Moisture sensors for agricultural engineering, hydrology and irrigation

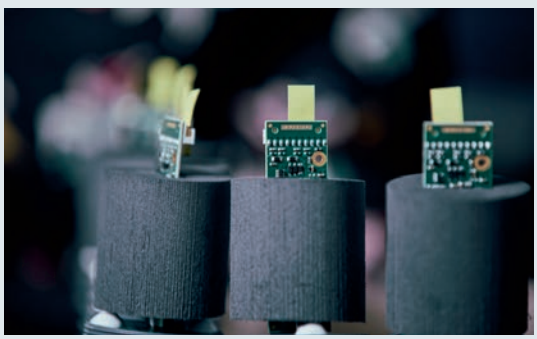
The right moisture sensor for every application

Moisture Sensor Experts

IMKO

History

- Founded in 1984 as an engineering firm, IMKO GmbH has been working on moisture measurement for over 30 years now.
- Based on the unique TRIME-TDR technology, IMKO experts developed sensors for science and meteorology in the early 90s. A few years later, the product range was extended with solutions for measuring moisture in grain, primarily for applications in the agricultural sector.
- Since the introduction of the SONO series in 2010, IMKO GmbH now offers a product portfolio that enables moisture measurement in any material, even for detection of just a few drops of water in solids, for example.
- Today, we are an innovative and motivated team of around 20 employees and, since October 2017, we have been a subsidiary of the Endress+Hauser Group. IMKO GmbH continues to develop and produce products with the "Made in Germany" quality mark at its original location in Ettlingen.



IMKO – Application fields

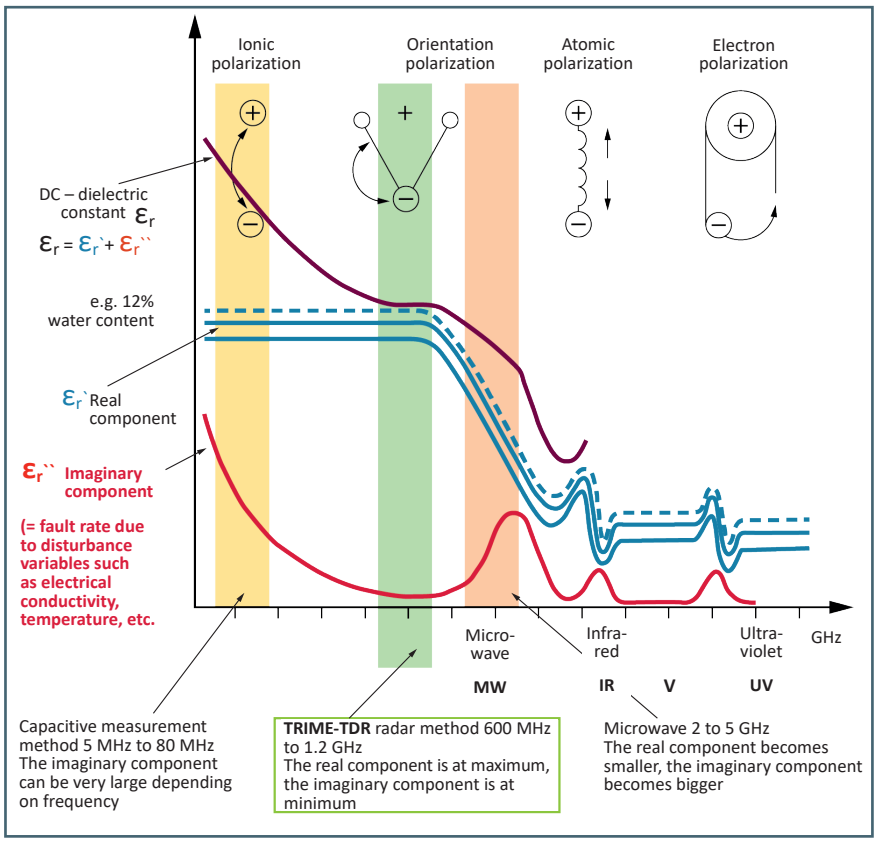
Soil

Concrete

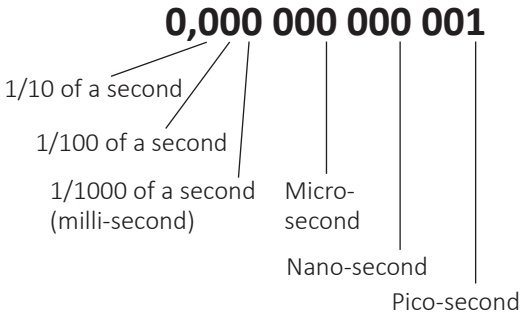
Bulk solids

The IMKO TRIME-TDR measurement method

The sensors developed by IMKO are based on measurement with **Time Domain Reflectometry**, or TDR for short.
In principle, this measurement method is suitable for a range of applications, such as cable break detection or even measurement of fill levels.
When applied specifically for measuring moisture in bulk solids and liquids, the physical effect is used, which correlates the propagation speed of electromagnetic waves with the dielectric properties of the material to be measured.
Since water has a significantly higher dielectric constant than the materials to be measured, such as sand, grain or even oil, it is possible to determine the water content with a high degree of accuracy.



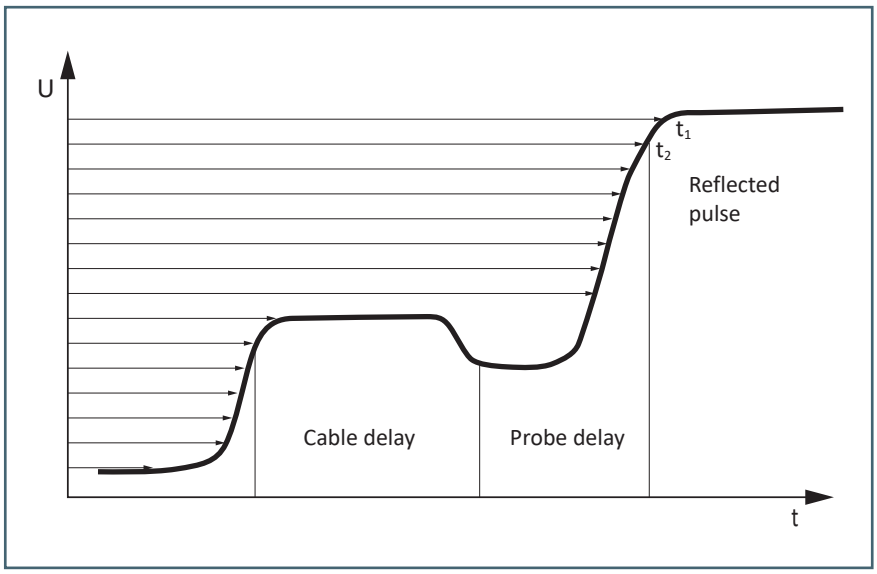
Time resolution of the IMKO sensory mechanism



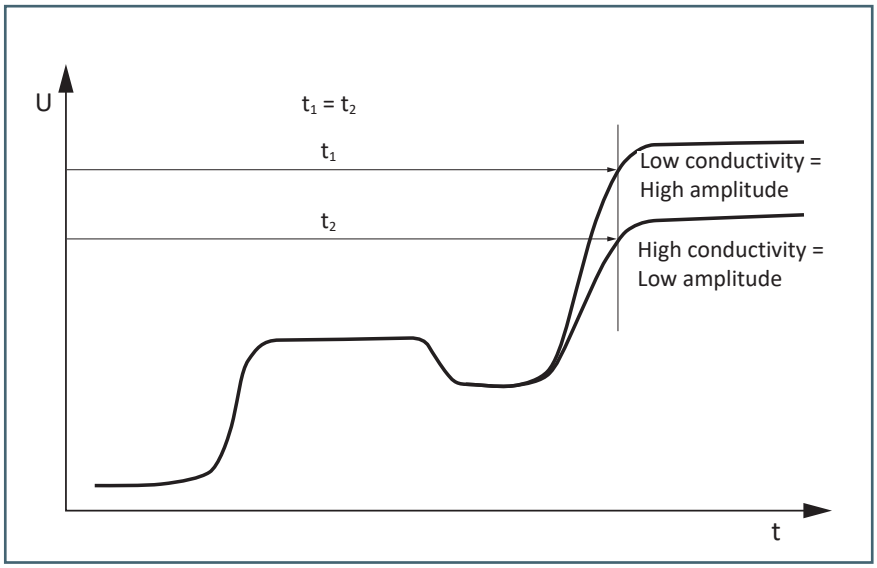
- Proprietary, automated and highly integrated measuring system
- No aging of the probes due to e.g. corrosion
- Long-lasting measuring technology also available as heavy-duty model for e.g. installation below railway tracks, airfields, movement areas and highways
- Very little calibration effort
- Various calibrations preinstalled
- Flexible geometry for different applications
- Free software for calibration & visualization
- Extensive range of training courses
- More than 25 years of expert knowledge

TDR measurement with the patented TRIME method

Implementing a TDR measurement is usually associated with significant technical effort. Very accurate pulses must be generated and the measurement requires the utmost in precision. Therefore, for a long time, TDR technology remained a laboratory measurement method kept back for science. Measuring devices based on TDR were not only very expensive, but also large and unsuitable for field use.
The TDR technology optimized by IMKO specifically for material moisture measurement, the **TRIME method** (**T**ime Domain **R**eflectometry with **I**ntelligent **M**icromodule **E**lements), is a robust measurement technology, which enables a compact and industry-compatible design with a very good price/performance ratio.



