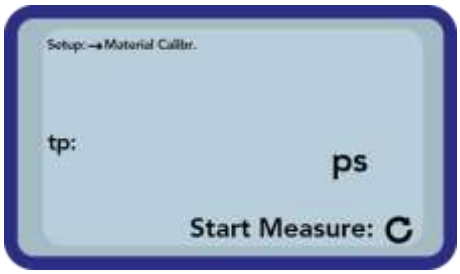
First you have to set the calibration curve to be changed (01 – 15) by pressing the buttons „Up“ ▲ and „Down“ ▼.

Apply your setting by actuating the button „Measurement“ C.



Next set the moisture oft the lower moisture point by pressing the buttons „Up“ ▲ and „Down“ ▼.

Apply your setting by actuating the button „Measurement“ C.

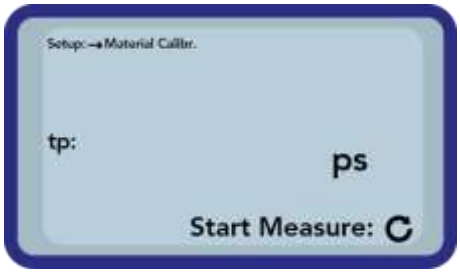


To start the measurement push the button „Measurement“ C. To increase the accuracy four measurements take place. The whole time of measurement is about 20 seconds. Afterwards the measured average impulse duration is shown for a short moment.

Notice: Ensure that the probe rods are totaly covered with the material the whole time of measuring.

Next set the moisture oft the higher moisture point by pressing the buttons „Up“ ▲ and „Down“ ▼.

Apply your setting by actuating the button „Measurement“ C.



To start the measurement push the button „Measurement“ C. To increase the accuracy four measurements take place. The whole time of measurement is about 20 seconds. Afterwards the measured average impulse duration is shown for a short moment.

Notice: Ensure that the probe rods are totaly covered with the material the whole time of measuring..

Attention: If you choose “SAVE” at the end of calibration, the stored calibration inside the probe is overwritten! The only possibility to get back the original calibrations is to connect the probe with a RS485 adapter (for example SM-USB) to the PC. Also you need the software PICO-CONFIG.

Finally you can store the calibration into the choosen calibration storage inside the probe. Choose „SAVE“ an confirm by pressing the button „Measurement“ . If you choose “DISCARD” everything is left untouched.

To track the changed calibration, ist name is left untouched, but a „OWN:“ is prefixed.

Hint: Save your calibrations which are stored inside the probe to your PC. All you need is a RS485 adapter (such as SM-USB) and the software PICO-Config. Hereby you can also copy the calibrations created by yourself to other probes.

11.3.3 Detecting Sensor/Probe

In the event that that communication problems arise with the probe at the activation of the SONO-DIS portable measuring instrument, or if no probe was connected, or it is intended to exchange the probe during operation, this menu item should be selected. After selection of this menu item, the SONO-DIS will again attempt to establish a connection to the connected probe. If this attempt is successful, the serial number of the probe will appear in the display.

Should a connection not be possible, „No probe detected“ will be generated on the display.

Notice: Should no connection to the probe be possible in spite of several attempts, check if the probe is connected properly. Should this not deliver a positive result, please contact our service department.

12 Handling of the SONO-M1 and SONO-M1 Probe

12.1 Introduction

The determination of the soil moisture content with the Time Domain Reflectometry (TDR) technology has in the mean time managed to well-establish itself on the market. In former times, the reliable measurement of the moisture was laborious and not always accurate. Since the development of the TRIME-TDR technology, there no longer any reason to rely on complicated and inaccurate technologies.

12.2 Measurement Volume of the SONO-M1 Probe

The penetration depth of the electrical and magnetic flux lines in theory reach indefinitely far into the measured material. However, the effective penetration depth of the SONO-M1 probes relevant for the measurement is approximately 2 cm in the vicinity of the probe rods. The illustration demonstrates the effectively registered measurement volume (green waveform).

