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Operating Instructions
Solitrend MMP20 (Option D)

Material moisture measurement

Endress+Hauser
People for Process Automation

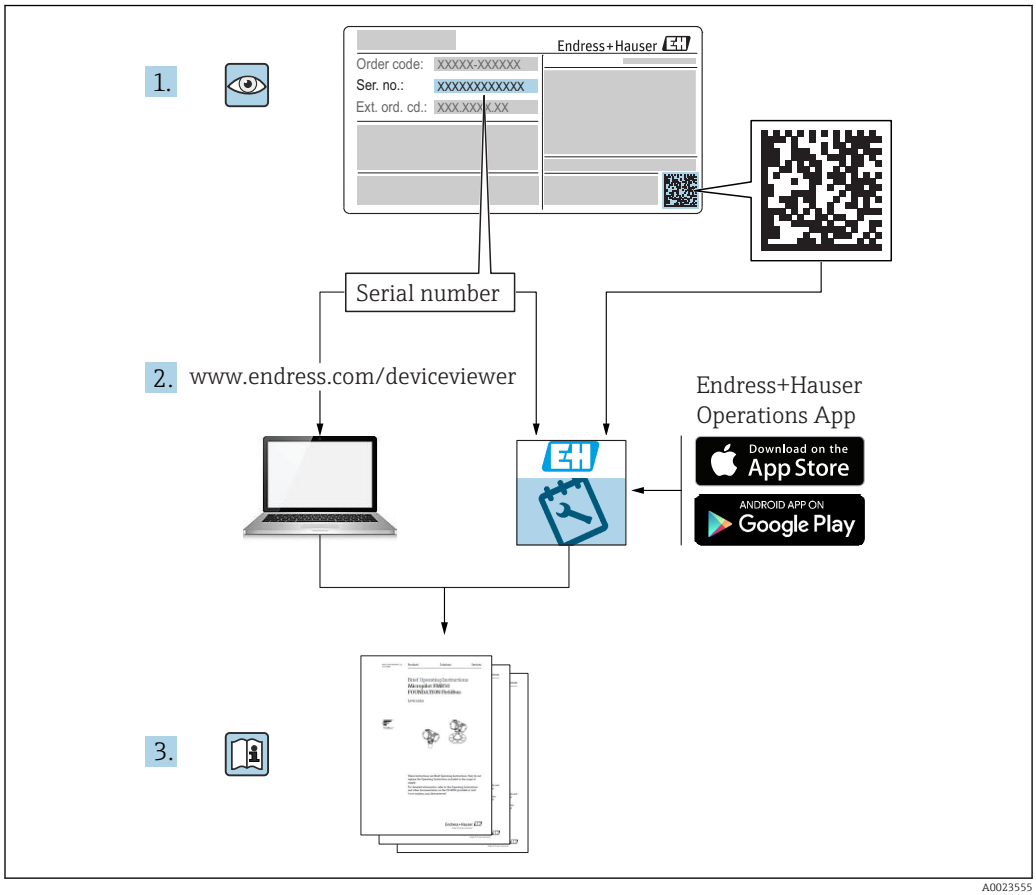

1.
Endress+Hauser
Order code: XXXXX-XXXXXX
Ser. no.: XXXXXXXXXXX
Ext. ord. cd.: XXX XXX XXX
Serial number
2. www.endress.com/deviceviewer
Endress+Hauser
Operations App
Download on the App Store
ANDROID APP ON Google Play
3.
A0023555

Table of contents

1 About this document

1.1 Document function

These Operating Instructions provide all of the information that is required in various phases of the life cycle of the device including:
- Product identification
- Incoming acceptance
- Storage
- Installation
- Connection
- Operation
- Commissioning
- Troubleshooting
- Maintenance
- Disposal

1.2 Symbols used

1.2.1 Safety symbols

⚠ DANGER
This symbol alerts you to a dangerous situation. Failure to avoid this situation will result in serious or fatal injury.

⚠ WARNING
This symbol alerts you to a dangerous situation. Failure to avoid this situation can result in serious or fatal injury.

⚠ CAUTION
This symbol alerts you to a dangerous situation. Failure to avoid this situation can result in minor or medium injury.

NOTICE
This symbol contains information on procedures and other facts which do not result in personal injury.

1.2.2 Symbols for certain types of information and graphics

✓
Permitted
Procedures, processes or actions that are permitted

✗
Forbidden
Procedures, processes or actions that are forbidden

ℹ
Tip
Indicates additional information

Reference to graphic

▶
Notice or individual step to be observed

1., 2., 3.
Series of steps

↳
Result of a step

1, 2, 3, ...
Item numbers

A, B, C, ...
Views

1.3 Terms and abbreviations

BA
Document type "Operating Instructions"

TI
Document type "Technical Information"

SD
Document type "Special Documentation"

TDR
Time Domain Reflectometry

HW
Hardware version

FW
Firmware version

1.4 Documentation

The following documentation types are available in the Downloads section of the Endress +Hauser website (www.endress.com/downloads):

For an overview of the scope of the associated Technical Documentation, refer to the following:
- *W@M Device Viewer* (www.endress.com/deviceviewer): Enter the serial number from nameplate
- *Endress+Hauser Operations App*: Enter the serial number from the nameplate or scan the 2D matrix code (QR code) on the nameplate

1.4.1 Technical Information (TI)

Planning aid
The document contains all the technical data on the device and provides an overview of the accessories and other products that can be ordered for the device.

2 Basic safety instructions

2.1 Requirements for personnel

The personnel for installation, commissioning, diagnostics and maintenance must fulfill the following requirements:
- Trained, qualified specialists must have a relevant qualification for this specific function and task.
- Personnel must be authorized by the plant owner/operator.
- Be familiar with federal/national regulations.
- Before starting work: personnel must read and understand the instructions in the manual and supplementary documentation as well as the certificates (depending on the application).
- Personnel must follow instructions and comply with general policies.

The operating personnel must fulfill the following requirements:
- Personnel are instructed and authorized according to the requirements of the task by the facility's owner-operator.
- Personnel follow the instructions in this manual.

2.2 Designated use

Application and media
The device serves as a mobile terminal for measuring material moisture.

The following probes can be connected: SWZ, S1, S1C, S2

Incorrect use
Only probes specially designed for this device may be connected to it. If a probe that is not designed for the device is connected to it, this may damage the device and/or the connected probe.

The manufacturer is not liable for damage caused by improper or non-designated use.

2.3 Workplace safety

For work on and with the device:
- Wear the required personal protective equipment according to federal/national regulations.

2.4 Operational safety

Risk of injury.
- Operate the device in proper technical condition and fail-safe condition only.
- The operator is responsible for interference-free operation of the device.

Conversions to the device

Unauthorized modifications to the device are not permitted and can lead to unforeseeable dangers.
- If, despite this, modifications are required, consult with the manufacturer.

Repair

To ensure continued operational safety and reliability,
- Carry out repairs on the device only if they are expressly permitted.
- Observe federal/national regulations pertaining to repair of an electrical device.
- Use original spare parts and accessories from the manufacturer only.

Hazardous area

To eliminate a danger for persons or for the facility when the device is used in the hazardous area (e.g. explosion protection, pressure vessel safety):

- Based on the nameplate, check whether the ordered device is permitted for the intended use in the hazardous area.
- Observe the specifications in the separate supplementary documentation that is an integral part of these Instructions.

2.5 Product safety

This device is designed in accordance with good engineering practice to meet state-of-the-art safety requirements, has been tested, and left the factory in a condition in which it is safe to operate.

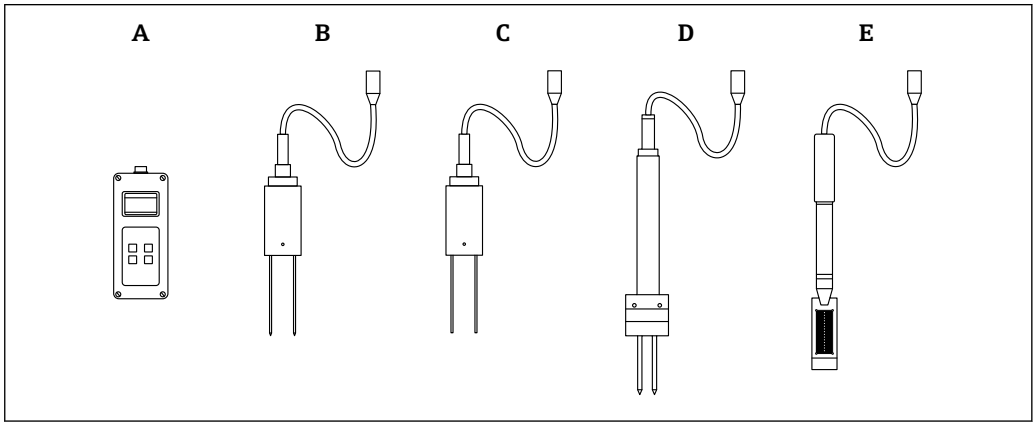
It meets general safety standards and legal requirements. It also complies with the EC directives listed in the device-specific EC Declaration of Conformity. The manufacturer confirms this by affixing the CE mark to the device.

3 Product description

The device is used to determine material moisture based on time-domain reflectometry (TDR) technology.

The measuring system is suitable for mobile use (battery operation) and consists of a handheld device and a connected probe.

3.1 Design



1

A Handheld device
B S1 two-rod probe
C S1C two-rod probe
D S2 two-rod probe
E SWZ probe

4 Incoming acceptance and product identification

4.1 Incoming acceptance

Check the following during incoming acceptance:

❑ Are the order codes on the delivery note and the product sticker identical?

❑ Are the goods undamaged?

❑ Do the nameplate data match the ordering information on the delivery note?

❑ If required (see nameplate): Are the safety instructions (XA) provided?

If one of these conditions is not met, please contact the manufacturer's sales office.

4.2 Product identification

The following options are available for the identification of the measuring device:
- Nameplate specifications
- Extended order code with breakdown of the device features on the delivery note

- Enter the serial number from the nameplates into *W@M Device Viewer* (www.endress.com/deviceviewer)
  - ↳ All the information about the measuring device and the scope of the associated Technical Documentation are displayed.

- Enter the serial number from the nameplate into the *Endress+Hauser Operations App* or use the *Endress+Hauser Operations App* to scan the 2-D matrix code (QR Code) provided on the nameplate
  - ↳ All the information about the measuring device and the scope of the associated Technical Documentation are displayed.

4.3 Manufacturer's address

Endress+Hauser SE+Co. KG
Hauptstraße 1
79689 Maulburg, Germany

4.4 Storage, transport

4.4.1 Storage temperature

−20 to +80 °C (−4 to +176 °F)

Use the original packaging

4.4.2 Transporting the product to the measuring point

Transport the device to the measuring point in the original packaging or case (accessory).

5 Electrical connection

5.1 Connecting the probe

The probe to be used is connected to the handheld device by means of a 7-pin plug.

Incorrect use
Only probes specially designed for this device may be connected to it. If a probe that is not designed for the device is connected to it, this may damage the device and/or the connected probe.

The manufacturer is not liable for damage caused by improper or non-designated use.

5.2 Charging the battery

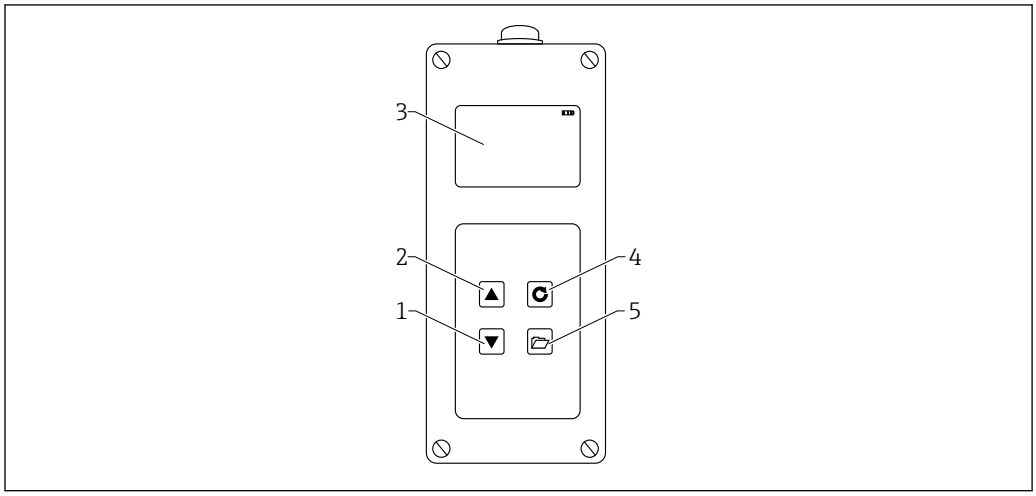
The maximum operating times indicated apply under ideal conditions. The ambient temperature and recharging cycle can significantly reduce the performance times. In addition, for technical reasons the recharging capacity drops over time or if the unit is stored at very high or low temperatures.

Only use the charger supplied to recharge the device. A different charging voltage can damage the device. If the device heats up while it is charging, this is normal behavior and is not dangerous. If the device only works briefly or not at all despite being charged repeatedly, the integrated battery is defective and must be replaced.

Never replace the in-built rechargeable battery yourself. If the battery is defective, contact the manufacturer directly.

6 Operating options

6.1 Operating elements



2 *Operating elements*

1 *"Down" navigation key*
2 *"Up" navigation key*
3 *Display*
4 *Enter key*
5 *Folder key*

6.2 Description of the function of the keys

6.2.1 Enter key

- **Switch on/off:** press and hold for 1 s
- **Take a measurement:** press briefly
- **Select/activate a menu item:** press briefly
- **Save a setting:** press briefly

6.2.2 Folder key

- **Activate device settings:** press and hold for > 1 s
- **Quit "Settings":** press briefly
- **Go back from the menu items:** press briefly

6.2.3 "Up" navigation key

Previous menu item or setting: press briefly

6.2.4 "Down" navigation key

- **Next menu item or setting:** press briefly
- **Clear the value memory (Average mode):** press briefly

6.3 Description of the icons on the display

3 *Remaining battery capacity*

4 *Measurement active*

5 *Setting saved*

6 *Brightness of background lighting*

7 *Time until switchoff (lighting / APO)*

8 *Press "Up" key*

9 *Press "Down" key*

10 Warning: water content values below 100 l/m³ are not taken into consideration or the validity of the measured value is called into question if the values vary too much.