One of the biggest interference influences in all kinds of moisture measurement is the electrical conductivity of the medium to be measured. Electrical conductivity influences the measurement result. Even in tap water, the mineral content fluctuates over the year by up to 50% compared to the annual average. TDR technology is very robust as far as the electrical conductivity of the medium is concerned too. Intelligent signal analysis compensates for this disturbance variable and, if necessary, the analyzed signal can even be used to record the enrichment or discharge of minerals.



TRIME®-TDR – Winner of multiple awards
Innovation awards, such as the Bauma Innovation Award 2016 and DLG Approved certification from the German Agricultural Society (DLG – 2018), show how successful the high-tech potential of TRIME-TDR technology has proven in practice. Countless industrial and scientific projects have demonstrated the advantages of TRIME technology.

GEWINNER DES: bauma Innovationspreis 2016

ANERKANNT 2018 DLG WWW.DLG.ORG
IMKO TRIME GWS
✓ Messgenauigkeit Weizen
✓ Messgenauigkeit Gerste
✓ Messgenauigkeit Raps
DLG-Prüfbericht 6936

The PICO probe as a "moisture tomograph"

The diagram illustrates how the guided radar wave (in green) spreads with a velocity close to the speed of light. The sensor measures the material in a disk-like manner layer by layer similar to a computer tomograph.

What may seem complicated at first glance has substantial advantages in practical use of the sensor. Due to this method the sensor has a large and robust measuring field, able to measure without measuring disturbances, even if the prevailing soil is very heterogenous and varies.

The innovative sensor design is available in different adapted designs. Variable rod lengths are used to adjust the volume to be measured. This ensures a high degree of flexibility regarding mechanical integration in the applications.

Since the TDR measurement principle itself is very tolerant to heterogeneity of soils, the moisture can be determined very precisely over a wide range of soil conditions without a prior calibration.

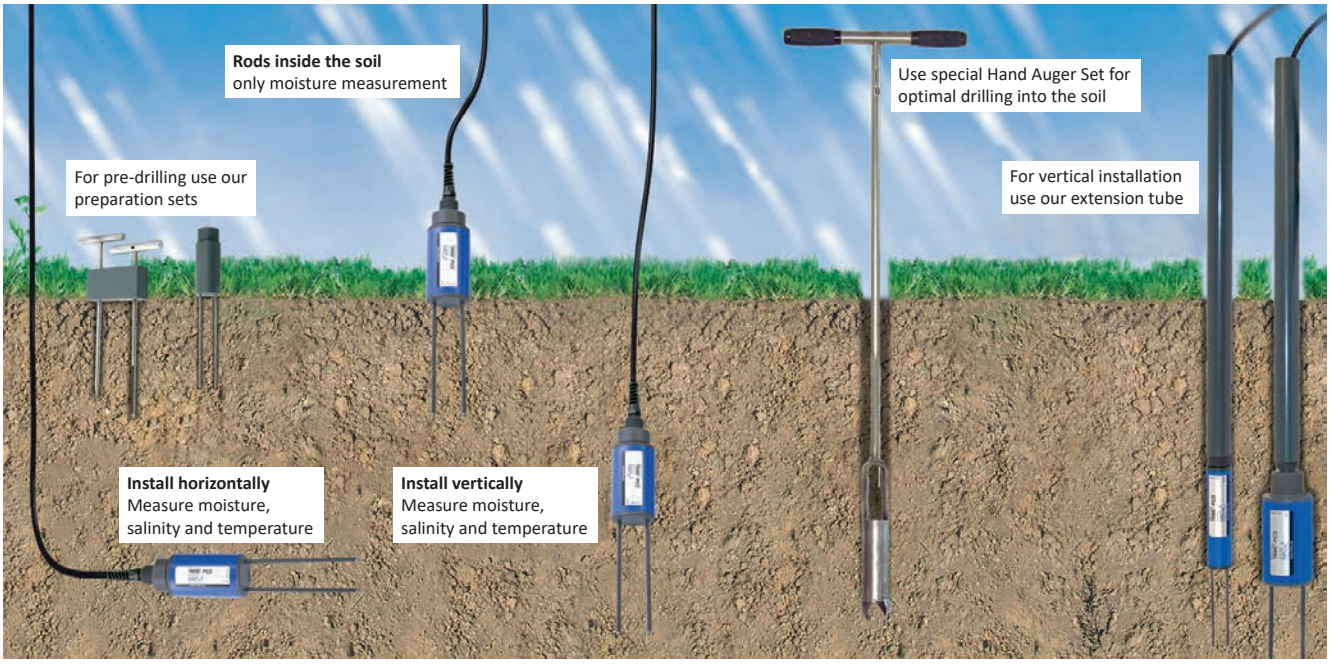
The determination of the electrical conductivity (EC) is very important for soils in agriculture. It correlates directly with the prevailing mineral concentration and can provide suppositions on the current fertilization status. Deviations from an optimal concentration of minerals have a negative impact on the crop yield. Our measurement technology enables a valuable contribution to an economically and ecologically sustainable management of farmland.

Plants require main nutrients such as nitrogen, phosphorus, potassium, magnesium in larger quantities. But micronutrients or trace elements such as iron, manganese or molybdenum contribute to crop yield as well as plant health. Nitrates are consumed by plants as nutrients and used in agriculture as fertilizers. They can be absorbed and used directly by plant organisms as a nitrogen source.
The optimal amount of ions or minerals in the soil is very important. Unadapted quantities of fertilizer may result in negative effects of soil and plants.

With IMKO TRIME TDR probes a very efficient method for measuring the salt content in soils has been introduced. By using coated rods, a determination of volumetric water content can be maintained even in salty environments and high conductivities. IMKO TRIME TDR detects salinity and states the value with “EC TRIME”. All measurements are maintained within fractions of a second without time consuming laboratory methods.

Examples of use

Applications vary from sand to pure clay with the same design of a sensor over a wide temperature range up to +50°C. Our soil moisture sensors are used in all areas with demand of precise and reliable moisture determination over a long period of installed sensor lifetime. The range of applications cover measurements in the substrate of a greenhouse, applications in deep field under the open sky, weather stations, scientific-geological applications, dams, applications in deep rock layers, mining, recycling, under railroad tracks and highways, in bridges and infrastructural buildings as well as measurements in sewage sludge and fresh concrete.



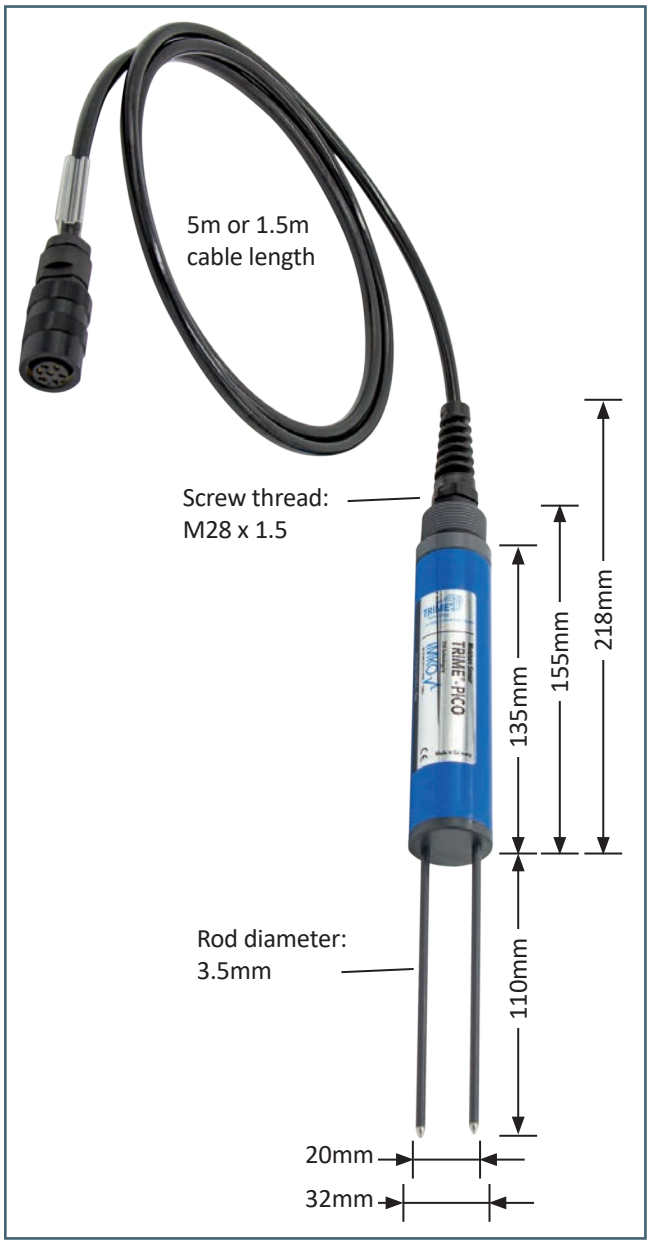
PICO32 – The measurement solution for high quality in resolution and selective measurement tasks

