Technical Data Sheet
Saturnia Probe

Manual Version 1.1
Saturnia Probe
Accompanied with software interface or;
Data through API

Royal Eijkelkamp B.V.
Nijverheidsstraat 9
6987 EN Giesbeek
Nederland
+ 31 313 880 200
info@eijkelkamp.com

1. Introduction

Agurotech's Saturnia probe is designed, manufactured, and produced in-house in the Netherlands. Agurotech's origins trace back to fundamental, Nobel Prize-winning science conducted at Nikhef, the Dutch National Institute for Subatomic Physics, where this technology has already been successfully applied by Innoseis, who holds a share in Agurotech, and has become market-leading for oil and gas exploration and satellite sensors.

The Saturnia probe is a fully sealed, cableless probe designed for insertion into the soil to provide accurate and reliable measurements. Utilizing Frequency Domain Reflectometry (FDR), it measures soil moisture, electrical conductivity, and soil temperature at different depths (15cm, 30cm, 45cm, and 60cm) through two distinct probe models.

The Saturnia probe employs cellular connectivity and is primarily used in open field agriculture for irrigation purposes. However, it is also suitable for applications in smart cities, greenhouses, and grasslands used for dairy farming. Designed for quick and easy installation, the Saturnia probe can be integrated with various data acquisition systems. It comes with either an API that supplies data from real-time measurements or an advanced app that provides precise irrigation recommendations. These recommendations, based on user inputs (e.g. soil- and crop type) and sensor data, are available through a subscription-based model to optimize yield while efficiently using water.

2. Key Features

- **Long Lifespan**: Engineered for over 10 years of reliable performance in harsh outdoor environments.
- **Built-in GPS Tracker**: Provides traceability and precise location tracking.
- **Quick Installation**: Can be installed in soil in under 5 minutes.
- **Low Maintenance**: Requires no regular maintenance, ensuring ease of use.
- **Compact Design**: Sensor protrudes less than 9 cm above the soil, allowing for easy maneuverability and minimal disruption to field operations.
- **Sensor Orientation Detection**: Automatically enters sleep mode when positioned horizontally and activates in a vertical position, indicating proper installation and operation.
- **Extended Battery Life**: Offers 3-5 years of operation with options for rechargeable or replaceable batteries.
- **Global Connectivity**: Supports 2G, 3G, 4G LTE (M), and NB-IoT, ensuring comprehensive coverage worldwide.
- **Servicing Dashboard**: Monitors key performance indicators (KPIs) for the sensor fleet, including battery level, location, timing, installation status, correct installation verification, and irrigation advice.
- **Accurate Calibration**: Provides precise measurements across all soil types.

3. Physical and Performance Specifications

Probe Model	Short	Long
Number of sensors	6	12
Dimensions: (length, width, height)	471x90x110mm	797x90x110mm
Outer Probe Diameter	24mm	24mm
Materials	Lexan Copolymer, Carbon fibre, RVS Steel	Lexan Copolymer, Carbon fibre, RVS Steel
Impact Resistance	Designed to withstand drops from a height of up to 1.5 meters without damage	
Pressure Tolerance	Insensitive to variations in normal atmospheric pressure	
Weather resistance	Weather Resistance IP68, for outdoor use, dust and water immersion resistant	
Weight	950g	1230g
Measurement frequency	1MHz, 100MHz	
Operating Principle	FDR Technology: measurement of the soil's dielectric constant by observing the change in frequency of an electromagnetic signal.	
Radio Access Technology	LTE-M, NB-IoT, 2G	
Moisture resolution	1:1000	1:1000
Moisture range (%)	0-100%	0-100%
Moisture Precision (%)	<1% VWC	<1% VWC
Temperature Accuracy	±0.2°C	±0.2°C
Operating Temperature	-20°C to 60°C	-20°C to 60°C
Storage Temperature	-20°C to 50°C -4°F to 122°F	
Calibration Requirements	None	None

Other	GPS tracker included GNSS Interfaces: GPS, GLONASS, BeiDou, Galileo

4. Electrical Specifications

Battery Voltage	7.2 V
Battery Capacity	48.24 Wh
Data security	End-to-end encryption over SSL/TLS ISO/IEC 27001:2022 compliant
Operation Current	0.1 mA to 2000 mA
Output Power Modem	23 dBm to 33 dBm
Operation Bands	1,2,3,4,5,8,12,13,20,25,26,28, 66, 85
Signal Range	Up to 12 km
Battery Type	Internal rechargeable Lithium-Ion battery
Antenna Type	Built-in multi-band ceramic antenna