6.4 Meaning of displayed text

Density: raw density value of the measured fresh concrete

Water content: kiln-dry water content in l/m3

EC-T: electrical conductivity based on the TDR radar signal and therefore an assessment of the cement in the concrete mix.

Serial No.: serial number of the probe

HW: hardware version

FW: firmware version

7 Commissioning

7.1 Checking the packaging contents

- Handheld device
- Power adapter (12 V/2 A)
- Charging adapter
- Protection cap
- Manual
- SWZ probe

7.2 Charging the battery

Charging the battery before using the probe for the first time

1. Insert the charging adapter into the 7-pin socket on the handheld device
2. Connect the power adapter to the charging adapter
   ↳ Charging commences immediately if the device is already switched on or the battery is over-discharged.
3. Otherwise, switch on the device by pressing the Enter key for approximately 1 s
   ↳ An animated battery symbol on the display indicates that charging is active. The built-in charging electronics charge the battery until it is fully charged. Charging takes around 2 h if the battery was fully discharged. As soon as the battery is finished charging, all 4 "battery bars" appear permanently on the display screen and trickle charging commences.

Only charge the battery at room temperatures. If the temperature is too low, end-of-charge cutoff might not work correctly and the battery may be overcharged. If ambient temperatures are too high, the device can be damaged by the heat generated during charging.

7.3 Connecting the probe

1. Insert the probe into the 7-pin socket on the device
2. Tighten the coupling nut

7.4 Switching the handheld device on/off

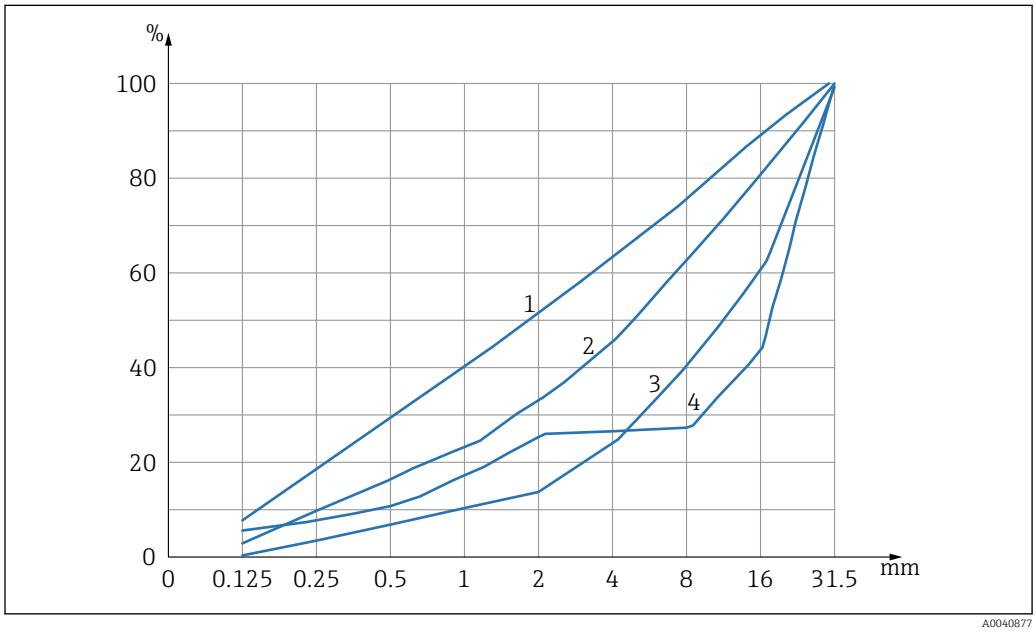
1. Press the Enter key for approximately 1 s
   ↳ The device tries to communicate with the connected probe during the power-up process. This takes around 4 s. If no probe is connected or if the probe cannot be found for some other reason, an error message appears on the screen. If the device managed to successfully find the probe, the measurement background appears on the screen, depending on the specific operating mode. The message "Calibrating" appears on the bottom of the display during the power-up process. The device adjusts to the probe.
2. The device is now ready for use
3. Switch off the device
   ↳ Press the Enter key for approximately 1 s

7.5 Configuration and measurement

For the device to be able to display the water content as a kiln-dried value with a required accuracy of ±1 to 3 l/m³, the system must be set beforehand to a specific "concrete formulation characteristic" and to the rock used. This setting is made using the CHAR and G-Set parameters.

7.5.1 CHAR parameter for the concrete formulation characteristic

With its radar measuring field, the SWZ probe shows the dependency of the grading curve on various concrete formulations. Therefore the handheld device offers users 4 different possible settings, which can be entered as a CHAR parameter.



11 *The 4 possible CHAR parameters*

1 *Fine (grading curve C)*
2 *Normal (grading curve B)*
3 *Coarse (grading curve A)*
4 *Special (gap-graded U)*

Fine (grading curve C)
The probe measures slightly too little water and therefore has to adjust the water content upwards slightly
- Concrete with a high mortar content, i.e. a very high quantity of sand, particularly with a high fines content, a high quantity of cement
- Standard admixtures, standard additives as well as perchloroethylene (PCEs)

Normal (grading curve B)
No or minor correction
- Constant and relatively well-distributed grading curves
- Standard admixtures, standard additives as well as PCEs

Coarse (grading curve A)
The probe measures slightly too much water and therefore has to adjust the water content downwards slightly
- Concrete with higher k-values and low mortar content
- Concrete with constant and relatively well-distributed B-grading curves with one peculiarity: low target water content that is less than 160 l/m³, and large amounts of superplasticizers (PCE) which improve general flow characteristics/rheology.

Special (gap-graded U)
The probe measures slightly too much water and therefore has to adjust the water content downwards slightly
- Very little or no gravel of size 2/8mm or 4/8mm
- Standard admixtures, standard additives as well as PCEs

7.6 General G-Set parameter

The probe measures both the free effective water in fresh concrete and a share of the core water or absorbed water. While there are types of rock that absorb very little core water, there are aggregates, such as sandstone or lime grit, that can absorb up to 50 l of core water. The core or absorbed water is not used to bind the cement and is therefore not processed for the w/c-ratio.

7.6.1 The SWZ probe measures three types of water

In principle, the probe measures the water parts as the kiln-drying method

The free water

The free water in the concrete mix which enters into the calculation of the w/c-ratio. This water is the actual value that is sought when using the probe.

A share of the core water

Water that is absorbed by the aggregates. The probe can only measure a percentage (approx. 1/3) of this core water. The core water can be 10 to 35 l/m³ depending on the type of rock. This (correction) value is represented in the G-Set parameter (approx. 2/3 of the core water), depending on the formulation and rock. The G-Set value is typically approx. −10 l/m³ assuming a core water content of 15 l/m³. These −10 l/m³ are then automatically subtracted from the measurement in the handheld device so that the reading in the handheld device matches the effective water content. See also the chapter on "Core moisture, core water and absorbed water".

Additives

Additives that behave like water are also measured by the SWZ probe. This must be taken into consideration.

For the G-Set parameter, it is therefore necessary to adjust the probe (one time only) to the type of rock that is used, which depends on the concrete formulation. To be able to display the effective (or kiln-dried) water content in the handheld device, it is necessary to factor in a value for the "G-Set" parameter for the formulation used with the type of rock. This value must be determined once.

If the water content that the probe displays for a special concrete is too high, G-Set must be adjusted by the corresponding number of liters. The exact G-Set value to be factored in for the concrete formulation with the rock type (location) and entered into the handheld device can be verified or determined in two ways:
- By comparing the probe measurements with several correct values for the water content of the concrete, for example by mixing concrete with dry aggregates.
- By comparing the probe measurements with several correct (!) kiln-dried values after kiln-drying. It is important to take the possible sources of error into consideration during the kiln-drying process.

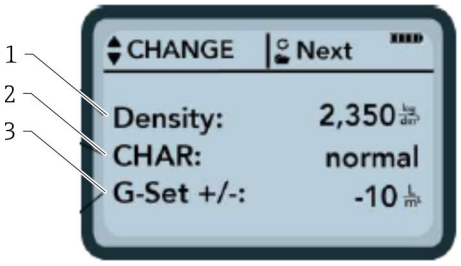
The kiln-dry water content is calculated as follows:

Kiln-dried value = effective water + core water + additives that behave like water. See also the chapter on "Core moisture, core water and water absorption".

7.7 Setting or changing the three concrete formulation parameters

7.7.1 Changing or entering the raw density

Values must first be entered for the configurable parameters before the handheld device can switch to the measurement mode to measure the water content.



1 *Raw density D*
2 *Characteristics*
3 *General-Set*

Characteristics of the concrete formulation with 4 possible settings: coarse A (minus correction), normal B (no correction), fine C (plus correction), or special U (minus correction for gap grading). Note: This parameter is significantly influenced by the mortar content in the concrete.

General-Set: Fine adjustment of the probe to concrete variety with rock type and core water. Entry max. ±50 l typically: −10 l (2/3 of core water) which are automatically subtracted during the measurement if the effective water content (the effective water) is to be measured.

If the kiln-dry water content is to be measured with the SWZ probe, enter a positive value for the G-Set, with 1/3 of core water!

Entering the raw density

1. The first parameter to be configured is the raw density, which can be set in increments of ±0.005. Ideally, the raw density is set correctly in the handheld device before the measurement of the water content
2. Set the density value D of the fresh concrete, which is determined with a concrete specimen, with the navigation keys ▲▼
3. Press Enter C to confirm your entry
   ↳ This automatically takes you back to the "Change" menu

It is important to enter the raw density value, as it is used directly to calculate the water content. If the raw density cannot be determined on site, it is also possible to enter the target raw density in order to obtain acceptable measurement results. A density deviation of ±0.02 would mean an error of ±1.6 l in the water content measurement. A difference of 0.1 in the raw density, i.e. from the density value 2.200 to 2.300 means a water content difference of 8 l!

7.7.2 Setting the CHAR formulation characteristic

The CHAR parameter is entered by activating one of the four possible settings:
- Fine C
- Medium B
- Coarse A
- Gap U

The CHAR parameter is significantly influenced by the mortar content in the concrete.

Entering the CHAR parameter

1. Using the navigation keys ▲▼, select one of the four possible options for CHAR (fine C, medium B, coarse A, or gap U)
2. Press Enter ↻ to confirm your entry

7.7.3 G-Set fine adjustment for concrete variety with rock type and core water

The G-Set value is entered in liters/m^3 and can be entered in increments of 1 l/m^3 up to a maximum of ±50 l/m^3. Once a G-Set value is identified for a certain type of rock, it is advisable to archive this value

Entering the G-Set value

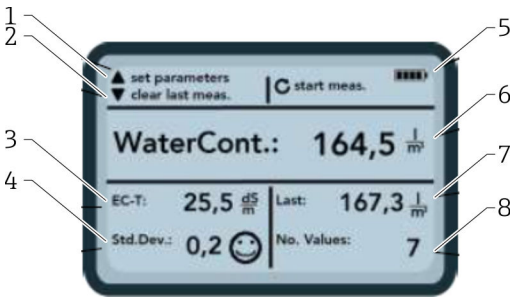
1. Using the navigation keys ▲▼, set the G-Set value in increments of 1 l/m^3 up to maximum ±50 l/m^3
2. Press Enter ↻ to confirm your entry
   ↳ Once you have changed or set the raw density, the CHAR parameter and the G-Set, you are taken automatically to the "Meas" menu when you press the Enter key ↻.

7.7.4 Measuring in the "Average" operating mode

The following screen appears in the "Meas" menu once the raw density and G-Set values have been entered. The handheld device generally measures in the "Average" mode and determines the kiln-dry water content of a fresh concrete sample in liters/m^3 using the raw density entered.

Starting a single measurement

1. Press the Enter key ↻ briefly
   ↳ The device starts the single measurement and a rotating symbol appears instead of the battery symbol in the top right-hand corner for the duration of the measurement process. No other actions can be performed during this time. A single measurement takes around 2 to 3 s. When the measurement is finished, the battery symbol appears on the display again.
2. The water content, calculated using the raw density D, is displayed in liters/m^3 on the screen. The number of individual measurements is displayed below this value in "No. values".



12 *The Meas menu*

1 *Set new parameters*
2 *Pressed briefly: delete last individual measurement value; pressed for longer: delete entire measurement series*
3 *Conductivity / assessment of the cement*
4 *Standard deviation: more single measurements are needed if the std-dev is > 0.5 !*
5 *Remaining battery*
6 *Water content as an average value*
7 *Last single measurement (can be deleted)*
8 *Number of measurements performed*

- To obtain a representative value for the material mix, take at least 5 individual measurements (see Measurement cycle for SWZ probe).
- In the case of concretes that tend to bleed, taking a higher number of individual measurements increases the accuracy and ensures a more representative value.
- Large gravel pieces directly at the surface of the probe can affect a reading; a lower water content is measured, for example.
- Incorrectly mixed concretes are difficult to measure with the probe.

Measurement quality:

The standard deviation StdDev displayed by the handheld device reflects the quality of the reading. If the StdDev value is >0.5, the concrete mix is too heterogeneous; more single measurements are required. At least 6 single measurements should be taken and a StdDev of 0.1 to 0.5 should be displayed before you can stop taking single measurements and accept the measured value as the final result.

It is very difficult, however, to achieve a StdDev of <0.5 for very heterogeneous concrete (e.g. concrete that bleeds significantly).

Smileys on the display screen indicate whether the standard deviation is good, acceptable or not acceptable:
- ☺ good (<0.2)
- 😐 acceptable (0.2 to 0.49)
- ☹ not acceptable (>0.5)

The handheld device automatically filters out water content values that are less than 100 l/m^3. For example, if the start button is accidentally pressed during a measurement series or if the probe was not yet fully introduced into the concrete.

Values that are too low are flagged with a warning sign ⚠ and are not used to calculate the average.

The measurement series can be cleared by pressing the navigation key ▼ and the handheld device is then ready for a new measuring cycle.