- Very compact dimensions
- Small cylindrical measuring field for high-resolution and near-surface monitoring (approx. 750ml measuring field size with 110mm rod length)
- Variable rod lengths: 50mm, 80mm and 110mm (standard 110mm) available
- Also suitable for laboratory applications
- Multiparameter probe (humidity, temperature and electrical conductivity)
- Various interfaces available
- Little calibration requirements thanks to TDR technology
- Durable and robust design in IP68

PICO32 – For near surface Monitoring or laboratory tasks

When it comes to measuring the soil moisture content, there are various requirements for sensors. In many applications, high-resolution measurements are to be carried out selectively in a very narrow pattern, for example when near-surface water conditions are intended to be investigated for water balance models or to attend evaporation experiments. But also in the laboratory or in the greenhouse, it is often necessary to limit the size of the moisture measuring field, so that undisturbed results are guaranteed. In all these applications, the PICO32 can demonstrate its assets . Thanks to the various interfaces, the probe can be integrated into many data environments without much effort.

As just described, the PICO32 is often used for volume-limited applications, as applications in topsoil, sports turf (golf, soccer), in parks, flower pots, scientific applications, in greenery on building facings and often to control irrigation or fertigation in agriculture. The application spectrum ranges from grown soil to artificial root ambience.

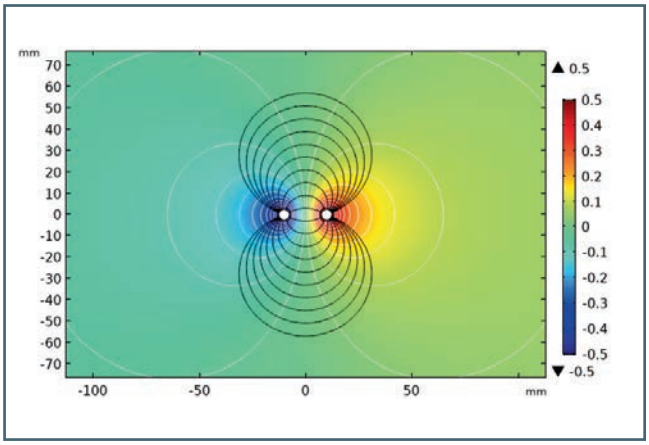


Interfaces

- RS485 (HD2 and PICO-BT)
- IMP-Bus (SM-SDI and SM-USB)
- SDI-12 (optional, for SDI-12 data logger)
- Analogue (0…1V, 0…20mA or 4…20mA)

PICO32 for measurements into soil - as a mobile probe, usually used with our HD2 handheld device or our Bluetooth® interface PICO-BT

PICO-BT Bluetooth Module to enable communication between PICO probes and any mobile Android device or smartphone. Incl. Battery, charger and software. The PICO-BT is an interface module and cannot save measurement data.



Measurement field of the PICO32 (size 750cm³)

Installation example close to the surface including cabling at the data station

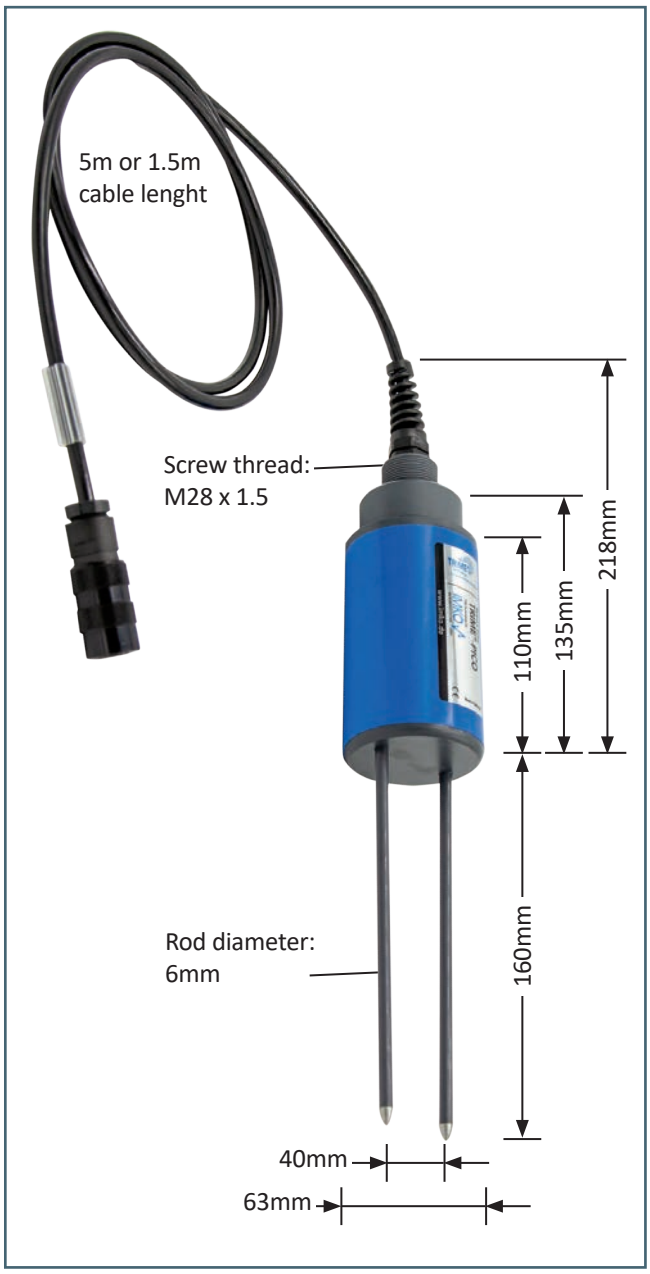
PICO64 – The measurement solution for heterogeneous soils and various measurement tasks

- Very rugged design
- Large measuring field for reliable measurement data even under difficult conditions
- Variable rod lengths 100mm, 160mm and 200mm (standard 160mm) available
- Suitable for measurements in stony heterogeneous soils
- Multiparameter probe (humidity, temperature and electrical conductivity)
- Various interfaces available
- Little calibration requirements due to TDR technology
- Durable and robust design in IP68

PICO64 – Precise measurements with a large measuring field in challenging conditions

Soils are frequently discovered homogeneous in their appearance close to the surface, with a positive impact on soil moisture probe installation: But subsurface conditions widely show heterogeneous patterns with increasing installation depths. A large proportion of stones, in an intended installation spot contrasts with installation and the measurement of soil moisture itself. In order to be able to produce a representative reading, large measurement fields are mandatory. The installation in woodlands and close to trees can cause difficulties if the roots have grown chunky. Especially for those cases the PICO64 is able to perform best, since the measuring field is not limited to the distance among the two probe rods, but a large volume of more than 2,5 liters around the probe rods. The probe can be integrated to almost every measurement environment without much effort thanks to the large variety of interfaces.

As previously described, the PICO64 is well known for its mechanical durability and is often used in infrastructure projects. The option of a ruggedized probe body brings even more stability e.g. for permanent installation under railway tracks, highways and infrastructural buildings (bridges, harbors, etc.).

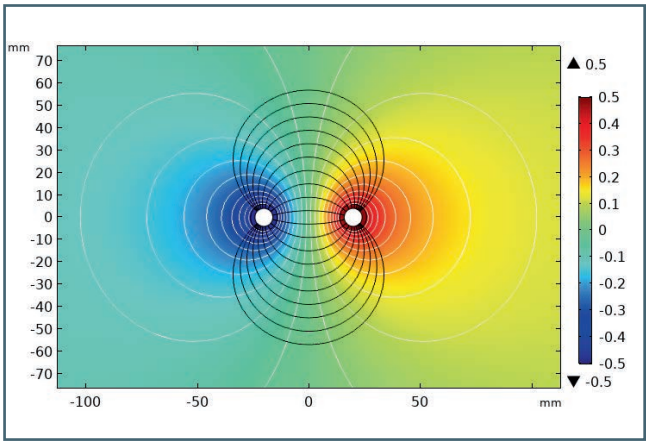


Interfaces

- RS485 (HD2 and PICO-BT)
- IMP-Bus (SM-SDI and SM-USB)
- SDI-12 (optional, for SDI-12 data logger)
- Analogue (0…1V, 0…20mA or 4…20mA)

PICO64 for measurements in the topsoil - as a mobile probe, usually used with our HD2 handheld device or our Bluetooth® interface PICO-BT

HD2 mobile handheld device to connect PICO probes for soil, sand and material moisture measurement. charger and rugged carrying case.