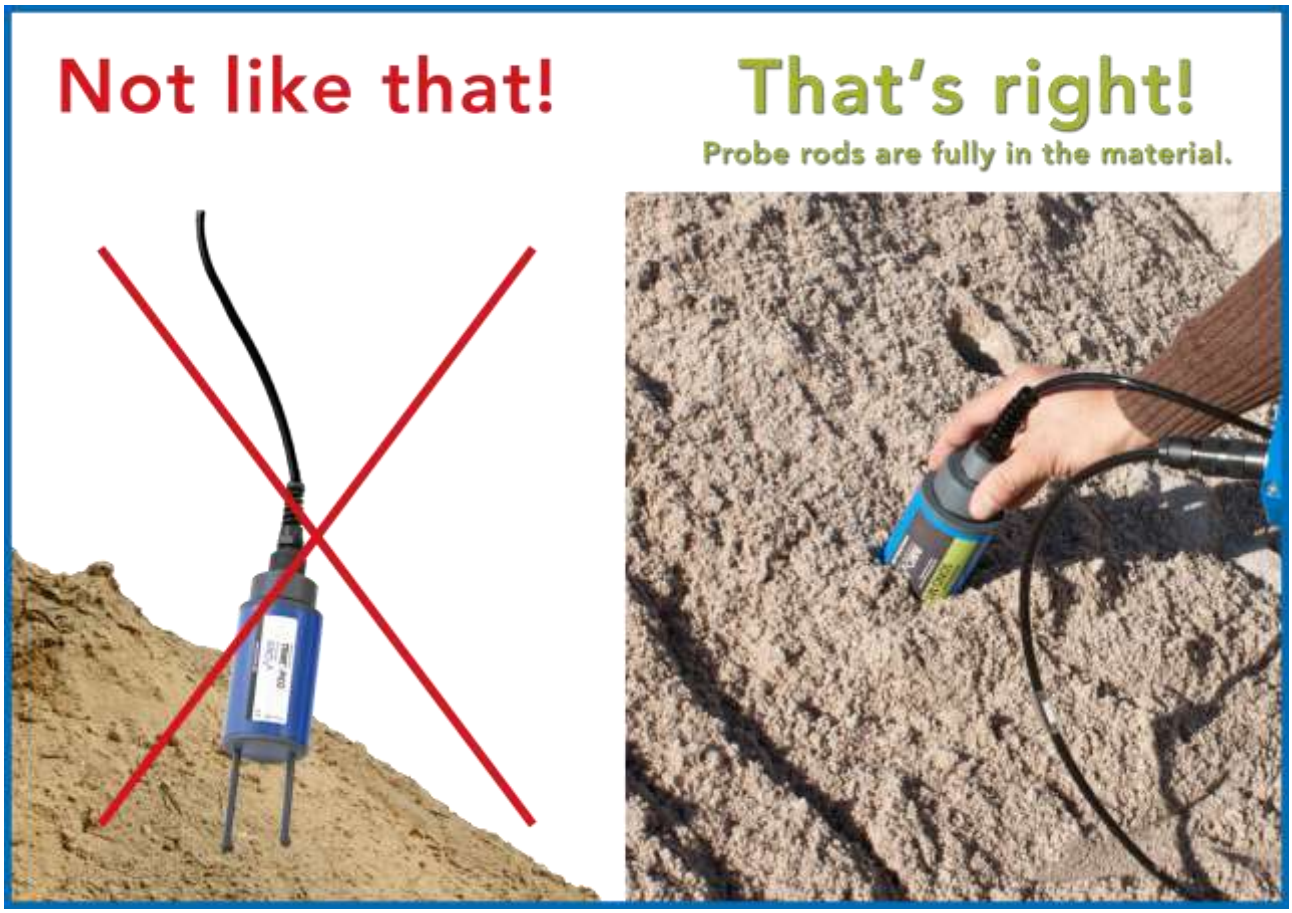
13 Recommended way to achieve the best possible accuracy with the SONO-DIS kit

13.1 Measurement directly in the sand and gravel pile

For measurements in sand pile, make sure that the probe (rods) is inserted in the material until the blue probe body. To obtain a representative moisture value of your material, select the operating mode "Average Value" and take measurements at different locations.