7.8 EC-T: a parameter for cement analysis

The EC-T parameter is displayed on the screen. With the TDR measurement method, the electrical conductivity (EC-T) of the concrete is determined using high-frequency attenuation of the radar pulse, making it possible to assess the cement content or cement type. The displayed EC-T parameter can be interpreted as a preliminary value for the cement content or cement type during single measurements, thereby ensuring enhanced

safety and reliability when monitoring and checking a known type of concrete. It is advisable for the user to document the particular varieties of concrete that are measured. This makes it easier to verify the values during subsequent control measurements.

EC-T measuring range
- Concrete with low cement content or special cement types: 15 dS/m
- Concrete with higher cement content or special cement types: 45 dS/m

The EC-T parameter can only be evaluated properly if the type of concrete is known.

7.9 General settings

Changing the settings:

1. Press the Folder key for longer (2 s)
   ↳ "Settings" menu
2. Press the navigation keys
   ↳ Navigate to a menu item
3. Press the Enter key
   ↳ Confirm the selected menu item
4. Press the Folder key
   ↳ Exit the current menu item and the "Settings" menu

7.9.1 Overview of the configuration options

- **Find probe**
  Searches for a connected probe
- **Language**
  Change the system language
  - German
  - English
- **Auto-power-off**
  Setting for automatic switch-off
- **Display lighting**
  Setting for background lighting
  - Switch-off time
  - Brightness
- **Display contrast**
  Setting for optimum contrast
- **Probe info**
  Displays information about the probe
- **Info**
  Displays information about the handheld device
- **Material calibration**
  Select calibration curve for different materials

7.9.2 Find probe

Select the "Find probe" menu item if:
- There are communication problems between the handheld device and probe during power-up
- The probe is connected for the first time
- The probe is to be changed during operation

Once this menu item has been selected, the handheld device makes another attempt to establish a connection to a connected probe.

The serial number of the probe appears on the display as soon as the connection has been established successfully.

"Probe not found" appears on the display if a connection cannot be established.

No connection established with the probe despite multiple attempts

- ▶ Check that the probe is connected correctly, contact the manufacturer's Service Department if necessary

7.9.3 Language

The language of the handheld device can be selected in this menu item.

Options:
- German
- English

1. Select the desired language using the navigation keys ▲▼
2. Press Enter C to activate the selected language
   - ↳ Once the setting has been activated, the 💾 symbol appears in the top right-hand corner

7.9.4 Auto-power-off

The automatic switch-off time can be selected in the "Auto-power-off" menu item

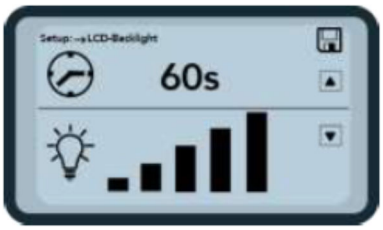
Options:
- -- minutes (switch-off function disabled)
- 1 minute
- 2 minutes
- 5 minutes
- 10 minutes
- 20 minutes

1. Select the desired automatic switch-off time using the navigation keys ▲▼
2. Press Enter C to activate the selected switch-off time
   - ↳ Once the setting has been activated, the 💾 symbol appears in the top right-hand corner

The handheld device only switches off automatically if a key has not been pressed within the set time interval. Pressing a key restarts the countdown to switch-off.

7.9.5 Display lighting

The background lighting of the display can be customized or switched off to achieve a longer operating time. The following screen is displayed once the item has been selected in the menu:

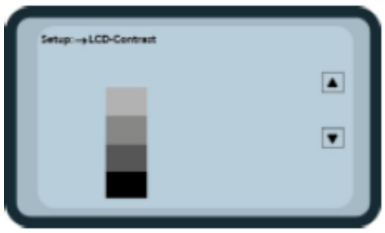


13 Display lighting

1. Select the desired automatic switch-off time by pressing the navigation key ▲ several times
2. Select the desired brightness of the display or switch it off completely by pressing the navigation key ▼ several times
3. Press Enter ↻ to activate and save the selected settings
   ↳ Once the setting has been activated, the 💾 symbol appears in the top right-hand corner

7.9.6 Display contrast

At extreme temperatures, it may be necessary to change the contrast setting to improve screen readability.



14 *Display contrast*

1. Using the navigation keys ▲▼, set the contrast so that you can clearly see all the gray gradations in the bar chart.
2. Press Enter ↻ to activate and save the selected setting
   ↳ Once the setting has been activated, the 💾 symbol appears in the top right-hand corner

7.9.7 Probe info

The following information about the connected probe is displayed in the "Probe info" menu item:
- Serial number
- Probe type
- Hardware version (HW)
- Firmware version (FW)

7.9.8 Info

The following information about the handheld device is displayed in the "Info" menu item:
- Serial number
- Hardware version (HW)
- Firmware version (FW)
- Battery capacity
- Battery voltage

7.9.9 Material calibration curves

The SWZ probe can be set to another material calibration curve in the "Material calibration curves" menu item.

When the device is switched on, the calibration curve configured in this menu item is displayed for approx. 3 s at the bottom of the screen.

Overall, up to 15 calibration curves can be managed for materials such as suspensions, sludges etc.

The sensitivity of the concrete measurement can be changed by selecting another calibration curve.

The standard calibration curve **"Cal. No.: 4"** is set by default for concrete.
- Do not change this setting, or only change this setting if you are measuring a material other than fresh concrete
- For more information, please contact the manufacturer's Service Department

8 SWZ probe

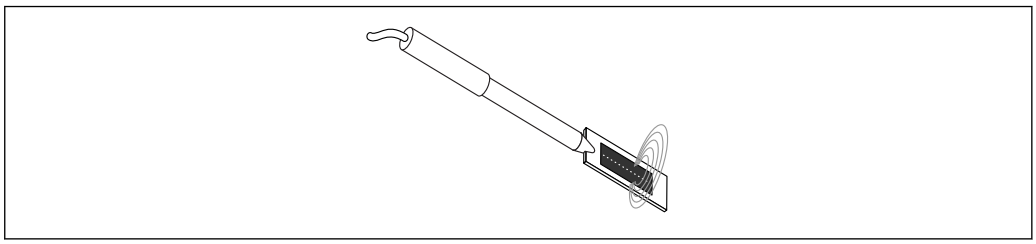
8.1 Introduction

The SWZ probe uses radar technology at 1 GHz and a probe whose measuring field penetrates deep into the material to be measured. Plastic and liquid fresh concrete with a consistence class of F2 to F6 can be measured by hand easily and directly. An automatic averaging function, with 4 to 10 single measurements taken, ensures a representative measurement of the material mix. Thanks to the structured measurement method, representative and precise measurement results are displayed within a few minutes.

The probe uses TDR technology (Time-Domain-Reflectometry) based on guided radar waves. Very low-power (only 10 mW) radar waves (i.e. no potential risk from electromagnetic radiation etc.) are also used in industrial level measurement, for example. In the measurement method, the radar pulse is attenuated based on the cement content and type and used as an EC-T conductance value in dS/m (decisiemens per meter) for the assessment of the cement.

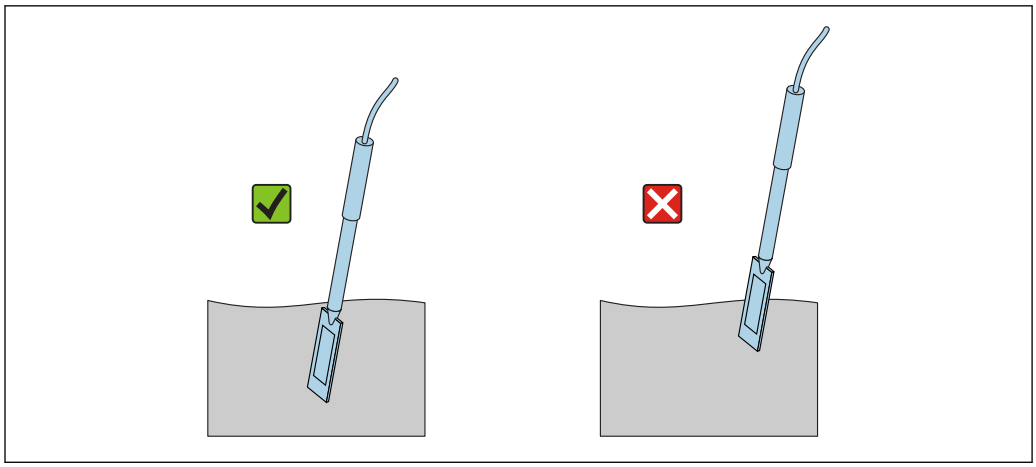
Please note that the measured value can fluctuate considerably in the case of concrete that does not meet the specifications of DIN EN 206-1 and DIN 1045-2 (e.g. concrete that tends to bleed). Incorrectly mixed concretes are difficult to measure!

8.2 Measuring volume



15 *Measuring field of the SWZ probe*

In theory, the electromagnetic field lines penetrate the material to be measured to an infinite depth. However, the probe's effective penetration depth, which is relevant for measurement, is max. 5 cm around the probe surface at the dark ceramic plate. The field lines around the probe are illustrated in the graphic. With regard to the intensity of the measuring field, it is important to consider that in all dielectric measurement methods the field line distribution is exponential rather than linear. This means that the field line is most intense directly at the probe head in all the measurement methods, and decreases exponentially the further the measurement is from the probe head. The consequence for moisture probes is that larger gravel pieces located directly at the probe head can falsify a reading. For this reason, moisture probes used in concrete mixers, for example, average and filter several individual measurements to achieve an accuracy of ±1.5 l/m³ with the mixer probe for instance. Just like the application in a mixer, when using the SWZ probe it is important to consider that larger gravel pieces located directly at the probe head can falsify a reading. Therefore, when taking measurements with the SWZ probe, the priority is to alter the bedding conditions of sand, cement and large gravel pieces so that a representative material mix is obtained with several single measurements. This is achieved by taking several single measurements with different bedding conditions around the probe head.



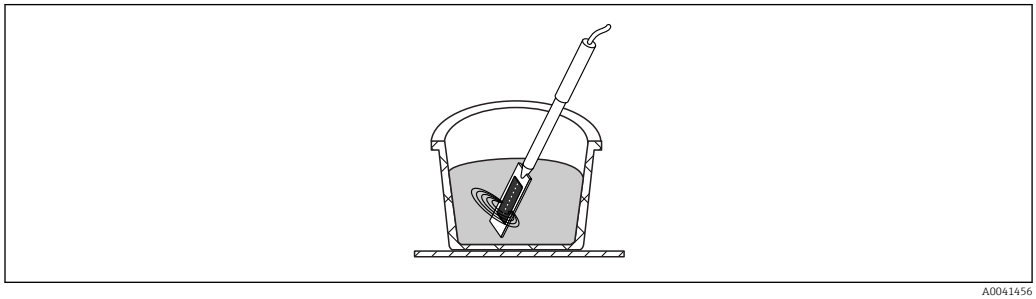
16 *Using the SWZ probe*

Correct use of the probe:
- The probe measuring field must be fully located in the concrete
- The probe head must be fully inserted in the concrete to be measured, without any "air gaps"
- When taking several measurements, the probe head should never be inserted in the concrete at the same point. If you only take measurements at one point, there is the danger of segregation at this point. This is because - when the probe head is removed - the empty space can be filled with finer or more liquid particles, and the water content value would become increasingly higher as a result.

8.3 Measurement procedure

8.3.1 Measuring in a plastic bucket

Fresh concrete should always be measured in a plastic bucket, as this rules out any influence of metal on the measurement. Due to the propagation of the measuring field (waves in the graphic), select a bucket with a capacity of approx. 10 l as shown below. The bucket should be high enough to ensure that there is still sufficient space between the probe and the base of the bucket when the probe is inserted into the concrete.



17 *Measuring field propagation of the SWZ probe*

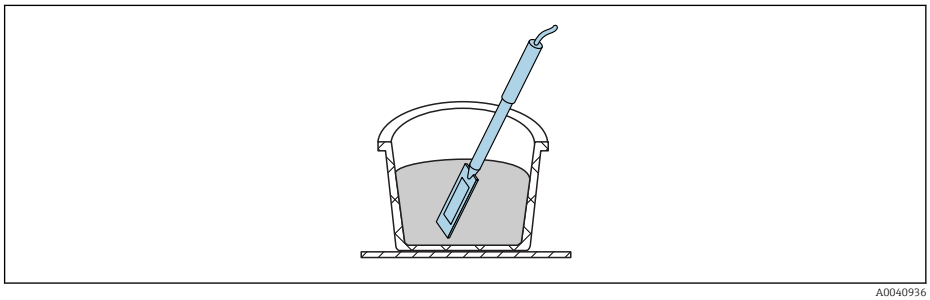
To prevent segregation, do not shake the fresh concrete in the bucket. Once the probe has been inserted, tap the side of the bucket 2-3 times with your foot so that the concrete is compact enough to ensure that the fresh concrete surrounds the probe surface at the dark ceramic plate without any air pockets.

At least 5 measurements should be taken; each time the probe should be inserted at the side of the bucket at different points, spaced at intervals of 70 °

Please note the following:
- There should not be any residue of old concrete around the ceramic on the probe surface. Clean the surface with a wire brush if necessary.
- The amount of concrete in the bucket should be at least 3 cm higher than the length of the probe head (<18 cm). In the case of concrete with a high water content, it is particularly important to ensure that the concrete does not segregate during or as a result of the measurement.
- Insert the probe head fully into the concrete at the edge of the bucket at a slight angle.
- Tap the side of the bucket to make the concrete more compact around the probe. This ensures that the fresh concrete is optimally packed around the probe surface for the measurement.