Qualitative representation of the PICO64 measuring field distribution (size approx. 2500cm³)

Example of the installation of PICO64 in an undisturbed subsoil

PICO IPH2 – The mobile measurement solution to realize depth-profiles

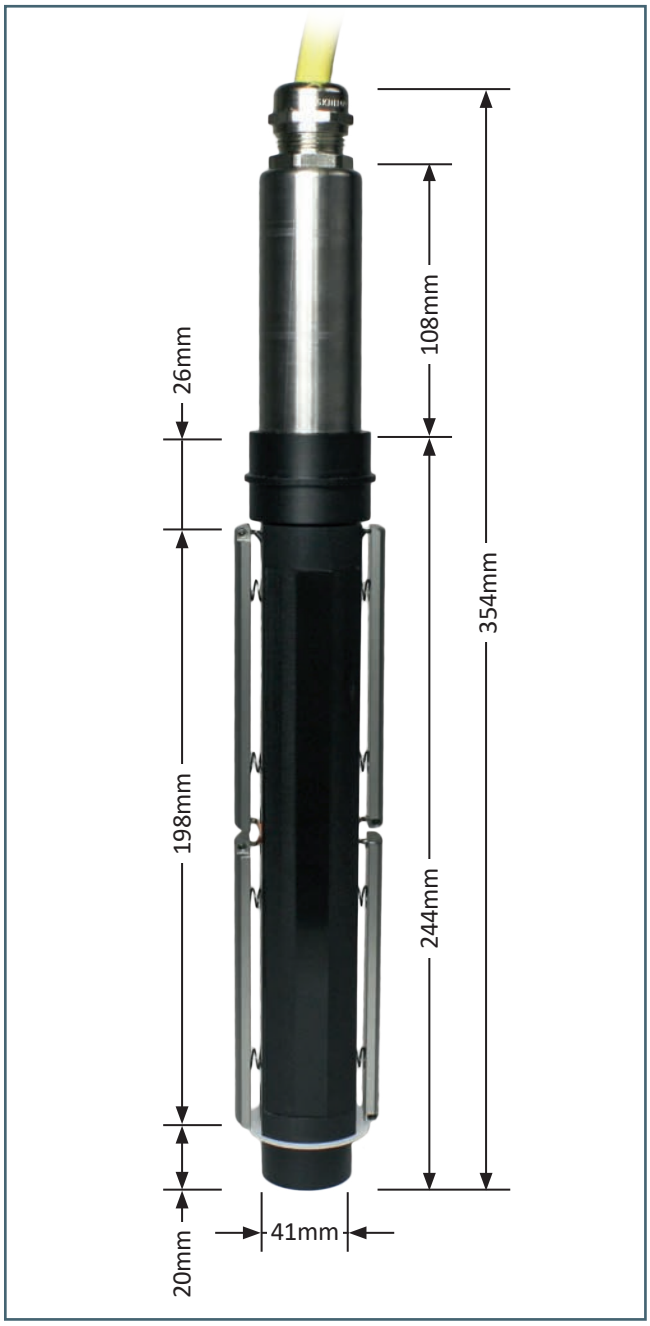
- Durable and rugged design
- Easy to use
- Very large measuring field for reliable measurements
- Simple installation of the measuring tubes without heavy equipment
- Profile measurement down to 3m depth
- Multiparameter probe (humidity and electrical conductivity)
- Little calibration requirements thanks to TDR technology

PICO IPH2 – Exact findings on the water balance in the vadose zones with easy to install equipment

A major unknown factor to establish a water balance model in a geography is the vadose zone, the unsaturated zone below soil surface and above the groundwater level. The acquisition of soil moisture data in this zone is essential to understand many other effects and take proper precaution accordingly: early flood warning, slope slide modeling, fog prediction for airports and highways. With the PICO IPH2 it is possible to acquire soil moisture data along with mineral content information quick and comprehensive in a soil profile. The probe is mobile, so it is possible to maintain as many readings in different locations as favored. With this, a very narrow observation pattern can be maintained in order to feed models and take action for irrigation or other farming measures.

The IPH2 can be used very flexible. Cable lengths are available up to 3.5m length.

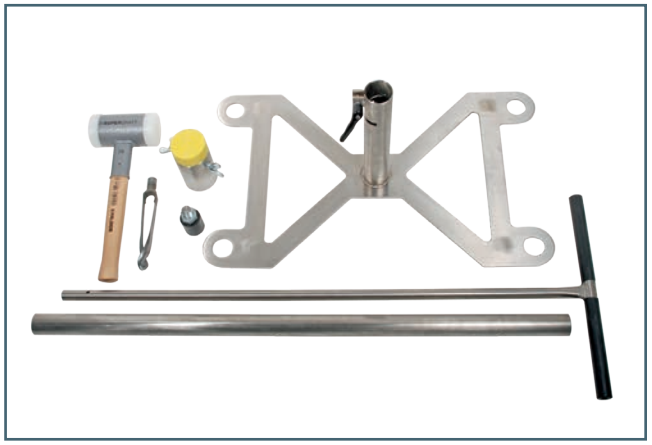
The larger brother of the IPH2 is the IPH T3 / 50, which can be customized with cable lengths up to 50m. The probes are designed to read 20cm segment wise with a large measurement volume into the surrounding soil.
Mobile probes hold a cost advantages compared to traditional static installations throughout the soil profile, since less probes are required and the probe itself is mobile to be used in many other locations, too.



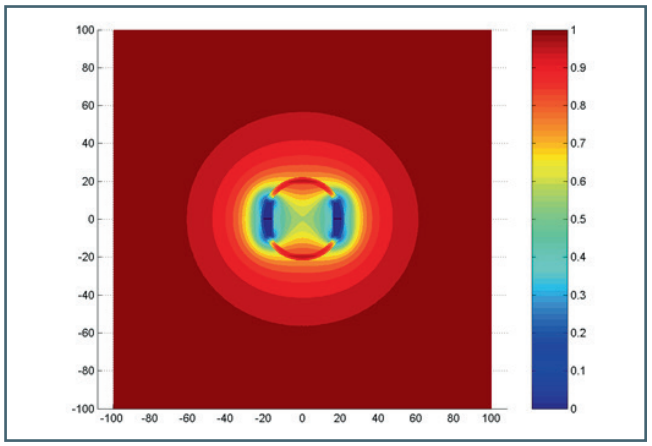
Interfaces

- RS485 (HD2 and PICO-BT)
- More on interfaces may be customized on request

Measuring with the PICO IPH2 using a pre-installed special polycarbonate tube



Auger equipment for precise and gap-free installation of the installation tube down to 1m depth



Qualitative display of the PICO IPH2 measuring field (size approx. 2500cm³)

Example of the utilization of an IPH2 in the undisturbed subsoil - the special polycarbonate tube is displayed in the center

PICO T3PN – The stationary measurement solution to realize simultaneous soil profile readings

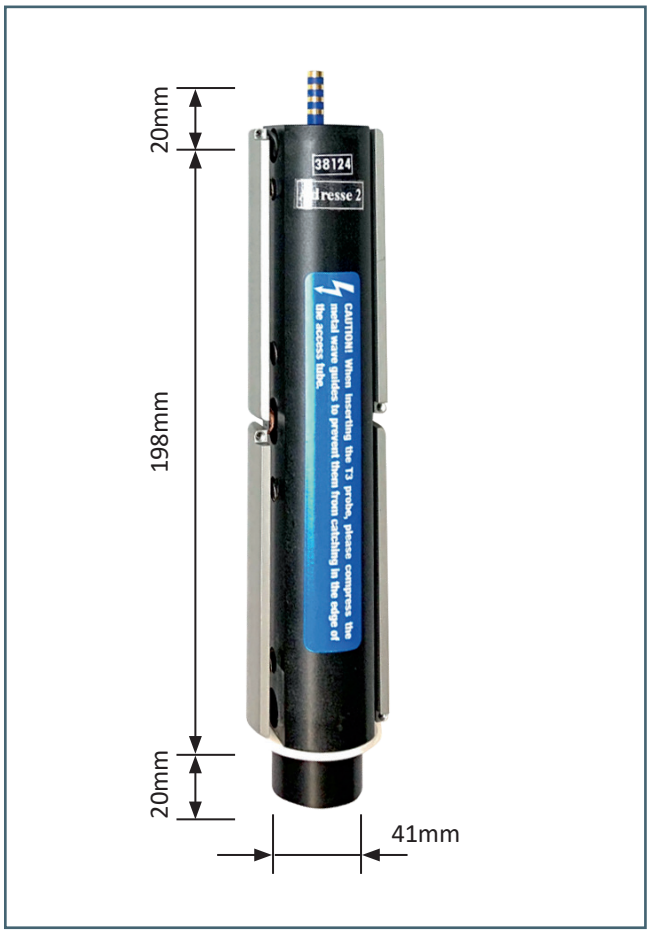
- Durable and rugged design
- Easy handling and configuration
- Very large measuring field for reliable measurement data
- Simple installation of the measuring tubes without heavy equipment
- Profile measurement down to 3m depth
- Multiparameter probe (humidity and electrical conductivity)
- Little calibration requirements thanks to TDR technology