Bitte beachten Sie dabei, dass Ihr Material bei langer Trockenheit oberflächlich trockener ist, als in tieferen Schichten. Hat es zum Beispiel nach längerer Trockenheit geregnet, ist das Material nun an der Oberfläche feuchter. Um das beste Messergebnis zu erhalten Messen Sie am besten an unterschiedlichen Stellen und in unterschiedlichen Tiefen.

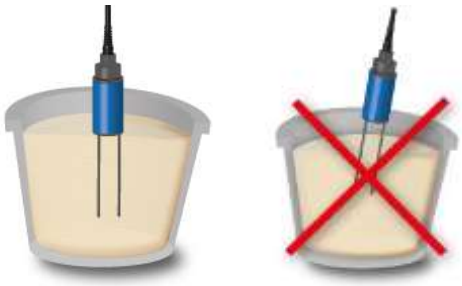
Please note that after drought your material is dryer at the surface, as in deeper layers. For example: Did it rain after prolonged drought the material is now more wet on surface as in deeper layers. To get the best results measuring in different places and at different depths.



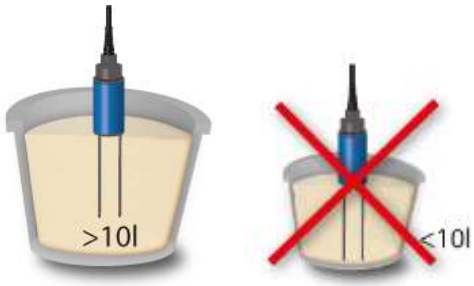
13.2 Measurement of laboratory samples in the bucket

Following requirements has to be fulfilled, to ensure the optimal accuracy of the system:

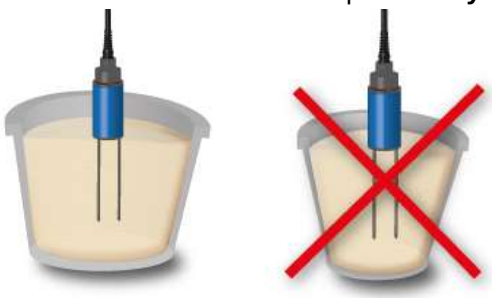
- The probe rods has to be covered **completely** by the material to be measured



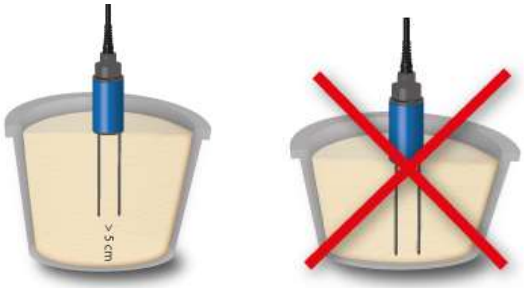
- The bucket has to have a volume of **10 liters or more** and has to be **non-metal**



- The bucket should be as far as possible **cylindrical**



- The **filling depth** of the bucket has to exceed the rod length **by minimum 5cm**



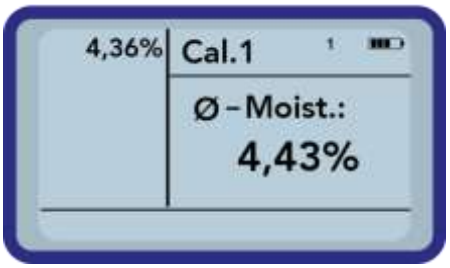
Are the above described requirements fulfilled and the measurements are executed as described below the optimal measurement results can be reached

1. Dump the sand sample into the bucket

2. Compact the sand sample by lifting the bucket 5cm and letting it fall down vertically onto a solid base and repeat this procedure 5 times **(if there is still to see a compaction after 5-times repeat this procedure until there is no more compaction to see!)**

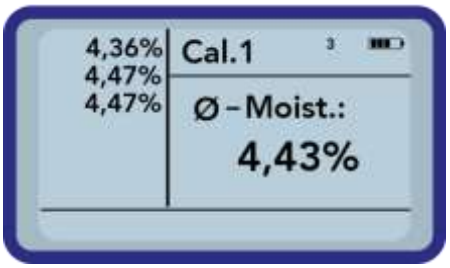
3. Insert the probe rods into the sand sample completely, if the probe body reaches the surface of the sand and press until you feel counter pressure of the sand **(neither jiggle nor rotate the probe while inserting!)**
    a. **For gravel and grit also compact the material before inserting the probe, additionally jiggle the bucket while inserting the rods, as the sensor is difficult to insert without, additionally this helps to ensure, that the material is in well contact with the probe rods!)**