8.3.2 Measuring concrete with flow class F2, F3 or F4

1. Insert the probe into the fresh concrete at the edge of the bucket



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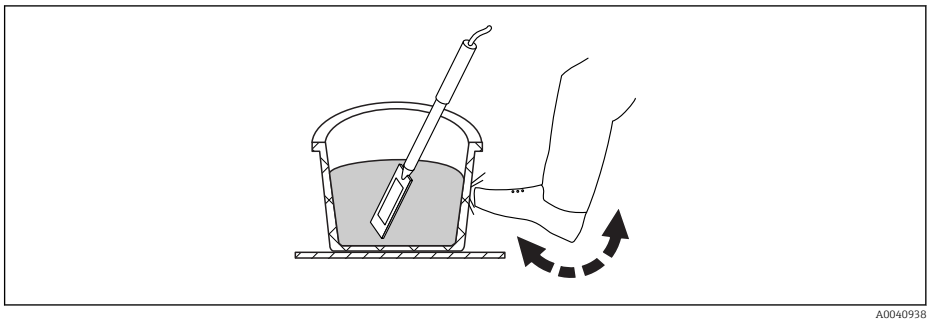
2. Take an individual measurement
3. Remove the probe from the bucket
   ↳ When the probe is removed from the concrete, the fresh concrete can segregate at this point and fine particles can enter the cavity.
4. Insert the probe into the fresh concrete again at the side of the bucket, spacing the probe approx. 70 ° from the previous position
5. Tap the side of the bucket (e.g. with your foot) to make the concrete more compact around the surface of the probe.



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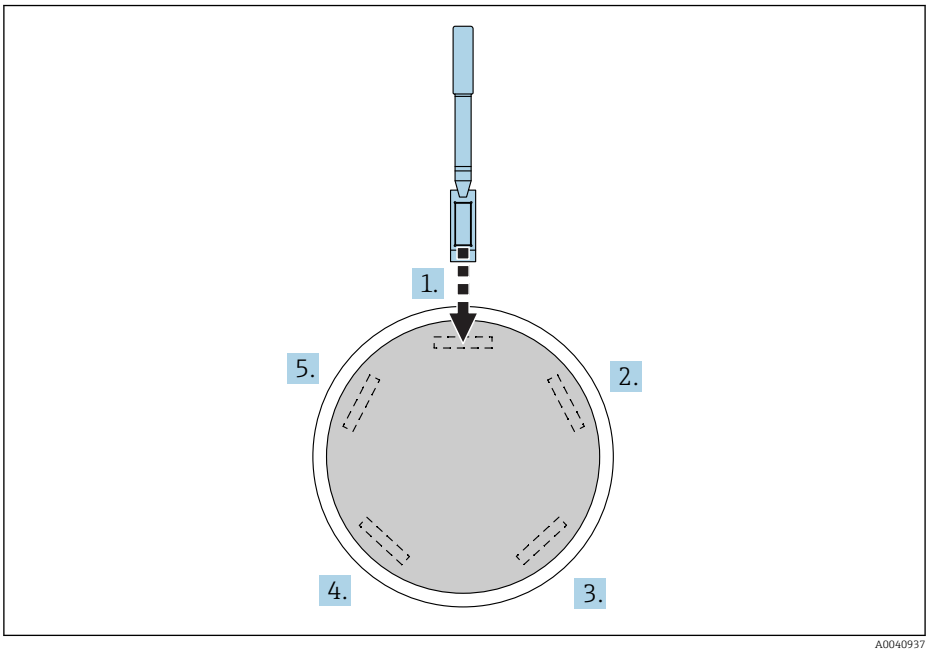
6. Take another individual measurement
7. Insert the probe again at the side of the bucket, spacing the probe approx. 70 ° from the previous position

8. Repeat the process 4 to 5 times in total



In the case of concrete that "sticks", the dark ceramic surface of the probe should be wiped clean before each measurement to ensure that concrete residue "sticking" to the surface of the probe does not falsify the measurement. Concrete with a flow class of F2, F3 and F4 does not segregate so easily. Therefore, this measuring method of inserting the probe at the side and tapping the side of the bucket to pack the concrete delivers the best possible measurement results. For relatively stiff F2 concrete, it may be necessary to place the bucket, together with the probe, on a shaking table to compact the concrete before the measurement.

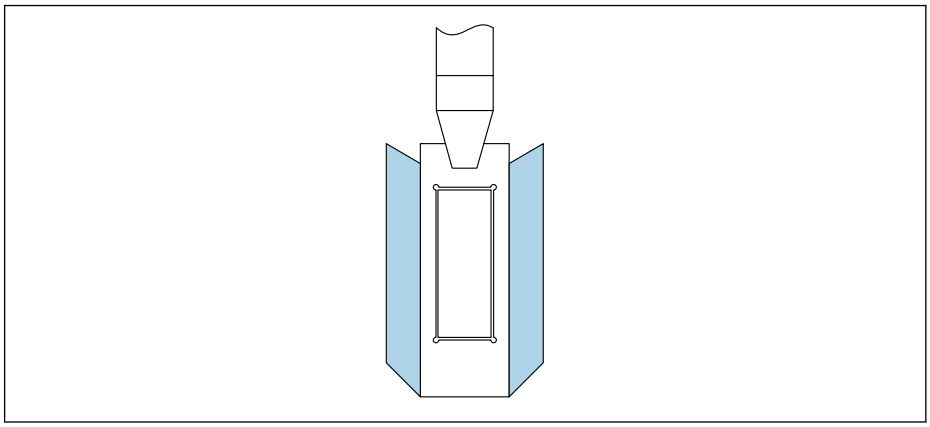
8.3.3 Measuring concrete with flow class F5 and F6

Very liquid concretes tend to segregate and there is the risk of larger parts accumulating on the base of the bucket. Once the SWZ probe is inserted, fine particles can gather around the surface of the probe and the values measured for the water content would be too high as a result.

Therefore, the following procedure is recommended when measuring concrete with flow class F5 to F6:

1. Fill 3/4 of a 12 l bucket with concrete

2. At the edge of the bucket, vertically insert the probe head with the plug-in blade (plastic) fully into the concrete.



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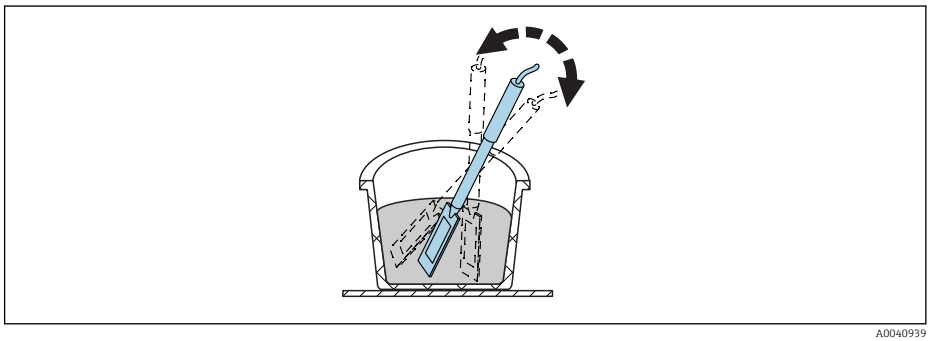
The plug-in blade ensures that the larger gravel pieces do not "drift away" from the probe head towards the side during the measurement, which can cause inaccuracies.

3. Slowly push the tip of the probe - with the black ceramic surface at the front - in a diagonal direction towards the opposite side of the bottom of the bucket. The handle should rest on the edge of the bucket afterwards.



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This ensures that a representative concrete mix is present around the surface of the probe.

4. Repeat this procedure several times, inserting the probe at a different point each time so that it is offset from the previous point.
   ↳ Delete any individual measurements that are far from the displayed average value

Kiln-dried sampling and kiln-dry testing of concrete with a flow class of F5 and F6 can also deliver inaccurate results. If the concrete for the kiln drying process is taken from the surface of the bucket or the base of the bucket, there can be a difference of up to 40 l in the water content in the case of concretes that tend to bleed!

After 4-5 measurements:

- If the standard deviation after 4-5 measurements is not acceptable (i.e. >0.5) or if the measured values fluctuate too much, additional individual measurements must be taken.
- Before taking the measurements, mix the fresh concrete in the bucket again with professional mixing tools. Do not mix the concrete for too long as water can escape from the concrete.
- Afterwards, additional measurements can be taken.

Non-ideal concrete formulations are more prone to measured value variations. In the case of concrete that does not meet the specifications of DIN EN 206-1 and DIN 1045-2 (concrete that tends to bleed segregates), the measured value can fluctuate. Incorrectly mixed concretes are difficult to measure with the SWZ probe (but also with the kiln-drying test)!

8.4 Potential problems in the laboratory and at the concrete plant

8.4.1 Situation 1: Mixing the concrete with dry aggregates

Depending on the rock, it can take some time for dry aggregates to become saturated after the mixing process. This can range from 3 to 5 min for relatively absorbent aggregates, to up to one hour for less absorbent aggregates. Given that the SWZ probe only "sees" one third of the core water, we recommend that you wait a "certain amount of time" after mixing dry aggregates before checking the water content with the SWZ probe.

Example: A dry, highly absorbent rock can absorb up to 30 l of water per cubic meter in a relatively short period of time. Due to the equilibrium moisture content, however, the rock that is used and stored is not entirely dry. Rather, it has a water content typically of 7 l/m³. For a concrete formulation with 175 l/m³ effective water content, 175 l + 23 l = 197 l were then used. Directly after the concrete has been mixed, the SWZ probe would measure approx. 185 l here and then display a reading of 175 l relatively quickly after approx. 3 to 5 min (depending on the rock). For the handheld device, two thirds of the maximum core water would have been entered for the G-Set parameter. In this case, two thirds of the 30 l maximum core water would have been entered in the handheld for the G-Set, i.e. G-Set = −20 l, if the effective water is to be measured.

When mixing with dry aggregates, it is important to wait a certain amount of time - depending on the rock type - before taking a reading with the SWZ probe!

8.4.2 Situation 2: Subsequent addition of water to the concrete

Problems and non-conformities during a laboratory test, which was performed as follows:

1. The water content of approx. 8 l of fresh concrete was measured in a bucket with the SWZ probe. A reading of 178 l/m³ was measured, for example.
2. After this, 50 g of water were added to the fresh concrete, which would correspond to an increase in the water content from 178 l/m³ to 184.25 l/m³, for example. After mixing the concrete for approx. one minute in a small mixer, the concrete was then tested with regard to the raw density and flow class. The concrete used to determine the density and flow class was then poured back into the measuring bucket for the purpose of determining the water content afterwards with the SWZ probe.
3. Then, the concrete water content was measured again with the SWZ probe. This time, however, the result was only 181 l/m³ and not 184.25 l/m³ as expected.
   ↳ When the concrete is mixed in the small mixer, some of the water already escapes. This is because when relatively small quantities of concrete are mixed in an open container, the water adheres to the wall of the container over a large surface area and evaporates. If this concrete is then also used afterwards to test the flow class and raw density, then no gravel and hardly any sand sticks to the outer walls of the testing instruments but the water and fines "cling" to these surfaces as a result of the adhesion of water. This effect can be easily checked. After the first SWZ probe reading of 178 l/m³, mix the concrete again for approx. one minute and then check the water content again with the SWZ probe. The 2 to 3 l/m³ reduction in the water content is then an indicator for the evaporative effect as a result of mixing.

Subsequent mixing of the concrete causes considerable deviations in the water content readings!

8.4.3 Situation 3: Sampling in the concrete plant

1. Before the concrete was transferred to a truck mixer, a concrete sample was taken directly from a twin-shaft mixer and transferred to a bucket.

2. The concrete sample with a normal-distribution grading curve and a water target value of 170 l/m³ was measured with the SWZ probe and 170 l/m³ was displayed as the reading.
3. After that, a 5 kg concrete sample was kiln-dried. A kiln-dried value of 149 l/m³ was determined, i.e. there was a difference of −21 l/m³.
   ↳ As the concrete was mixed in the twin-shaft mixer without being continuously mixed again in the truck mixer, the kiln-dried sample during the first sampling contained a lot of large gravel pieces. These large gravel pieces resulted in a considerable error during sampling: there were simply too many large pieces of gravel in the sample which "drove down" the kiln-dried value to 149 l/m³ (gravel pieces have no water content). The cement paste, which was very high as a result, caused the SWZ reading to deviate from the (actually incorrect) kiln-dried value.

Influence of large gravel pieces when sampling:
- **Kiln-dried sample of 1.5 kg (3.31 lb):** ± 2 large gravel pieces produce an error of ±9 l/m³
  - Formulation A with a relatively high fines content and low 16/32mm gravel content: approx. 5 pieces of 16/32mm gravel
  - Formulation B with gap-grading, i.e. low 4/8mm gravel content and high 16/32mm gravel content: approx. 15 pieces of 16/32mm gravel
- **Kiln-dried sample of 5 kg (11 lb):** ± 2 large gravel pieces produce an error of ±3 l/m³
  - Formulation A with a relatively high fines content and low 16/32mm gravel content: approx. 16 pieces of 16/32mm gravel
  - Formulation B with gap-grading, i.e. low 4/8mm gravel content and high 16/32mm gravel content: approx. 100 pieces of 16/32mm gravel

A single piece of 16/32mm gravel weighs 10 to 50 g (0.35 to 1.76 oz). Therefore, correct sampling has an important impact on accuracy

9 Commissioning fresh concrete measurement

NOTICE

During the measurement process, there should never be any metal parts in the vicinity of the probe head, as metal can affect the measuring field of the probe. Fresh concrete should always be measured in a plastic bucket, as this rules out any influence of metal on the measurement. The probe surface must be clean and free from any residue. No concrete should be caked to the surface of the probe.

▶ Clean the probe with a wire brush if necessary

- To obtain a representative value for the material mix, take at least 5 individual measurements (see Measurement cycle for SWZ probe).
- In the case of concretes that tend to bleed, taking a higher number of individual measurements increases the accuracy and ensures a more representative value.
- Large gravel pieces directly at the surface of the probe can affect a reading; a lower water content is measured, for example.
- Incorrectly mixed concretes are difficult to measure with the probe.

The standard deviation StdDev displayed by the handheld device reflects the quality of the reading. If the StdDev value is >0.5, the concrete mix is too heterogeneous; more single measurements are required. At least 6 single measurements should be taken and a StdDev of 0.1 to 0.5 should be displayed before you can stop taking single measurements and accept the measured value as the final result.

The operation of the handheld device with the individual keys, probe connection, charger, etc. is described in detail in the manual. The following section only explains individual actions with the LCD display and the keys.

To be able to display the exact water content, the system must be set beforehand to the "formulation characteristic" and to the variety of concrete with the rock type.

The device can be set to the characteristic of the concrete formulation with the "fine", "coarse", "normal" or "special" setting in the CHAR parameter (see the "Settings and measurement" section).