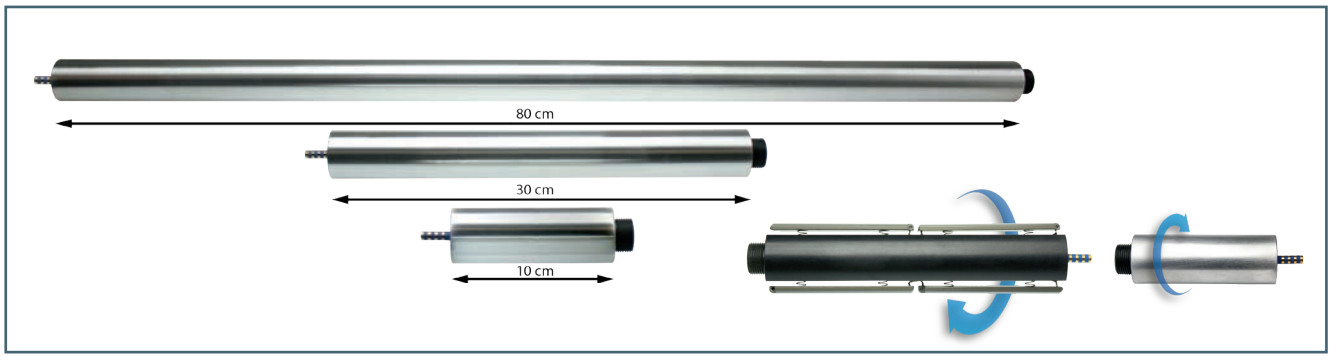
PICO T3PN – Exact findings on the water balance in the vadose zones with easy to install equipment

For many test scenarios, a measurement of a moisture profile once a day or even only once a week would fully suit the research or monitoring approach to track long-term trends. But with a more challenging scenario in terms of real time determination of soil moisture, electrical conductivity and temperature a more sophisticated approach is required. The design of the PICO T3PN allows to mount single 20cm PICO segments to each other or to spacer elements. This helps to design a specific profile probe, which will be able to generate reading in defined layers simultaneously. A classic setup would be an in/out setup in a rootzone: one PICO T3PN segment close to the surface and one PICO T3PN segment right where the rootzone ends. But more challenging projects define a seamless determination of soil moisture for 5, 10, 25m depths. This can easily be achieved by integrating the probe alignment into SDI-12 networks. As an alternative, a PC can be connected to the profile probe via the IMKO interface in order to implement a cost-efficient testing solution and data logging.

Interfaces

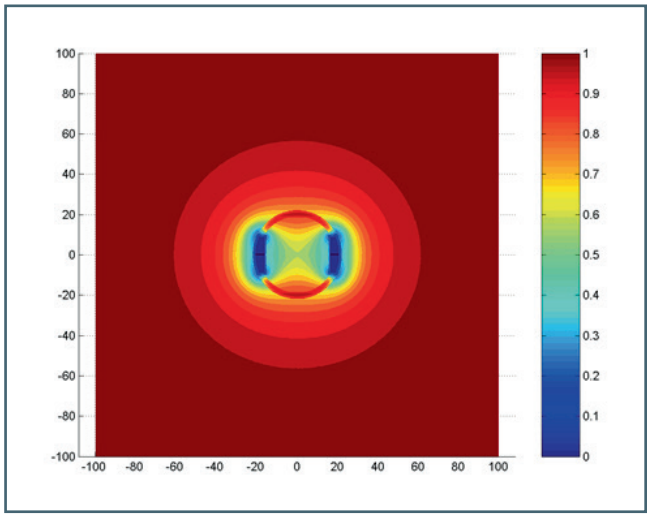
- SDI-12 (for SDI-12 data logger)
- IMP-Bus (SM-SDI and SM-USB)
- RS485 (for data logger)





Easy setup of the probes and spacer sequences to the intended total system. The probes are 20cm long, spacer segments are available in 10, 30 and 50cm lengths.

Installation of a PICO T3PN at the Reutgraben demo field – A comparative measurement of PICO32 / PICO64 at this location - visualization has been maintained through a microcomputer and local web application



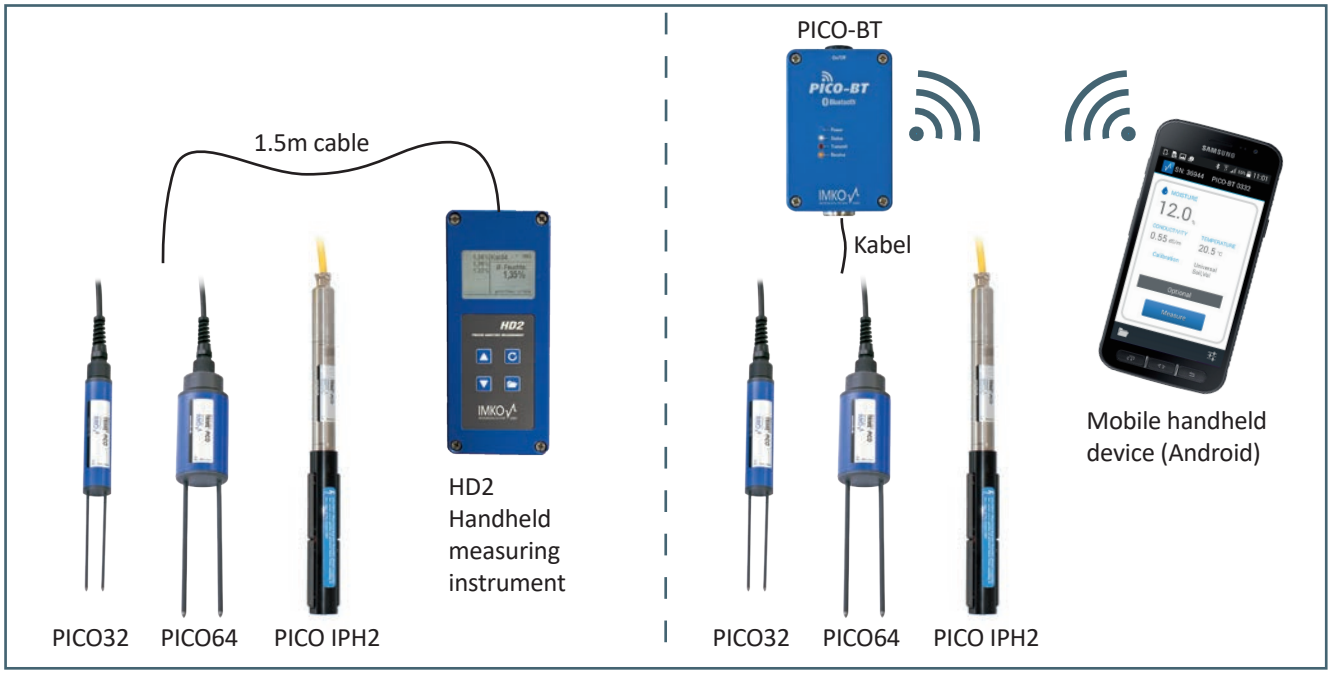
Qualitative display of the PICO T3PN measuring field (size approx. 2500cm³)

The PICO T3PN is the perfect compact and cost effective alternative for a lysimeter installation. The probe segments can be arranged to the prevailing examination pattern of the specific location, readings can be drawn by the particular depths.

Wireless transmission of measurement data, automatic storage of individual values and calculation of mean values

Interfaces mobile

Options for PICO probe connection



HD2
Mobile and rugged handheld device to read PICO probes while measuring soil, sand, gravel, substrate and material moisture.

Key facts:
Very rugged handheld device, IP67, long-life battery, 7 display languages

PICO-BT
Bluetooth module to enable a communication among PICO probes and a mobile handheld device (Android). The PICO-BT is an interface and cannot save any measured values itself, the data is sent to the mobile device, where they can be stored or forwarded.