4. Measure once with the SONO-DIS handheld device



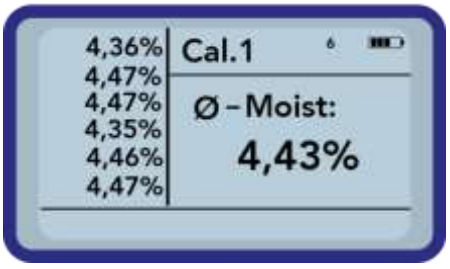
5. Remove the probe out of the material and jiggle the bucket to loosen up the material

6. Repeat the steps 2. to 4. Twice until you have determined three values



7. Dump the sand sample into another bucket, the measure the sample from the bottom side **(this is especially recommended for gravel and grit and if the sand sample is close to saturation, as in this case it could be possible that the free water is moving through the material to the bottom of the bucket!)**

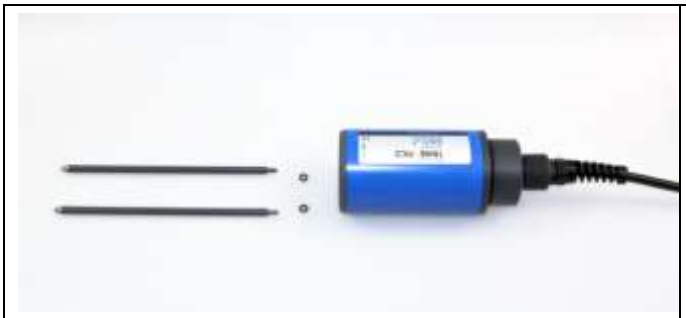
8. Repeat the steps 2. to 4. three more times until you have determined six values



9. The average value out of the six measurements now can be used for your documentation

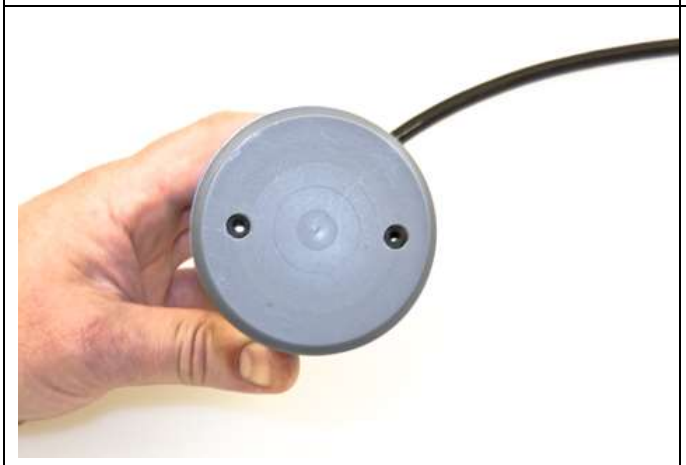
14 Exchange of the Probe Rods

In the event that the probe rods are damaged, the same can be easily exchanged.



1) Prepare the gaskets, the probe body, and the probe rods

2) Press the gaskets into the bore holes



3) Press the gaskets until they reach the interior thread

4) Screw the rods into the probe body

15 Technical Data SONO-M1 probe

For measurement of the moisture content in sand, and gravel

- State-of-the-art sensor with integrated TDR-electronics
- Measurement Value Range 0..40 vol.%
- Integrated Temperature Sensor
- Deployable up to more than 5dS/m Total Conductivity (Bulk-Soil-Conductivity).
- Measurement Volume ≙ 1000ml
- Robust (IP68), proven, and suited for long-term installation