It is possible to fine-tune to the variety of concrete with the rock type using the G-Set parameter. If the G-Set value has a positive sign, the set value is automatically added or subtracted during the measurement. If a water content that deviates from the reference continues to be displayed, the G-Set value would need to be reduced, for example from −10 to −8. The exact G-Set value which has to be factored in for the concrete variety with the rock type (location) and entered into the device can be checked or determined in two ways:

- By comparing the measurements of the SWZ probe with several correct target values for the water content of the concrete
- By comparing the measurements of the SWZ probe with several correct values of a laboratory method (e.g. kiln drying)

9.1 Procedure

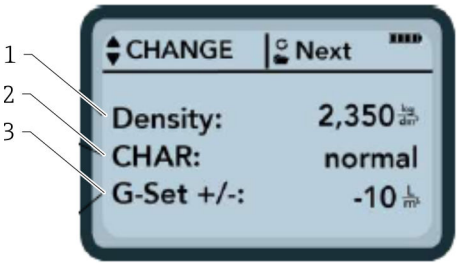
9.1.1 1. Switching on the handheld device

Pressing the Enter key C for long (>1 s) switches on the device in the "CHANGE" formulation menu. Pressing the Enter key C again for longer (only in this measuring window!) switches the device off again. The device switches off automatically after 10 min if it is not operated during this time (this time can be shortened or increased to up to 20 min in the "Auto-Power-Off" menu item).

9.1.2 2. Changing the raw density, CHAR parameter and G-Set

The raw density of the concrete to be measured must be entered before the water content is measured. In addition, the characteristic of the concrete formulation must be set to "fine,

coarse, normal or special" with the CHAR parameter (see the "Settings" chapter). The device is set to the variety of concrete with the corresponding rock type with the G-Set parameter. G-Set is entered in liters/m3 and can be entered in increments of one liter up to ± 50 l.



1 Raw density D
2 Characteristics
3 General-Set

Characteristics of the concrete formulation with 4 possible settings: coarse A (minus correction), normal B (no correction), fine C (plus correction), or special U (minus correction for gap grading). Note: This parameter is significantly influenced by the mortar content in the concrete.

General-Set: Fine adjustment of the SWZ probe to suit the concrete variety with rock type and core water. Entry max. ±50 l typically: −10 l (2/3 of core water) which are automatically subtracted during the measurement if the effective water content (the effective water) is to be measured.

If the kiln-dry water content is to be measured with the probe, enter a positive value for the G-Set, with 1/3 of core water!

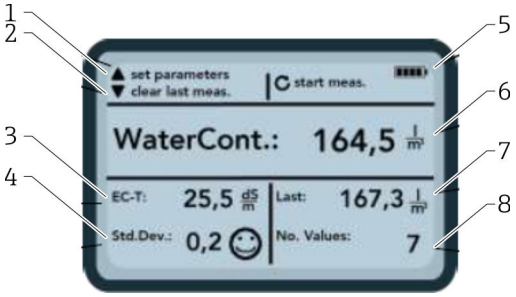
1. The user can scroll through the parameter list by pressing the navigation keys ▲▼
   ↳ The selected parameter is shown darker on the display
2. The selected parameter is activated by pressing the Enter key C
3. Once activated, the parameter can be configured with the navigation keys ▲▼
4. The configured value is accepted by pressing the Enter key C
   ↳ Automatic return to the "CHANGE" menu where more parameters can be configured
5. Once you have entered the raw density, the CHAR parameter and a possible value for "G-Set", you are taken automatically to the "Meas" menu when you press the Enter key C.

It is important to enter the raw density value, as it is used directly to calculate the water content. As an alternative to determining the raw density on site, it is also possible to enter the target raw density in order to obtain acceptable measurement results. A density deviation of ±0.02 would mean an error of ±1.6 l in the water content measurement. A difference of 0.1 in the raw density, i.e. from the density value 2.2 to 2.3, means a difference of 8 l in the water content!

9.1.3 3. Introducing the SWZ probe and starting the individual measurement

Two different procedures apply:
- F2, F3 and F4 concrete: Insert the probe at the edge of the bucket at a slight angle, compacting it somewhat by tapping the bucket.
- F5-F6 concrete: Use the plug-in blade for the SWZ probe. Insert the probe vertically into the concrete at the edge of the bucket and slowly slide the probe tip diagonally to the opposite side of the bucket so that there is a representative concrete mix around the probe.

1. Make sure that no air is trapped in the fresh concrete
2. Press the Enter key C to "Start measurement". The water content, determined using the raw density, is calculated in l/m³ and displayed. "No. values" indicates the number of individual measurements that have been taken.
   ↳ The first individual measurement is taken and indicated on the screen by a rotating symbol C. The measurement takes approx. 2 s.



18 *The Meas menu*

1 *Set new parameters*
2 *Pressed briefly: delete last individual measurement value; pressed for longer: delete entire measurement series*
3 *Conductivity / assessment of the cement*
4 *Standard deviation: more single measurements are needed if the std-dev is > 0.5 !*
5 *Remaining battery*
6 *Water content as an average value*
7 *Last single measurement (can be deleted)*
8 *Number of measurements performed*

- To obtain a representative value for the material mix, take at least 5 individual measurements (see Measurement cycle for SWZ probe).
- In the case of concretes that tend to bleed, taking a higher number of individual measurements increases the accuracy and ensures a more representative value.
- Large gravel pieces directly at the surface of the probe can affect a reading; a lower water content is measured, for example.
- Incorrectly mixed concretes are difficult to measure with the probe.

Measurement quality:

The standard deviation StdDev displayed by the handheld device reflects the quality of the reading. If the StdDev value is >0.5, the concrete mix is too heterogeneous; more single measurements are required. At least 6 single measurements should be taken and a StdDev of 0.1 to 0.5 should be displayed before you can stop taking single measurements and accept the measured value as the final result.

It is very difficult, however, to achieve a StdDev of <0.5 for very heterogeneous concrete (e.g. concrete that bleeds significantly).

Smileys on the display screen indicate whether the standard deviation is good, acceptable or not acceptable:
- ☺ good (<0.2)
- 😐 acceptable (0.2 to 0.49)
- ☹ not acceptable (>0.5)

The handheld device automatically filters out water content values that are less than 100 l/m³. For example, if the start button is accidentally pressed during a measurement series or if the probe was not yet fully introduced into the concrete.

Values that are too low are flagged with a warning sign ⚠ and are not used to calculate the average.

The measurement series can be cleared by pressing the navigation key ▼ and the handheld device is then ready for a new measuring cycle.

9.1.4 4. Starting the next individual measurement

To prevent the segregation of the concrete, it is recommended to mix the fresh concrete again after 5 measurements. With regard to the representativeness, this simply involves changing the material mix or composition with different sized gravel pieces at the probe head.

- ▶ Press the Enter key to "Start measuring"
  - ↳ The second measurement is performed; this also takes approx. 1 s. The new measured value is used for averaging and an average water content value is calculated from the first and second (or more) measurements and displayed.

9.1.5 5. Taking additional individual measurements

Proceed as explained in Step 4. A higher number of individual measurements improves the representativeness and accuracy of the final result. It is strongly recommended to take a higher number of individual measurements if the readings tend to vary greatly (e.g. due to concrete bleeding). After performing a certain number of individual measurements, the standard deviation Std-Dev should show a value <0.5 so that the quality of the measurement is guaranteed and the water content result in l/m³ can be accepted.

Pressing the navigation key clears the measurement series; the device is then ready for a new measuring cycle.

9.2 Core moisture, core water and water absorption

The SWZ probe measures both the free water in the fresh concrete and usually 1/3 of the maximum core water with a higher weighting of the core water of sand. While there are types of rock that absorb very little core water, there are aggregates, such as sandstone or lime grit, that can absorb up to 50 l of core water.

Therefore the SWZ probe must be set once to the concrete formulation being used, with the type of rock or rock location.

To ensure that the device can display the effective water content or alternatively the kiln-dry water content, it is necessary to factor in a value for the "G-Set" parameter for the type of rock used. This value must be determined once.

SWZ probe - measurement of effective water:

If, for example, a rock has 15 l core water, the SWZ probe only sees 1/3 of this amount. This means that the remaining 2/3 must then be specified as a negative value for the G-Set to be able to measure the effective water content. In this example, the G-Set then = −10 l/m³ if the core water is typically 15 l/m³.

SWZ probe - measurement of kiln-dried water:

If the SWZ probe is to measure the kiln-dry water content, one third of the positive value of the core water must be entered for the G-Set. In this case, G-Set = +5 l if the core water is typically 15 l/m³.

The exact positive or negative G-Set value which has to be factored in for the rock type (location) and entered into the device can be checked or determined in two ways:

- By comparing the measurements of the SWZ probe with several correct target values for the water content of the concrete. With concrete mixes that are blended with dry aggregates.
- By comparing the measurements of the SWZ probe with several correct kiln-dried values or by determining the water content after kiln-drying.

The kiln-dry water content is calculated as follows:

Kiln-dried value = effective water + core water + additives that behave like water.

The SWZ probe also measures additives that behave like water during the measurement process. This must also be taken into consideration when evaluating and determining the w/c water content.

Applicable value for the core water for the calculation when kiln-drying:

If a very absorbent lime grit absorbs 2 % water, for example, this would be 34 l of core water with one cubic meter aggregate fraction, presuming a bulk density of the aggregates of 1 700 kg/m³ (3 748 lb/ft³). Core water = moisture * raw density of rock /100 = 2 % × 1700 / 100 = 34 l/m³ water absorption (WA24)

Applicable value for the G-Set in the handheld device:

As the SWZ probe cannot measure 100 % of the core water, in this example a G-Set value of approx. −23 l/m³ could be suitable (= 2/3 of total core water of 34 l) if the effective water content or effective water is to be measured with the SWZ probe. The G-Set value which has been determined or assumed for the rock type or location should be determined or checked by performing comparison measurements either with reliable mixes with dry aggregates or with several reliable kiln-dried values.

9.3 Kiln-drying as a reference value

The G-Set parameter, which can be configured in the device, can be used to adapt the calibration of the SWZ probe to the concrete formulation with the rock type by performing kiln-dried comparison measurements. It is important to note, however, that it is not easy to kiln-dry fresh concrete correctly. Fresh concrete must be kiln-dried relatively quickly to prevent the cement from gradually setting during the kiln-drying process. If the kiln-drying process is too slow there is the danger of the free water in the fresh concrete binding in the cement. This would falsify the measurement result when the sample is weighed because the water in the kiln would be chemically or crystalline-bound and the calculated kiln-dry water content would be too low as a result.

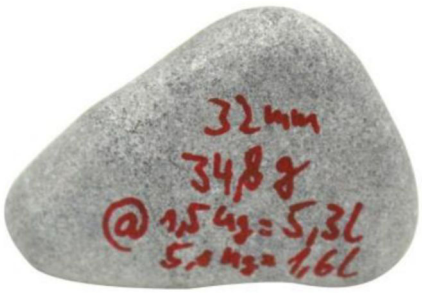
Potential problems or influencing factors when kiln-drying:

- When kiln-drying with a gas burner (blowtorch), make sure that no solid particles escape into the air (or from the kiln vessel!) as the loss of weight would mean that the water content values determined would be too high. Some users stir the fresh concrete when kiln-drying, while others do not. This results in different kiln-dried values. If the fresh concrete is not stirred, there is the danger that the water would be chemically bound in the concrete due to the longer drying time. Such water cannot escape even at very high temperatures. The measured water content is generally higher when the concrete is stirred vigorously than when it is not stirred, as too many solid particles can escape to the air due to the stirring action.
- When drying with a microwave oven, it is important to select the drying time depending on the power (800 W or 1 000 W), and also pay attention to the volume of the kiln-dried sample (e.g. 1.5 to 2 kg). With the same fresh concrete sample, deviations of up to ±3 to 10 l/m³ are not unusual when drying with gas burners or microwave ovens. The information sheet published by the German Society for Concrete and Construction Technology (DBV) entitled "Special Fresh Concrete Checks" deals specifically with kiln-drying procedures with microwave ovens. Note that the water can be chemically bound in the concrete with drying times >20 min. This can falsify the result as the water content would then be too low. If the sampling volumes in the microwave are too large, there is also the danger of the chemical binding of water, which would cause the reading for the measured water content to be too low.
- When taking concrete samples for kiln drying, considerable deviations can occur. If the concrete has been left in the bucket for quite a while, it may segregate, with the result that the water content of kiln-dried samples of concrete taken at the surface would be far too high. This is particularly true of concrete with flow class F5 and F6.

- When weighing the dry kiln-dried sample, pay attention to the temperature of the kiln-dried sample. When weighing a very hot kiln-dried sample, the upward lift of air streams can produce a considerable error on the scales. For example, when weighing a 4 kg weight, the hot air stream can produce a difference of 30 g, depending on the weighing unit. With a weight of 4 kg, this would correspond to a moisture difference of +0.75 %. In the worst case scenario, the +0.75 % moisture then corresponds to an error of +17 l/m³!
- Additives in the concrete behave like water during the kiln-drying process, i.e. they enter into the measurement of the kiln-dry water content and the measurement with the SWZ probe.
- There are additives that bind water chemically in such a way that water is crystalline-bound relatively quickly and therefore cannot fully escape during the kiln-drying process (particularly if kiln-drying with a microwave without stirring).

If the measurement performed with the SWZ probe does not match a correct kiln-dried sample which is measured in parallel, it is possible to set the device to a correct water measured value using the "G-Set" parameter in the "CHANGES" menu.

9.3.1 Material sample



19 Gravel

The importance of having a representative sample for kiln-drying is illustrated using the example of this 32mm piece of gravel. Given a sampling volume of 1.5 kg for kiln-drying with a microwave, this single piece of gravel represents a value of 5.3 l/m³ of water! If 5 kg of sample is kiln-dried, the piece of gravel still represents 1.5 l/m³. Therefore, one piece of gravel more or less can produce considerable errors, depending on the kiln-drying method and sampling.

9.4 Measurement of earth-dry fresh concrete (i.e. no-slump, stiff concrete) with F1 consistence

Stiff fresh concrete with an F1 consistence class has large air pockets and cannot be measured with the SWZ probe.