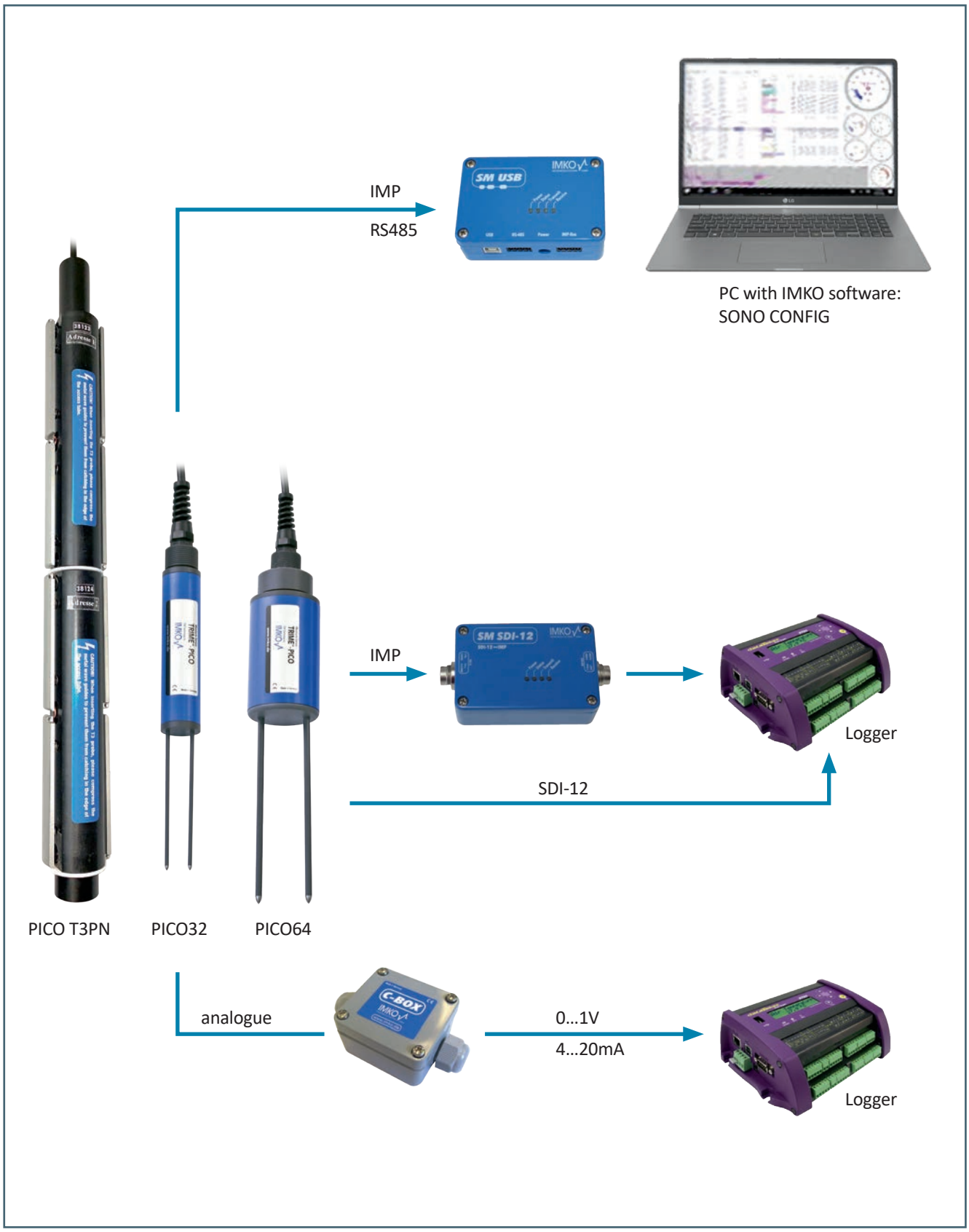
Key facts:
Android, data storage, export to csv file, creation of an unlimited number of measuring points, Bluetooth®

Rugged carrying case for your mobile IMKO solutions

Free software

- **TRIME®-Blue App**
  Software to connect PICO probes and an Android system for field data acquisition and storage
- **PICO-Config Software**
  To be used with the optional probe interface SM USB: The software enables to communicate with the probe, add and edit calibrations, and record measured values on a PC.
- **TRIME®-WinMonitor Software**
  As a measurement solution software to acquire data of small sensor networks with a SM USB interface

Interfaces for static installations



Static installation of PICO probes in an 8m deep lysimeter system in China (in operation, during installation, during the installation of the towers)

Use cases

Determination of soil moisture in arable crops: greenhouses, spice and medicinal plant cultivation and irrigation

Use case strawberries

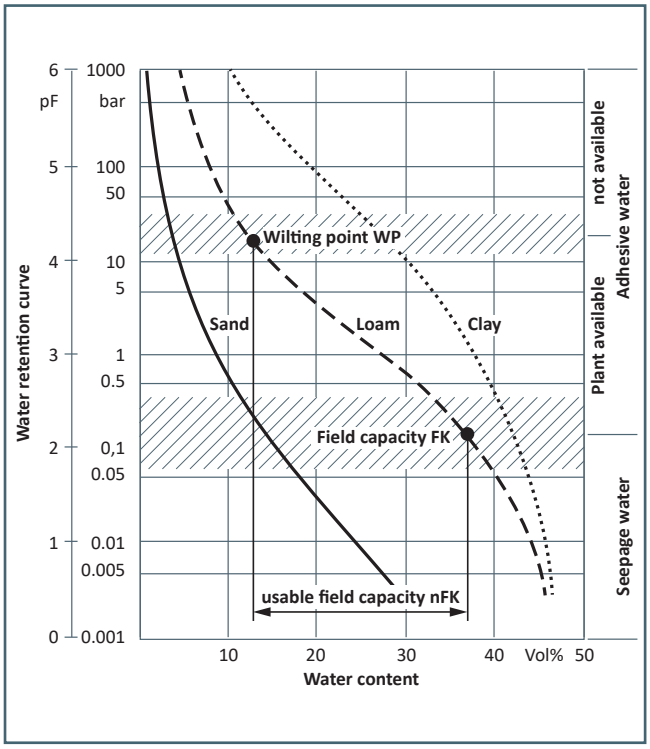
Success in cultivation of strawberries requires a good knowledge of the prevailing conditions in the rootzone. Soil or substrate type and plant available water in the root area have a major impact on the predictable success in cultivation.

Heavy soils and waterlogging are tending to cause root diseases, which lead to a significant reduction or a full loss of yield. When irrigating strawberries, usually drip irrigation is used in order not to damage leaves and fruits by the application of irrigation water. State of the art drip irrigation systems also offer the possibility to apply fertilizers directly into the rootzone, which reduces evaporative losses and prevents salinization effects.

Soil moisture measurement is crucial to control and operate modern irrigation systems. IMKO developed a moisture sensor based on a guided radar system 35 years ago, which measures soil moisture, electrical conductivity and temperature very precisely and without further calibration.

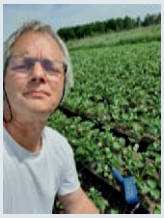
Cultivation of strawberries in an artificial environment and in the field / measurement of soil moisture with the HD2 by IMKO

The availability of soil moisture (volumetric water content) is characterized in soil science through specific parameters for each location and can be translated to predict required irrigation events. The wilting point indicates the degree of water in the soil where plant roots can no longer extract water from the soil (Scheffer et al., 1992). Field capacity describes the water content that can remain in the ground against gravity (Mattheß, 2003). With different types of soil, field capacity and wilting point prevail for different water contents. 30% vol. water content in sand have already saturated up to field capacity, in loam 30% vol. water content would be available to plants, in clay 30% vol. would have reached the wilting point already (figure on the right: water retention curve). The conductivity holds information on the state of fertilization within the root zone, especially when the soil type is known. In this way, fertilization can be controlled and regulated effectively and economically. The temperature provides information about the rates of water absorption, for example when seeds emerge, or for the maturity of root vegetables (asparagus). Our systems are available as independent handheld devices (IP67) or Bluetooth® solutions (Android mobile device is required for display, storage and forwarding of data).



Water retention curves in different soils (Kleisinger, Sinn 2005)

Berry Konsult based in Netherlands has been using our handheld measuring devices since 2011. They are very happy with the performance, durability and the accuracy of the measured values, obtained in different soils and substrates.