Power supply:	7V..24V-DC
Power consumption:	100mA @ 12V/DC during 2..3sec. of measuring
Moisture measuring range:	0..100% volumetric water content
Accuracy (in % volumetric water content):	±0.2%
conductivity range:	0..5dS/m
Repeating accuracy:	±0.3%
Temperature caused drift of electronics (full range):	±0.3%
Material temperature measuring range:	-15°C...50°C
Material temperature measuring accuracy:	±0,5°C (permanent installed, complete in the Material)
Measurement volume:	1,0L ≅ 130x100mm diameter
Operating Temperature:	-15°C...50°C
Calibration:	Calibration for sand and gravel is installed
	customizable material specific calibration storage of up to 15 user defined calibration curves calibration of dialectric permittivity is possible
Probe body:	waterproof sealed PVC (IP68)
Size:	155 x Ø63mm
Rod lenght:	standard: 130mm
Rod diameter:	6mm
Interface:	1,5m cable with 7-pin female connector

16 Savety Notes

In this documentation, text points are highlighted, which require special attention.

DANGER:
The Warning Triangle with the exclamation mark warns you against personal injury or property damage.

Intended Use
Sensors and measuring systems of IMKO GmbH may only be used for the purpose described, taking into account the technical data. Misuse **and use of the e**quipment other than for its intended purpose **are not eligible.** The function and operational safety of a sensor or measuring system can only be guaranteed if the general safety precautions, national regulations and the special safety instructions in this operating manual are observed during use.
The moisture sensors and measuring systems of IMKO GmbH are used to measure moisture according to the measuring purpose and measuring range defined and defined in the technical data. Only adherence to the instructions described in the manual is regarded as intended use. The manual describes the connection, use and maintenance of IMKO sensors and IMKO measuring systems. Read the manual before connecting and operating a sensor or measuring system. The manual is part of the product and must be kept close to the sensor or measuring system.

Impairment of safety
The sensor or the measuring system has been designed and tested in accordance with EN 61010 safety regulations for electronic measuring instruments and has left the factory in a safe and safe condition. If the sensor or the measuring system can no longer be operated safely, it must be put out of operation and secured by means of marking before further commissioning. In case of doubt, the sensor or the measuring system must be sent to the manufacturer or his contractual partner for repair or maintenance.

Modifications
For safety reasons, it is not permitted to carry out any modifications or modifications to the sensor or the measuring system without the consent of the manufacturer. The opening of the sensor or hand-held meter, adjustment and repair work, as well as all maintenance work other than the work described in the manual may only be carried out by a specialist authorized by IMKO. The sensor or the measuring system must be disconnected from the power supply before installation or maintenance work. Do not open or repair the hand-held unit and the power supply!

Hazard Warnings
Danger due to improper operation. The sensor or the measuring system may only be operated by instructed personnel. The operating personnel must have read and understood the operating instructions.

Danger by electricity
The hand-held meter must not be immersed in water or other liquids. The sensor is insensitive to moisture contained in the typically measured products. Only connect the hand-held meter to a properly installed outlet with the supplied voltage supply cable, the voltage of which corresponds to the technical data. Make sure that the power outlet is well accessible, so that you can unplug the power supply quickly if necessary. Use only the adapter that is suitable for your outlet.

Only operate the meter with the supplied original accessories. If you need additional accessories or replacement, please contact the manufacturer.
Do not use the meter in following case:
- if the measuring instrument, sensor, plug-in power supply or accessories are damaged,
- the sensor or the measuring system does not operate as intended,
- the power cord or plug is damaged,
- the sensor or the measuring system has fallen down.

Unplug the power supply from the wall outlet in following case:
- if you do not use the sensor or the measuring system for an extended period of time,
- before cleaning, unpacking or changing the sensor or the measuring system,
- if you are working inside the sensor or measuring instrument, e.g. connect devices,
- if a fault occurs during operation,
- during thunderstorms.

Caution - Property damage
Ensure that there is a sufficient distance to strong heat sources such as heating plates, heating pipes. Disconnect the sensor or handheld device from other devices before relocating or transporting it. Disconnect the connectors on the device.

Do not use aggressive chemical cleaning agents, scouring agents, hard sponges or the like.

Precise Moisture Measurement

in industry, hydrology, forestry, agriculture, environmental and earth science, civil engineering, as well as individual applications!