9.5 The three types of water measured by the SWZ probe

The SWZ probe measures the same parts of water as the kiln-drying method:

- **The free water** in the concrete mix which enters into the calculation of the w/c-ratio. This water is the actual value that is sought when using the SWZ probe.
- **A share of the core water**, water that is absorbed by the aggregates. The SWZ probe can only measure a share (approx. 1/3) of the core water here. The core water can be 5 to 35 l/m³ depending on the type of rock. This (correction) value is represented in the G-Set parameter (approx. 2/3 of the core water), depending on the formulation and rock. The G-Set value is typically −10 l/m³ assuming a typical core water value of 15 l/m³ of water. These −10 l/m³ are automatically subtracted from the measurement in the device so that the reading in the device matches the effective water content.
- **Additives** that behave like water are also measured by the SWZ probe. This must be taken into consideration.

9.6 Air voids, glass fibers and steel fibers

Air voids and glass fibers reduce the concrete density and therefore the moisture.

The SWZ probe does not react to either air voids or glass fibers. As a result, the water content it displays for concrete with air voids or glass fibers is somewhat too high. Depending on the proportion of air voids or glass fibers, the reading shown on the device can be 5 to 10 l/m³ too high. We recommend reducing the G-Set parameter in the device by −5 to −10 l/m³, depending on the concrete formulation.

In the case of concrete with steel fibers, the water content displayed by the device is also somewhat too high due to the steel content. Here too it is recommended to reduce this by −5 to −10 l/m³ in the device using the G-Set parameter.

10 Managing and archiving concrete formulations

With the correct settings for the CHAR parameter (fine, coarse, normal, special) and G-Set parameter (core water and additives), the measurement results of the SWZ probe should correlate relatively well with verified actual values or target values. In order to achieve the best possible accuracy with the SWZ probe, we recommend that you document the necessary settings for the handheld terminal if different varieties of concrete are used and checked repeatedly.

The following list shows one way of archiving the information.

- **Variety of concrete or variety number:** F600TL
  - Target raw density: 2.422
  - CHAR parameter: coarse
  - G-Set parameter: -10
- **Variety of concrete or variety number:** AAV2
  - Target raw density: 2.441
  - CHAR parameter: normal
  - G-Set parameter: -5
- **Variety of concrete or variety number:** 163802
  - Target raw density: 2.330
  - CHAR parameter: normal
  - G-Set parameter: -8
- **Variety of concrete or variety number:** 3716CL
  - Target raw density: 2.367
  - CHAR parameter: fine
  - G-Set parameter: -5

11 S1 moisture probe

The handheld device can be used in conjunction with the S1 probe to measure moisture in sand, gravel and other bulk solids.

11.1 Connecting the S1 probe

1. Connect the S1 probe to the handheld device
   ↳ Insert the 7-pin plug into the socket provided on the handheld device
2. Tighten the coupling nut
   ↳ The handheld device detects the probe automatically

Meaning of displayed text:
- **Cal.:** number of the active calibration in the probe
- **Moisture:** moisture measured value
- **EC-T:** electrical conductivity based on TDR measurement
- **Serial No.:** serial number of the probe
- **HW:** hardware version
- **FW:** firmware version

11.2 Measurement

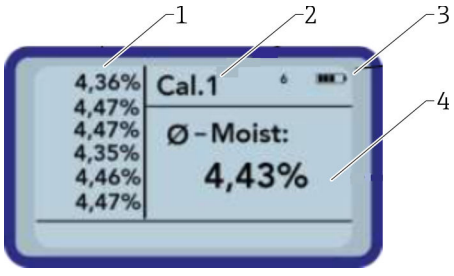
The handheld device operates in the "Average" operating mode in connection with the S1 probe.
"Average" operating mode: in the "Average" operating mode, the device displays the average moisture value calculated from up to 6 individual measurements

No additional actions are possible during a measurement. The user must wait until the measurement is finished.

11.2.1 "Average" operating mode

In this mode, only the moisture is determined and an arithmetic average is calculated from up to six individual values. The gravimetric moisture is displayed here. This operating mode is suitable for measuring the moisture values of large volumes of material (e.g. sand, gravel etc.).

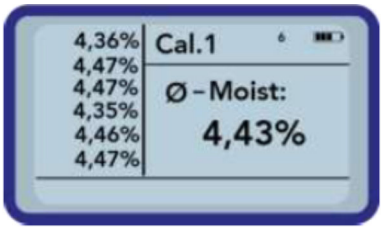
After switching on the handheld device, the following screen is displayed in the "Average" operating mode after the initial start-up screen:



1 Individual measurement values
2 Number of the selected calibration
3 Remaining battery capacity
4 Average of the measurements

1. Press the Enter key briefly to start the measurement
   ↳ The device starts measuring and a rotating symbol appears in place of the battery symbol in the top right-hand corner for the duration of the measurement process. No other actions can be performed during this time. The measurement takes around 4 to 5 s. Once the measurement is finished, the battery symbol appears on the display again. The individual measurements are displayed on the left of the screen. The last measured value appears at the top of the list, and older values are displayed one position down. The arithmetic average is displayed on the right of the screen. The average value is calculated from the existing individual values (maximum of six).
2. To delete the measurement series, press the "Down" navigation key

Only a maximum of 6 values can be saved temporarily in the list. Older values are removed from the list and are no longer used to calculate the average.

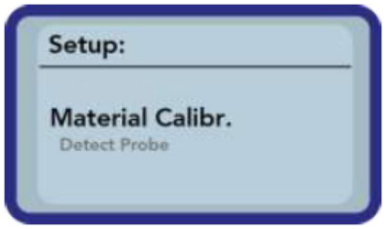


Six measurements in the "Average" operating mode already gives the user a representative measurement result for all the measuring points over a broad range of material.

11.3 Settings

The settings for the handheld device can be changed and adjusted in a variety of ways.

1. Press the Folder key
   ↳ The following menu structure appears



2. Select the desired entry using the navigation keys
3. Press the Enter key to select
4. Press the Folder key
   ↳ This user exits the current menu item and the Setup menu

Overview of the configuration options

- **Mode:**
  "Average": get an average of up to 6 moisture measured values
- **Material cal.:**
  - Select the desired material calibration in the probe
  - Customize a material calibration
- **Find probe:** search again for a connected probe (if an error occurred during power-up)
- **Language:** change the system language
  - German
  - English

- **Auto-power-off:** setting for automatic switch-off
- **Display lighting:** setting for background lighting
  - Switch-off time
  - Brightness
- **Display contrast:** setting for the optimum contrast
- **Probe info:** displays information about the probe
- **Info:** displays information about the handheld device

11.3.1 Average mode

In the "Average" operating mode, only the moisture is determined, in %grav, or the transit time in tp. The measured value is saved temporarily in a list with up to six measured values. The arithmetic average is calculated from this list.

Only a maximum of 6 values can be saved temporarily in the list. Older values are removed from the list and are no longer used to calculate the average.

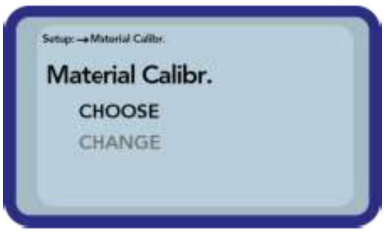
11.3.2 Material calibration

Different calibrations are saved in the probe depending on the intended application of the probe. This can be gravimetric calibrations for sand moisture measurements or also transit time calibrations, for example.

In the "Material calibration" menu item, the necessary calibration can be selected, depending on the application. In this way, one probe can cover a variety of applications.

In addition, it is also possible to perform your own calibrations in order to be able to measure special materials.

1. Select the "Material cal." menu item
2. Select either "Choose" or "Change"



"Choose": set one of the 15 calibrations
"Change": program a new calibration to one of the 15 calibrations saved in the memory

"Choose" menu item

The 15 calibrations, and the names of the calibrations, appear on the display. Then a screen similar to that shown below appears:

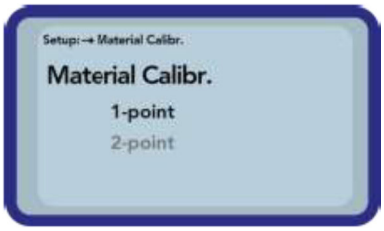
1. Use the navigation keys to scroll through the list and select the desired calibration. The "!" symbol in front of a calibration indicates the calibration that is currently active.

2. Press the Enter key
   ↳ This activates the selected calibration
   Afterwards, the 💾 symbol appears in the top right-hand corner of the display indicating that the option has been activated. In addition, the "!" symbol appears in front of the active calibration.

Press the navigation key ▲ to go directly from the measuring screen to the "Choose" menu item

"Choose" menu item

You can perform your own material calibrations or customize existing calibrations to suit your particular needs. Two options are available for this:



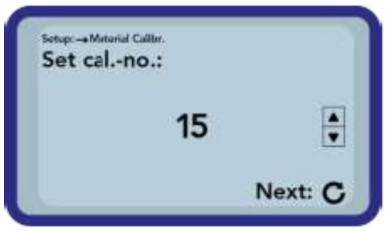
- **1-point calibration:**
  - Adjusts the calibration curve to the selected point
  - The slope is not changed as a result
  - Just one material sample is required
- **2-point calibration:**
  - Creation of a linear calibration between two measured points
  - Two material samples with different moisture values are required

1-point calibration:

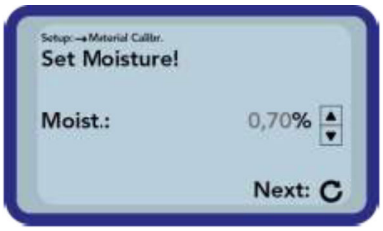
This material calibration option merely adjusts (offsets) the configured calibration. As the slope is not changed, it is important at the start to select a calibration curve that suits the material.

A sample of the material being measured is required to perform a 1-point material calibration. The moisture value must be determined with another laboratory method (e.g. moisture analyzer, kiln drying) before the calibration.

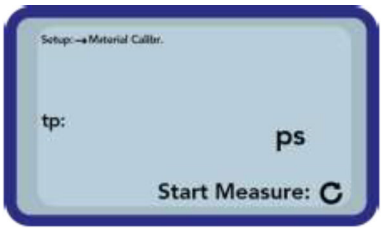
1. Set the calibration memory (01 – 15) to be overwritten value using the navigation keys
   ↳



2. Press the Enter key
   ↳ The setting is accepted

3. Select the percentage moisture using the navigation keys
   ↳


4. Press the Enter key
   ↳ The setting is accepted
5. Press the Enter key again
   ↳ The material measurement process is started



   Four measurements are taken in order to increase the accuracy. An average of these measurement values is then calculated. The measuring time is approximately 20 seconds. When the measurement is finished, the measured pulse transit time is displayed briefly.

6. After this, the calibration can be saved to the calibration memory set at the start ("Save").
   ↳

7. Press the Enter key
   ↳ The selected memory is overwritten.
   The word "OWN:" now appears in front of the original memory name to clearly indicate which memory has been overwritten.

NOTICE

If "SAVE" is selected at the end of the calibration, one of the pre-configured (or already modified) calibrations in the probe is overwritten!

► The original calibrations can only be restored by our Service Department.

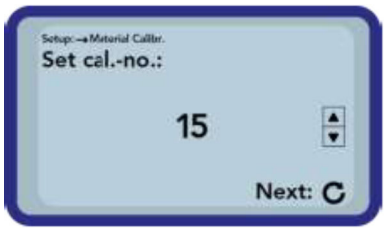
Before the measurement commences, make sure that the rods of the probe are fully immersed in the material to be measured. The probe must remain in the material for the entire duration of the measurement and should not be moved.

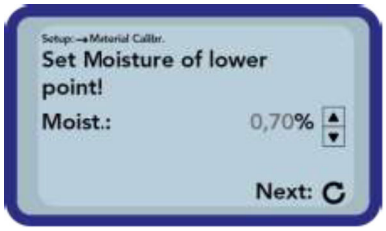
2-point calibration:

In a 2-point calibration, two material samples of different moisture content are measured and a linear equation (f(x)=mx+b) is then calculated from this information. While a

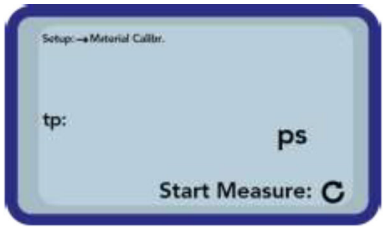
higher-value polynomial is useful to achieve better accuracy, the linear equation often suffices, particularly in the lower moisture range, and delivers very good results.

Two material samples with different moisture values are required to perform a 2-point material calibration. The moisture values must be determined with another laboratory method (e.g. moisture analyzer, kiln drying) before the calibration. It is important to adhere to the following sequence: first "lower moisture value" (drier material) and then "upper moisture value" (wetter material).

1. Set the calibration memory (01 – 15) to be overwritten value using the navigation keys
   ↳
   

2. Press the Enter key
   ↳ The setting is accepted
3. Select the percentage moisture of the lower moisture value using the navigation keys
   ↳
   

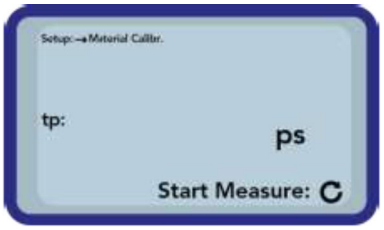
4. Press the Enter key
   ↳ The setting is accepted
5. Press the Enter key again
   ↳ The material measurement process is started

   Four measurements are taken in order to increase the accuracy. An average of these measurement values is then calculated. The measuring time is approximately 20 seconds. When the measurement is finished, the measured pulse transit time is displayed briefly.
6. Select the percentage moisture of the upper moisture value using the navigation keys
   ↳
   

7. Press the Enter key
   ↳ The setting is accepted

8. Press the Enter key again
   ↳ The material measurement process is started



   Four measurements are taken in order to increase the accuracy. An average of these measurement values is then calculated. The measuring time is approximately 20 seconds. When the measurement is finished, the measured pulse transit time is displayed briefly.

9. After this, the calibration can be saved to the calibration memory set at the start ("Save").
   ↳

10. Press the Enter key
    ↳ The selected memory is overwritten.
    The word "OWN:" now appears in front of the original memory name to clearly indicate which memory has been overwritten.