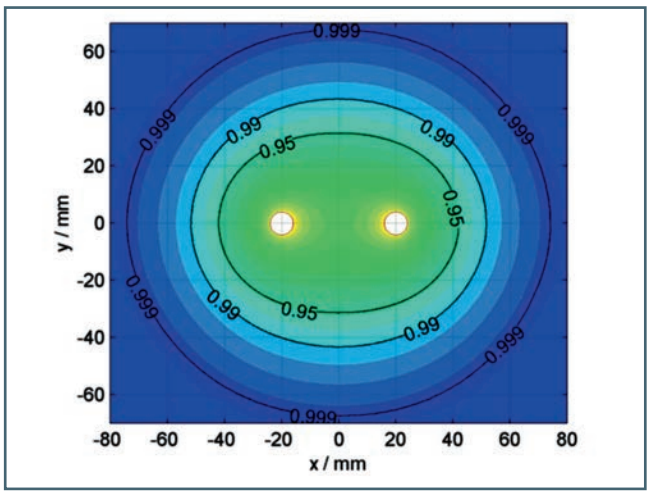


"Every day, I visit a strawberry farmer, I work with the HD2 with PICO32. Before I used this device I had endless discussions upon the state of moisture content in soil or substrates. As I started using the HD2 with PICO32 the discussion vanished. The numbers clearly indicate, whether it is too dry or too wet."

Klaas Plaas, Managing Director Berry Konsult (www.berrykonsult.eu)

In addition, you can read much more from the IMKO measurements and quickly grow into an expert level: conductivity, soil temperature and soil moisture are the three most significant indicators describing the prevailing conditions in the root area. With the IMKO measurement solution, you can do this right at the spot of which information is essential: at the root itself. Measurements in drainage water or on the surface of the soil are capable of drafting an indirect picture on root relevant conditions.
"The nice thing about the EC-TRIME measurements is that the measurement in the substrate specifies more precisely what is happening in the root area than the indirect measurement of the conductivity (EC) of the drainage water. The measurement of the drainage water can only display the conductivity in the root zone with a delay of 2-4 days, depending on the irrigation intensity and the type of soil or substrate."

Easy field measurement for farmland strawberries with the PICO32



We have introduced this easy to use technology for soil moisture data acquisition more than 25 years ago with the first generation of our handheld device. Constant product improvements over the last years resulted in more accuracy, more interfaces and a Bluetooth® interface (requires Android).

Measuring soil moisture and conductivity with the HD2 and a PICO probe offers clear advantages, as it displays high-resolution measured values for each individual root zone in a clearly defined measurement volume. The size of the measuring volume can be varied by selecting the probe geometry, i.e. the rod length or the rod spacing. The PICO32 is a classic topsoil probe with narrow rods. Rod lengths of 50-110mm are ideal for the root area of strawberry.

The PICO64 is designed for more coarse soil conditions and is characterized by wider and longer probe rods that reflect a larger measurement volume.

Rootdistribution of a strawberry plant

Mobile and high-precision determination of soil moisture with more than 25 years experience (TRIME-FM, 1998)

PICO32 (topsoil) and PICO64 (subsoil) in the Reutgraben demo field in Ettlingen

Our product range contains sensors for permanent installation, too. With switch boxes and data interfaces as well as with mobile bore-hole probes for the detection of entire soil profiles and deeper root spaces, which can be segmented in 20cm steps. Simply install plastic pipes in the undisturbed soil, connect the desired sequence of probe segments and measure (see below).

Three segments profile probe with spacers (sequence: 20cm PICO T3PN - 10cm spacer - 20cm PICO T3PN - 10cm spacer - 20cm PICO T3PN)

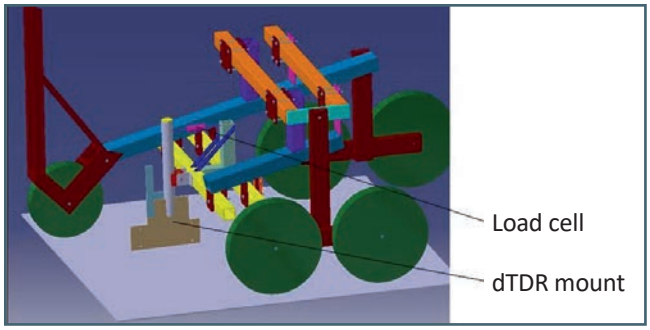
Research report: Control of rain gun irrigation

Measurement of soil moisture while field passage

Efficient control of irrigation is close to IMKO throughout the last decades as the knowledge of soil moisture content gives a clear view on irrigation quantities to be applied in order to maintain a stable and forecastable yield.

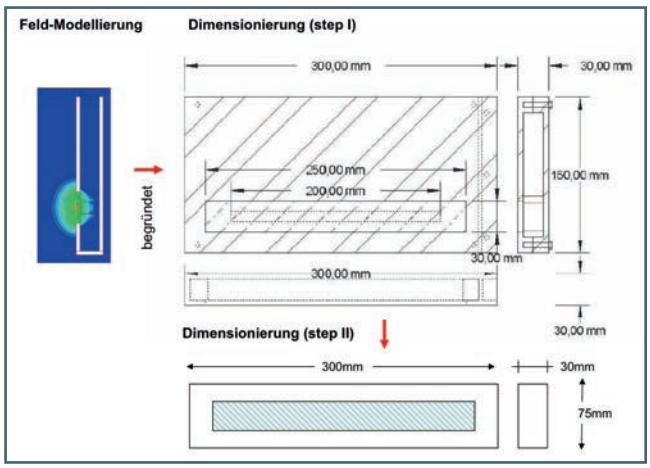
The characteristics of soils have grown ever since through all geological phases of earth's development. One of the factors, influencing cultivated soils are the most recent anthropogenic influences through farming. Soil conditions are heterogenous if you look at them on a broader perspective. In order to maintain a balanced management of farmland and a similar ripening of crops on field scales, the application of fertilizers and artificial irrigation is considered good farmers practice. Both can be applied best, if the soil properties are known and the momentary conditions of moisture and electrical conductivity are measured.

Soil properties differ, which is translated in water retention curves even if climate and geography are same. In order to detect spatial differences and maintain proper actions, readings can be carried out in allocated spots of rootzones (see strawberry measurements with the HD2 and PICO32) as well as while field passage. A detailed feasibility study of dynamic acquisition of field data while passage has been conducted from 2003-2007 at the department of agricultural engineering of the University of Hohenheim, Germany. The project resulted in a prototype of a highly sophisticated spray gun irrigation cart, capable of self-regulating irrigation quantities. The largest effects could be seen for heterogenous plots and arable crops with a high water demand. The project has been funded through the German Federal Ministry of Education and Research. The funding priorities have been focusing on the efficient use of resources in farming. The project itself focused on the development of suitable technology enabling resource conservation (water, fertilizer) preventing cropping losses caused by wrong farming decisions.



Prototype of the autonomous irrigation cart

Soil moisture detection by IMKO while field passage of an irrigation cart



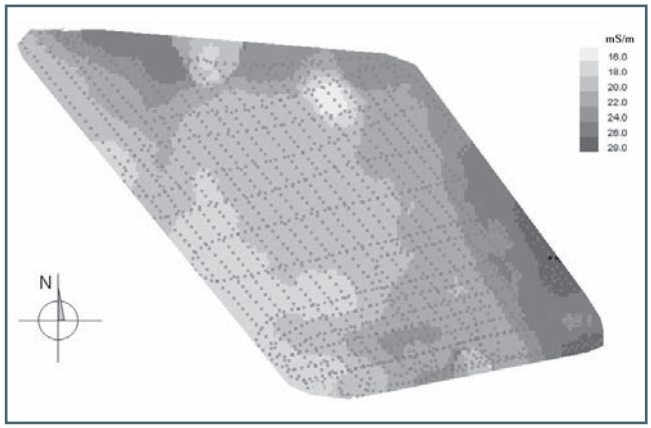
A model of the measurement field displays the penetration depth and shape to conclude on moisture and electrical conductivity

Traction forces diagram had been recorded for all 3 spatial axes (pre trials had been maintained in the small Hohenheim soil bin at the Department of Agricultural Engineering of the University of Hohenheim)

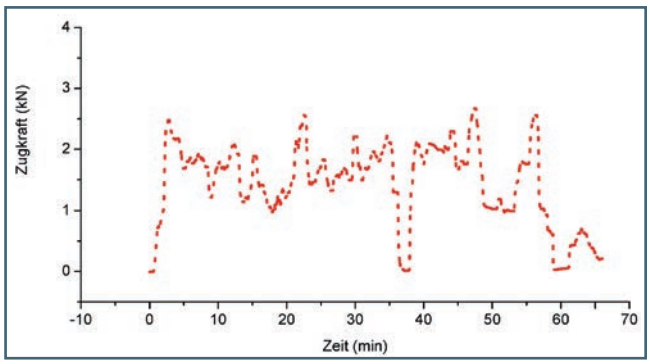
Field application of the project filled up the root-accessable water quantities to be used before the next scheduled irrigation event. Yields and ripening degree could be maintained close to ideal with the application of the modified irrigation cart. The picture displays a functional model of the trial setup.

Climate change has caused more prominent effects in dry summers, excessive weather events (flood, storm, erosion) over the last years. This has a direct effect on middle European farming, traditionally water-fed through natural precipitation. A new best practice has to be shaped, given the use of natural and artificial resources lots of thought to come close to a sustainable situation for farming. IMKO technology holds a large advantage in data acquisition for the described sustainable goals, since the technology measures temperatures, electrical conductivity and moisture at the same time.