NOTICE

If "SAVE" is selected at the end of the calibration, one of the pre-configured (or already modified) calibrations in the probe is overwritten!

► The original calibrations can only be restored by our Service Department.

Before the measurement commences, make sure that the rods of the probe are fully immersed in the material to be measured. The probe must remain in the material for the entire duration of the measurement and should not be moved.

11.3.3 Find probe

Select this menu item if:

- There were communication problems with the probe when the handheld device was switched on
- A probe has not yet been connected
- The probe is to be changed during operation

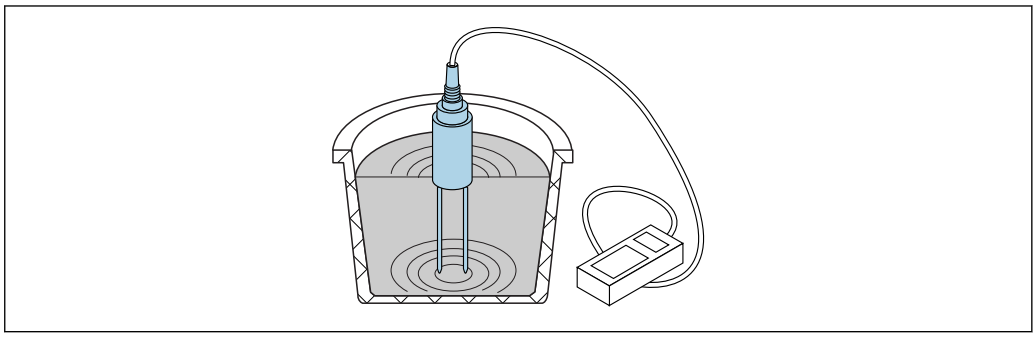
Once this menu item has been selected, the handheld device makes another attempt to establish a connection to a connected probe. The serial number of the probe appears on the display as soon as the connection has been established successfully. "Probe not found" appears on the display if a connection cannot be established.

If a connection is not established, check that the probe is connected correctly. If this does not rectify the problem, please contact the Service Department.

11.4 Using the S1 probe

11.4.1 Measuring volume

In theory, the electric and magnetic field lines penetrate the material to be measured to an infinite depth. However, the effective penetration depth of the S1 probe, which is relevant for measurement, is approximately 80 mm (3.15 in) (twice the distance between the rods).



A0040907

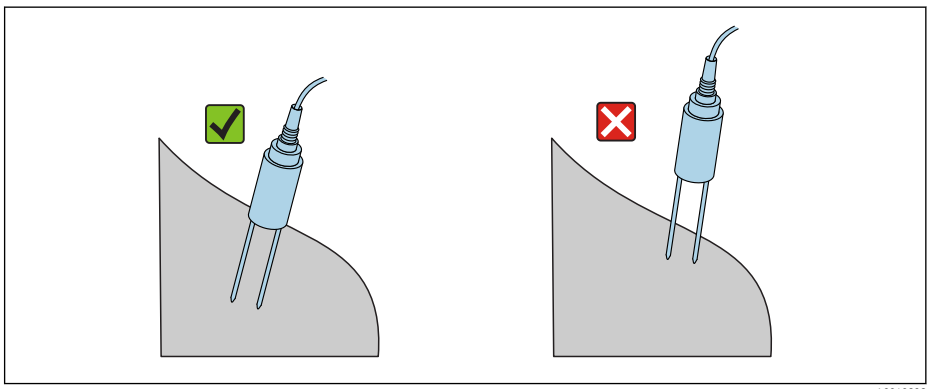
20 *Effective measuring volume (waves illustrated)*

11.4.2 Accuracy

Recommended approach to achieve the best possible accuracy with the S1 probe

Perform measurements directly in piles of sand and gravel

1. Insert the probe as far as the blue probe body into the material to be measured



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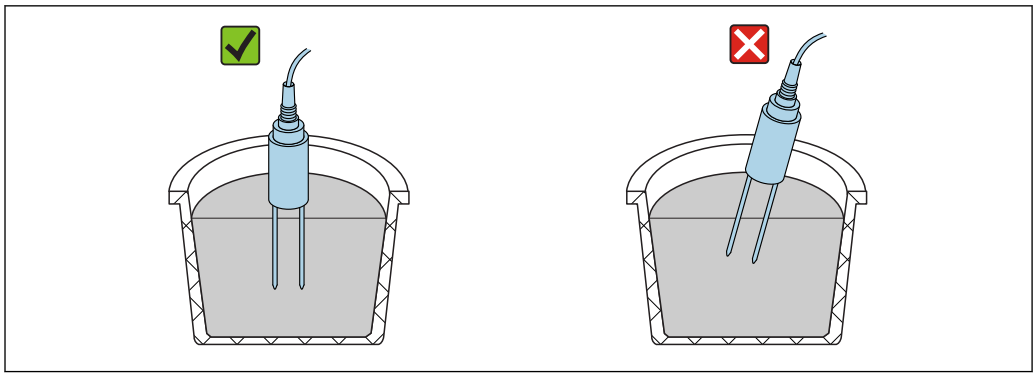
2. Select the "Average" operating mode
3. Take measurements at different points
   ↳ This produces a representative moisture value for the material

After a longer period of dry weather, the material will be drier at the surface than in lower layers. However, if it has recently rained after a longer dry spell, the material at the surface will be wetter. For the best measurement result, the moisture should be measured at different points and at different depths.

Measurement of laboratory samples in a bucket

The following conditions must be met to achieve the best possible accuracy of results:

The entire length of the rod probes must be located in the material to be measured



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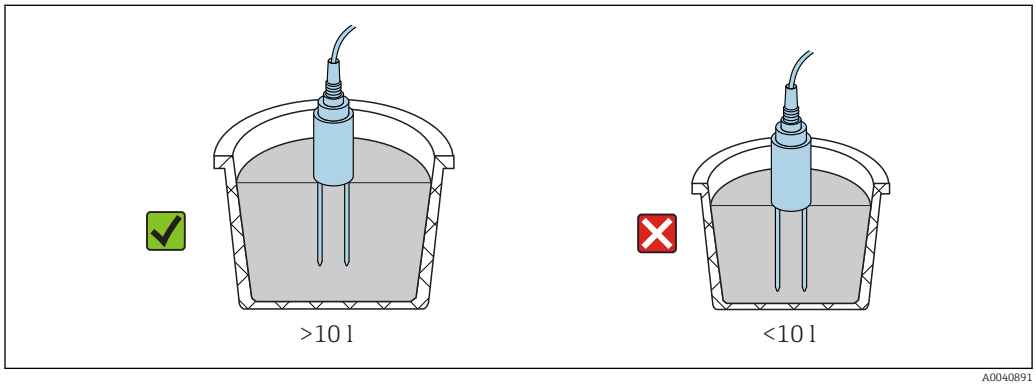
The container must have a volume of 10 l or more and must be of a non-metal material



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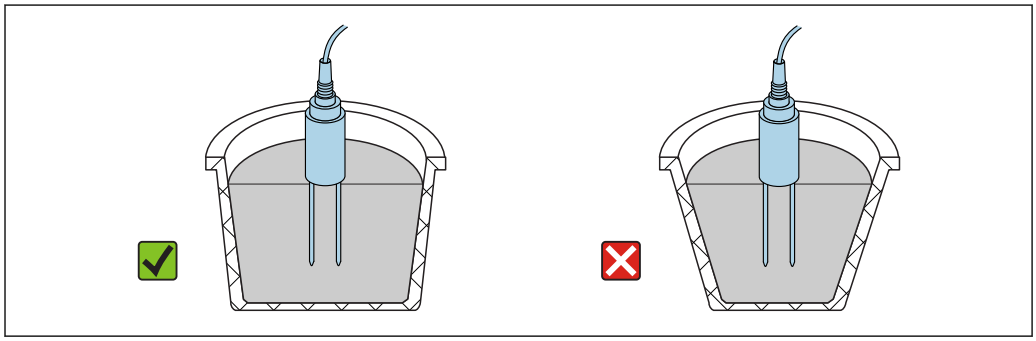
The container must be roughly cylindrical



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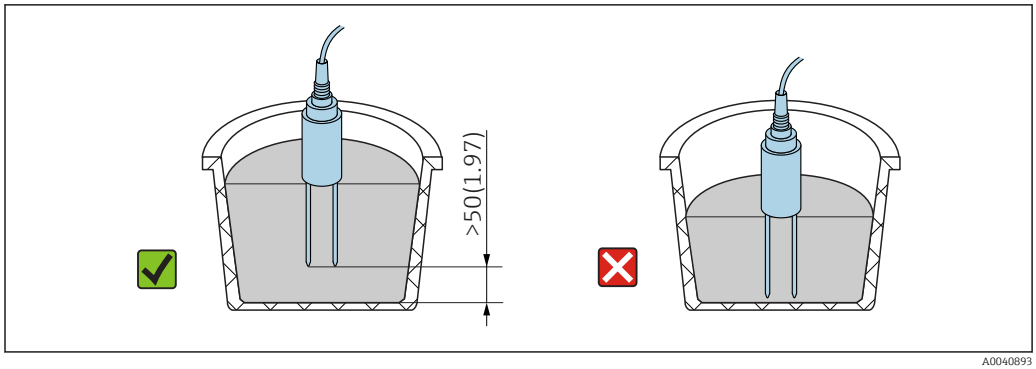
The level of product in the container must be at least 5 cm greater than the probe rod length



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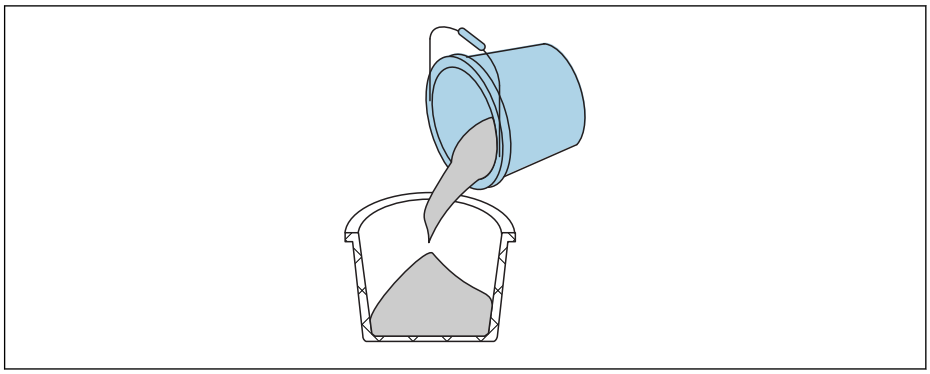
Take the measurements according to the following procedure:

1. Fill the container with sand



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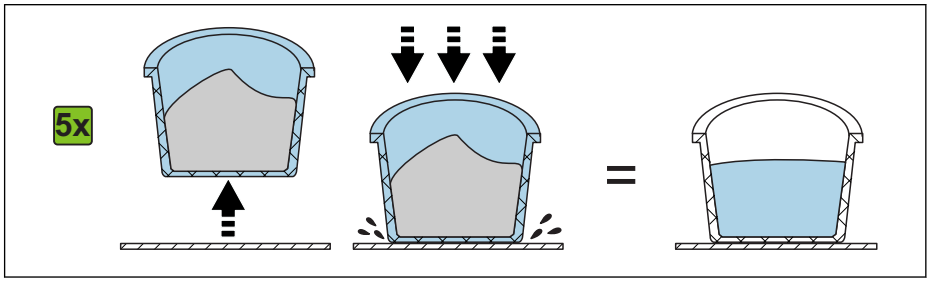
2. Lift the container approximately 5 cm and then drop it. Repeat this five times (more if necessary).

   ↳ This packs (compresses) the sand.



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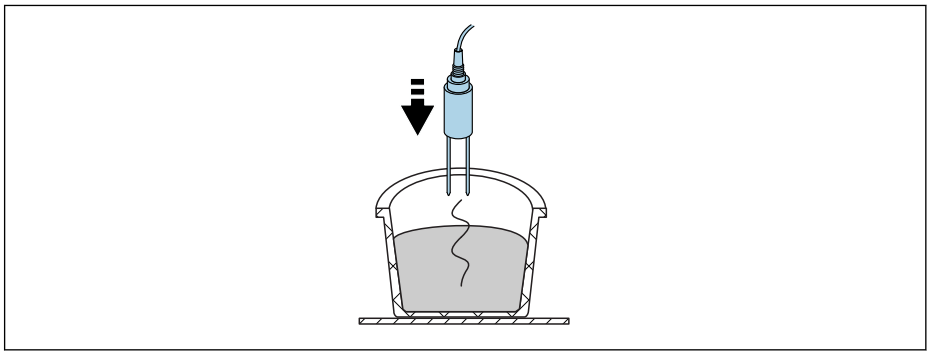
3. Insert the probe into the sand. Once the base of the probe reaches the sand surface push the probe in slightly further (do not jiggle the probe or turn it while inserting it!). In the case of gravel and grit, shake the container while introducing the probe. Otherwise it is very difficult to introduce the probe into the material. Shaking the container places the material optimally around the probe rods.



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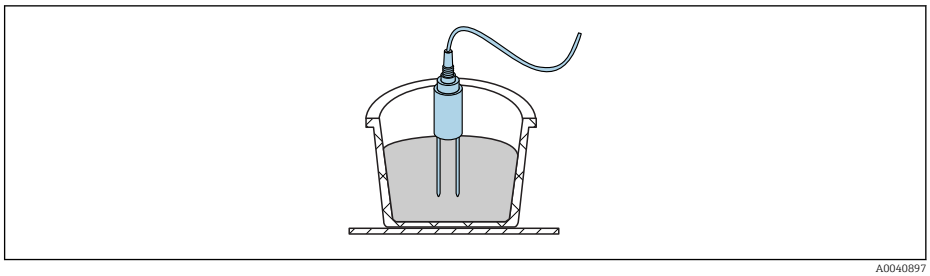

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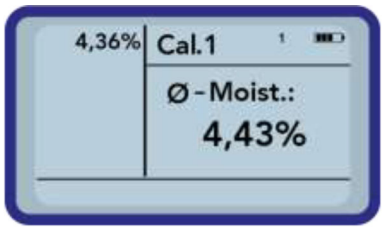
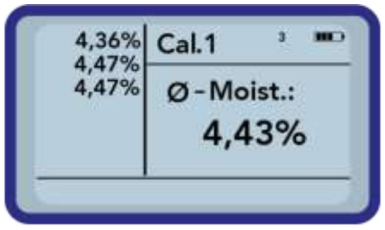
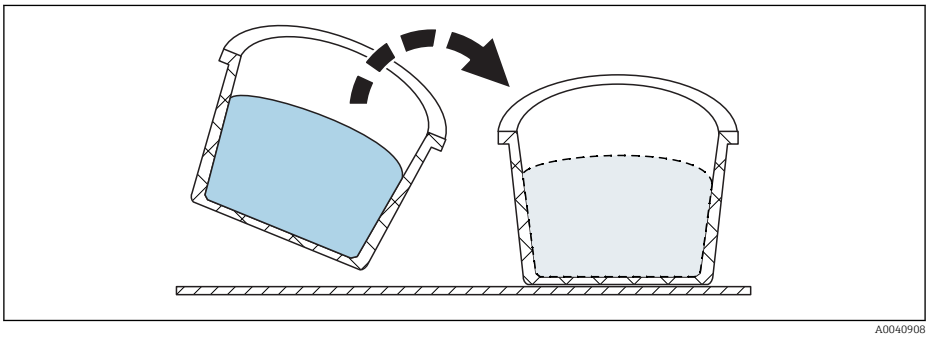
4. Take the measurement with the handheld device



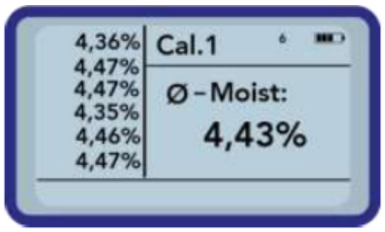
5. Remove the probe from the sand and shake the sand to loosen it again
6. Repeat steps 2 to 4 two more times so that you have 3 measured values in total



7. Pour the sand into a second bucket so you can take readings from the sand at the bottom (this is particularly relevant for gravel and if the sand is close to saturation as any free water can settle at the bottom of the container!)



8. Repeat steps 2 to 4 three more times so that you have 6 measured values in the end



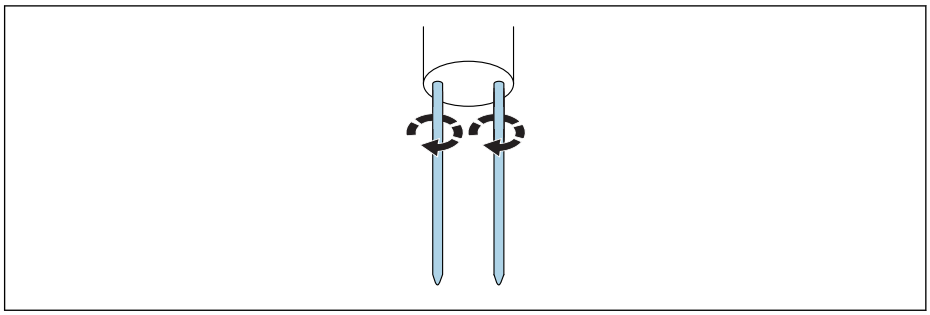
9. Document the average of the 6 measurements

11.4.3 Replacing the probe rods

The probe rods in the S1 probe can only be replaced by the Service Department.

In the case of the S1C probe, you can replace the rods as follows:

1. Unscrew the probe rods from the probe body



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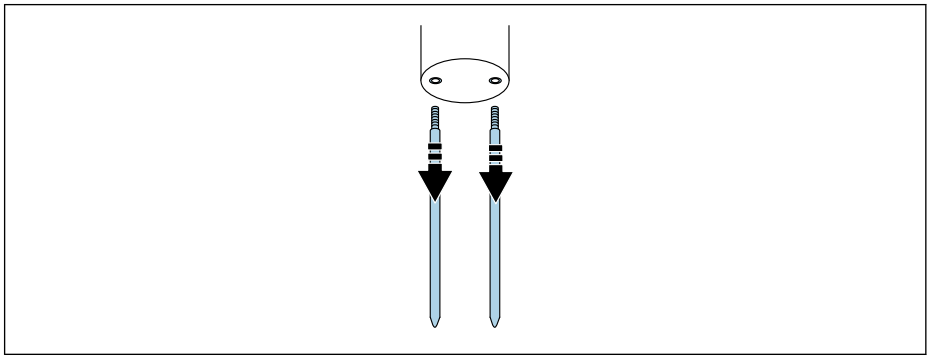
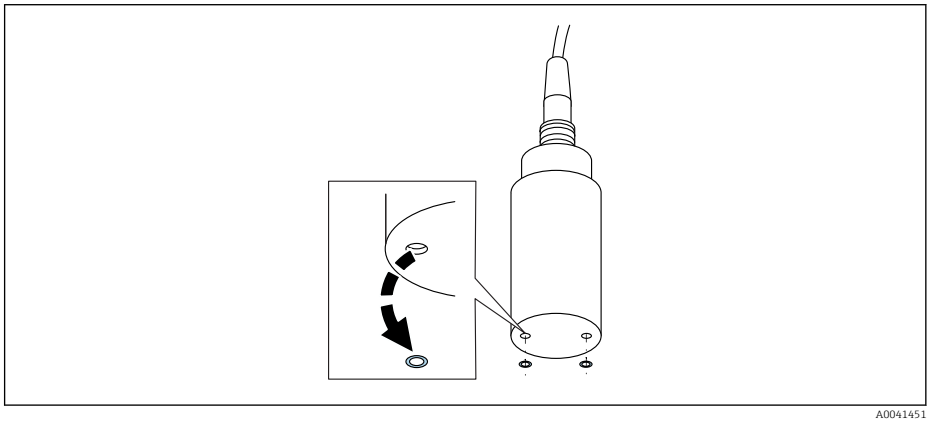
2. Remove the probe rods



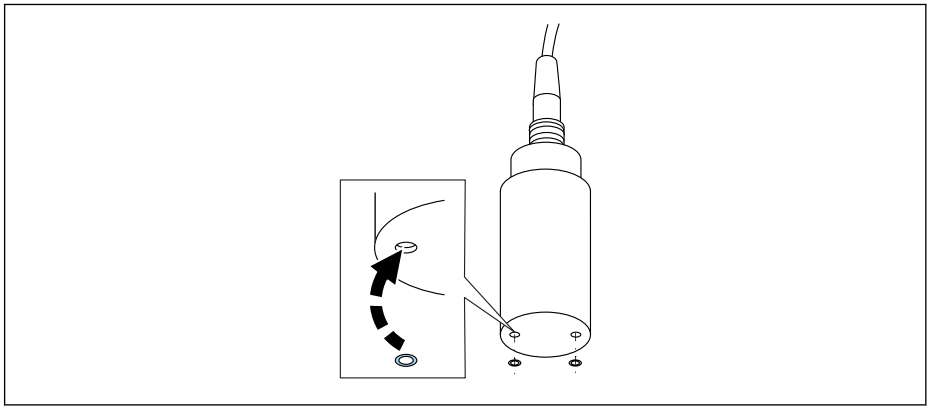
A0041450

3. Remove the sealing rings



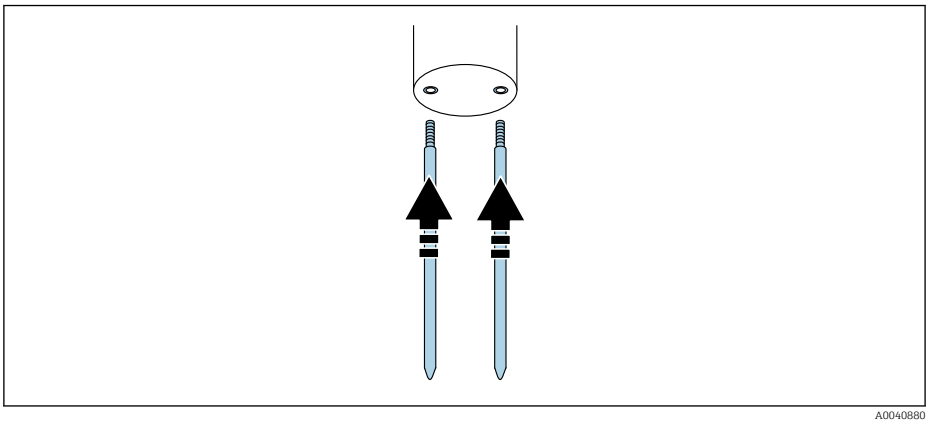
A0041451

4. Insert new sealing rings into the bore holes and push them in as far as the thread



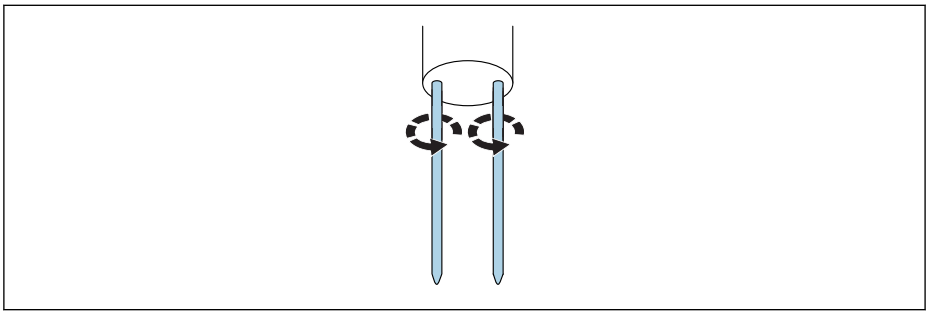
A0040879

5. Insert the probe rods



A0040880

6. Screw the probe rods into the probe body



A0041452

12 Technical data

12.1 Handheld device

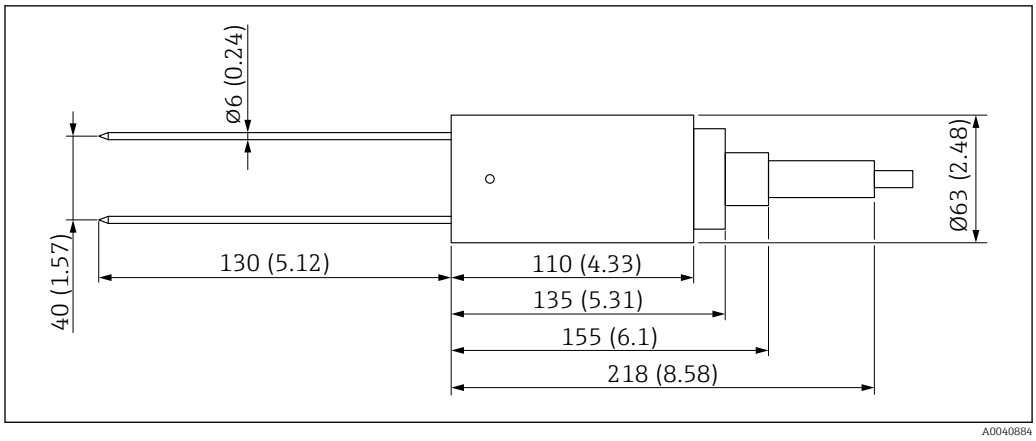
- Height: 36 mm
- Width: 64 mm
- Length: 150 mm
- Weight: (with battery) approx. 437 g
- Power demand:
  - Power down: 35 µA
  - Idle:
    - Background lighting off: 26 mA
    - Background lighting on: 56 mA
  - Probe switched on: 100 mA
  - Measurement: 350 mA
- Measurements per charge: up to approx. 5000 (20 °C / background lighting max.)
- Probes that can be connected: SWZ, S1, S1C, S2
- Storage temperature: −20 to +70 °C (−4 to +158 °F)
- Operating temperature: −20 to +70 °C (−4 to +158 °F)
- Charging temperature: 10 to 30 °C (50 to 86 °F)
- Charging voltage: nom. 12 V, max. 15 V, min. 12 V
- Charging current: approx. 1 A
- Charging time: approx. 2 hours if battery fully discharged
- Accumulator: Ni-MH (4 × 1.2 V) (AA), 2 000 mA/h, >1000 measurements
- Physical BUS: RS485
- Bus protocol: IMP-BUS protocol II

12.2 SWZ probe

- Power supply: 12 to 24 V_{DC}
- Current consumption: 150 mA @ 12 V_{DC} during 2 to 3 s measuring cycle time
- Measuring range: 0 to 100 % vol. water content
- Repeatability, water content measurement (with probe at rest in concrete): ±2 l/m³
- Absolute accuracy: ±3 % of the water quantity
- Conductivity range: 0 to 20 dS/m
- Measuring volume: 0.5 l
- Probe temperature range: 0 to 50 °C (32 to 122 °F)
- Calibration:
  - Pre-programmed calibrations for fresh concrete
  - Own calibrations possible
  - Up to 15 calibration curves can be saved in memory
- Degree of protection: IP68
- Dimensions: 155 mm× 60 mm
- Interfaces: 1.5 m cable with 7-pin coupling socket

12.3 S1 probe

For moisture measurement of bulk solids such as sand and gravel
- Sensor with integrated TDR electronics
- Screw thread: M28 × 1.5 (on cable side)



- Power supply: 12 to 24 V_{DC}
- Current consumption: 100 mA @ 12 V_{DC} during 2 to 3 s measuring cycle time
- Measuring range: 0 to 25 % vol. water content
- Accuracy: up to ±0.2 % abs vol. water content
- Conductivity range: 0 to 1 dS/m
- Repeatability: ±0.3 %
- Temperature drift: ±0.3 %
- Measuring volume: 1 lcorresponds to Ø 130 mm × 100 mm
- Probe temperature range: −15 to 50 °C (5 to 122 °F)
- Calibration: pre-programmed calibrations for sand, gravel and grit
  - Own calibrations possible
  - Up to 15 calibration curves can be saved in memory
  - Calibration curve possible for the dielectric constant
- Degree of protection: IP68 (PVC)
- Dimensions: 155 mm× 63 mm
- Rod length: 130 mm
- Rod Ø: 6 mm
- Interfaces: 1.5 m cable with 7-pin coupling socket

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