The results of this PhD Thesis and development of a dynamic moisture probe has helped to give birth to a new generation of moisture probes: The IMKO SONO VARIO series, which is dedicated to measure in industrial applications. The measurement principle stays the same. The only difference is the propagation of the sensor. On farmland – the sensor needed to travel, in industry application – the substrate travels and reveals a very precise view on every slice of a process.



Enriched field data (Electrical conductivity by IMKO and a EM38 device)



The acquisition of soil moisture and simultaneous recording of traction forces draws a clear picture of prevailing soil properties. Thus, the existing soil maps can be enriched with additional data to perform best practice in farming.

Literature:

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- Figures and photographs © by C. Jantschke

UNIVERSITÄT HOHENHEIM

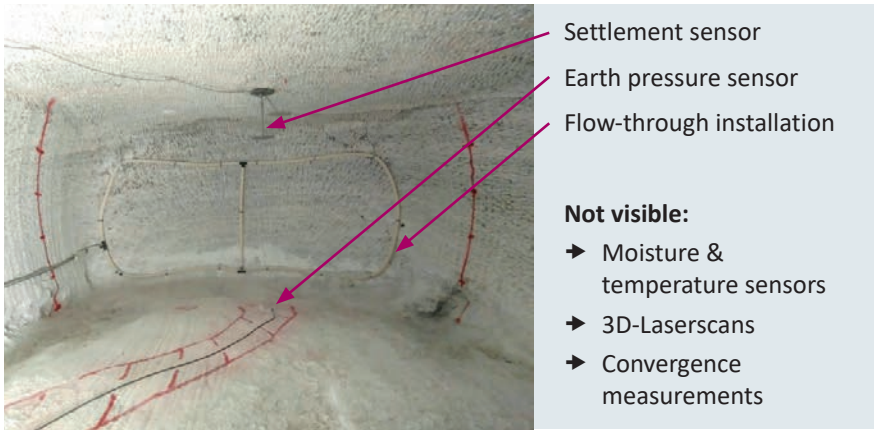
Special application determining material moisture while backfilling salt mines

The exact determination of the prevailing moisture plays a major role for the quest and evaluation of suitable terminal storages for radioactive or chemo-toxic waste. The same pattern can be applied, seeking a permanent shelter to archive cultural assets worth protecting. The penetration of subsoil water into mines and cavities would be a termination criterion seeking a long-term storage. The IMKO moisture measurement system can be used for similar applications under buildings and within essential infrastructures such as bridges or dams as a warning system for penetrating of water.

In this context, the University of Resources in Freiberg, Germany is examining the long-term stability of backfilling underground cavities and mines. This backfilling (a so-called offset) supports the geological layer and consequently lowers the risk of fluid mobility in between the material stored and the surrounding biosphere. In the pursued concepts, deposit-typical or deposit-specific materials are used as back-up materials in order to ensure the long-term stability of the artificial backfilling bodies. For the disposal in saline formations, salt grit are of particular importance as a close to natural material.

The GESAV project (structure-stabilized salt grit offset; BMWi-FKZ: 02E11557) has been launched to seek for new forms of rapid structural stabilization of salt grit in order to maintain stable backfilling in saline environments. For this purpose, a salt cement is used as a stabilizing component. This component is added to the salt grit in order to generate an artificial re-crystallization, maintaining a natural strength of the novel mineral formation.

In the GESAV research project, a salt binder has been developed upon natural salt minerals. The project is aiming towards best possible mechanical integrity of artificial salt grit.



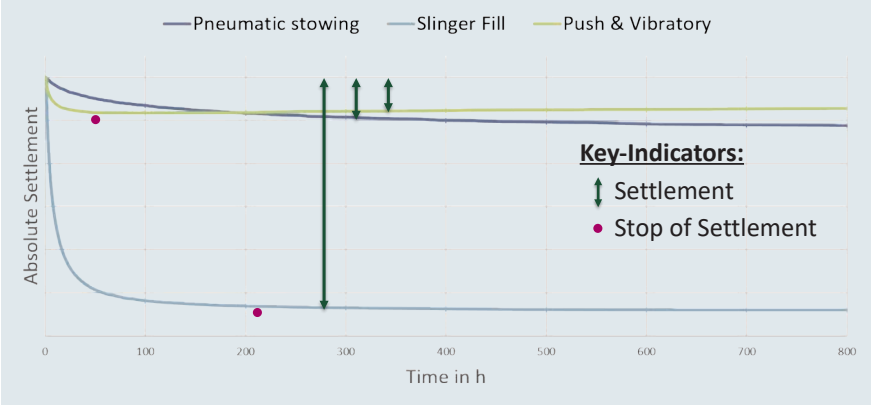
Testing scenario in a salt mine (750m below surface)

In the broader context of this project, parameters as settlement, integral permeability and the mechanical properties of the backfill have been examined. A whole series of sensors were used to maintain this task, in order to be able to precisely evaluate the change of mechanical properties under different scenarios.

About 80 tons of material have been required for one batch of test backfill with structure-stabilized salt grit. This consists of three components: salt grain, salt binder and salt solution.

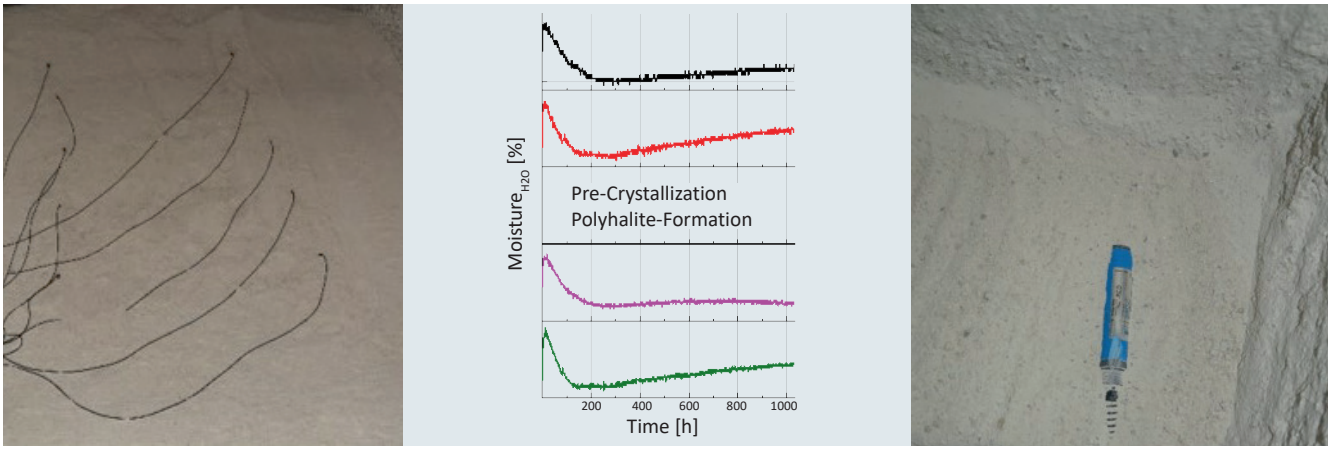
Three phases of mixing a structurally stabilized salt grit backfill

A key parameter installing the material is the density of the salt grit installed. In order to achieve the highest possible density, various methods have been analyzed upon their influence on the installed backfill: pneumatic offset (installation with compressed air, pneumatic stowing), centrifugal offset (installation with a centrifugal wheel, sling fill) and installation using vibrating plates (push & vibratory). Depending on the process, the initial settlement processes of the bulk material are completed after a few days, latest after one month.



Settlement process of the materials for different installation methods

The course of the salt mineral formation in the backfill material can be characterized by determining the moisture content in the backfill (IMKO PICO32). The process of new salt mineral formation is usually monitored by cyclic P-XRD tests on samples taken in the laboratory. The moisture measurement system offers an additional, continuous monitoring of the salt mineral formation. As part of the GESAV R&D project, the basis for such monitoring is being developed.



Test trials in order to determine the degree of re-crystallization of salt grit with IMKO PICO32 (with a special calibration for salt)

The measurements in such a challenging environment regarding salt contents require a special calibration for the moisture sensors. This is mandatory to be able to detect clear moisture signals once the probes are installed in the test scenario.

The technique is used in research project, as well as similar applications where a commercial description of environmental prepositions is necessary (control of geothermal energy use under buildings, early warning for structures close to the ground-water, in bridges, under railway tracks and in dams (detection of the aging conditions of concrete, backwater display).

We would like to thank the University of Resources in Freiberg, Germany for the exciting and successful cooperation in the context of this and future projects. We are pleased to have contributed to a better understanding of the special features of the introduction and crystallization of structure-stabilized salt grit.

Literature:

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