5. Saturnia illustrations

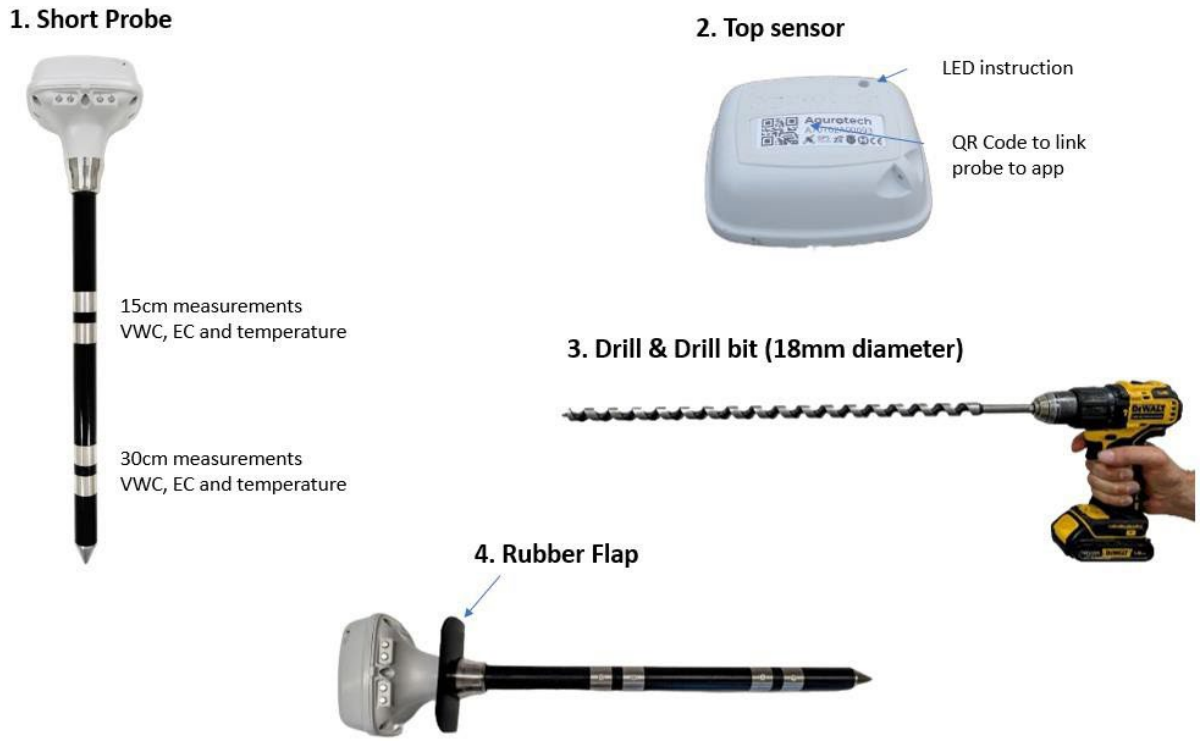

Figure 1 illustrates a “short” probe that measures Volumetric Water Content (VWC), Electrical Conductivity (EC), and temperature at depths of 15 cm and 30 cm. The rod, or the long part of the sensor, is completely buried in the soil, with only the top enclosure visible above the surface. The top enclosure contains integrated battery with built-in GNSS and cellular antenna. The rod contains the acquisition hardware, which sends a signal through one of the rings for each depth. The same rings are used for EC and VWC measurements.

Figure 2 shows the top section of the probe, which features a waterproof enclosure with a built-in GPS tracker. On top of the rod, there is an LED light that uses different colors to provide installation and troubleshooting instructions for the end user. For more details, refer to Section 7 on Operating Instructions. Each probe has a QR code on top that users can scan with the Agurotech application.

Figure 3 depicts the drill bit included with each probe. This drill bit is precisely dimensioned to ensure a good installation with proper soil contact. It is essential for the probes to have good soil contact to ensure accurate readings.

Figure 4 demonstrates the rubber flap accompanying each probe. The rubber flap ensures that water uptake around the probe is representative as for the remainder of the field and no water flows into the soil along the probe's measurement points.

6. Installation Guidelines

Installation of the Saturnia probe requires the following items:

- The Saturnia probe;
- A drill with the recommended 18 mm Agurotech drill bit, or another drill bit with similar dimensions and;
- The rubber flap

Installation can be successfully completed in just a few minutes by following the instructions. It is crucial that the probe makes good contact with the soil to ensure accurate readings. If there is space and air around the sensor, the Volumetric Water Content (VWC) readings will not be accurate. Using the Agurotech drill bit and ensuring that the drilled hole is as compact as possible will help avoid this issue. A rubber cover is provided to place underneath the sensor to prevent water from dripping down. For instructional videos, please visit our website at Agurotech Instructions. Installation steps are provided below:

- **Use the Agurotech Drill Bit**: Use the drill bit provided by Agurotech.
- **Prepare the Area**: Clear the installation area and ensure the drill is clean.
- **Drill the Hole**: Drill gently into the ground, keeping the drill steady and vertical to ensure a narrow hole for good soil contact. Drill until the bit is fully in the ground.
- **Turn Off the Drill**: Turn off the drill and clear any loose soil around the hole.
- **Remove the Drill**: Slowly pull the drill straight out of the hole and avoid disturbing the hole and making it wider.
- **Attach the Rubber Flap** : Make sure the sensor has the rubber flap attached underneath.
- Turn the sensor into vertical position: Turn the sensor from horizontal into vertical position to switch it on. If the sensor was positioned vertically, ensure to turn it upside down for 1 minute and back to vertical position before installing.
- **Insert the Sensor**: Push the sensor into the hole as far as possible with your hands.
- **For harder soils**: If it is not possible to push the sensor entirely into the soil until the top is reached carefully step on the sensor to push it fully into the ground.

In rare cases, such as with very dry, sandy soils, the soil may be too hard for the standard installation process. In such cases, we recommend the following:

1. **Use a Funnel**: Place a funnel into the hole.
2. **Add Water**: Fill the funnel with water until it is level with the soil surface.
    - **Note**: Avoid adding too much water, as this can result in inaccurately high Volumetric Water Content (VWC) measurements.

For detailed instructions, please visit our website at Agurotech Instructions.

7. Operating Instructions

7.1 Operating Modes

The device has three operating modes: Powered Off, Installation Mode, and Operation Mode. Each mode is described below.

Powered Off: The device is turned off when placed horizontally on a flat surface. In this deep sleep mode, the device consumes very little power (< 1mW), and the LED is off.

Installation Mode: To activate installation mode, place the device vertically. The sensor will detect this position and begin sending measurements. During this mode, the LED will flash green every second.

Operation Mode: After installation mode, if the device remains vertical, it will enter normal operation mode. In this mode, the device takes measurements throughout the day and transmits 10 measurements every 6 hours over the wireless network. The LED will be off during normal operation.

7.2 Data Transmission Frequency

The Saturnia Probe features an proprietary adaptive data transmission algorithm, providing efficient and responsive performance.

- **Automatic Detection**: The sensor detects new installations based on angle and movement, ensuring immediate activation without manual intervention.
- **Initial Intensive Monitoring**: Once stationary, the sensor measures every 10 seconds for 100 seconds, ensuring accurate initial readings. These data are promptly transmitted, providing immediate feedback on soil conditions and installation success to end-users.
- **Regular Data Acquisition**: After the initial setup, the sensor performs data acquisition with as default every 36 minutes, transmitting the collected data every 6 hours. These frequencies can however be customized based on user requirements. This regular monitoring ensures continuous and up-to-date soil moisture information, optimizing irrigation and resource use.
- **Energy Efficiency**: When the sensor is removed from the field and placed horizontally, it enters the deep-sleep mode with low power consumption. In this mode, it transmits a status message once a month, significantly extending battery life and reducing maintenance needs, while still allowing to transmit key data points such as location and battery levels.

7.3 LED Instructions

LED State	Mode	Description
LED Off	Normal Operation	The sensor is in an ultra low-power mode. This mode is automatically initiated when the node is installed or in horizontal position.
Flashing Red	Error	This indicates that an error has occurred, or the angle of the sensor is not vertical enough. Re-installation of the sensor is required.
Fast Flashing Orange	Searching	The sensor is searching for network. No action is required by the end user.
Slow Flashing Orange	Installation	The sensor is still in movement and waiting for a stable position. Complete sensor installation and do not further move the sensor.
Green Light Flashing	Installation	The sensor detected no more movement. The installation is completed and the LED will automatically switch off. No further action is required by the end-user.

7.4 Upgrades

Saturnia sensors are equipped with an Over the Air (OTA) Update functionality, enabling us to deploy new firmware updates globally to our fleet of sensors. This capability allows for periodic firmware upgrades throughout the product's lifecycle, enhancing user experience, extending product longevity, and optimizing battery usage. Communication between the probe and software is bi-directional. Hence configuration settings (such as frequency of measurements) of the probe can be controlled through our back-end software.

7.4 Servicing

The features of the probe allow us to track the performance of our sensor fleet globally and inform the users of key events to enhance the user experience for our solution. This includes:

- Live feedback to end users on whether probes are installed correctly
- Prompt to users when sensors have been (re)moved based on GPS tracker
- Real-time insights on battery status
- Real-time insight on probe location with GPS coordinates
- Real-time feedback on (connectivity) signal strength
- Alerts on irrigation needs
- Prompt when sensors are installed to closely together (within 10 meters)
- Feedback when customers may have not entered realistic soil or crop specifications

When offline, the device sends out a status message once a month with the location. In cases of theft the device can be located using these coordinates.

7.4 Calibration requirements

The Saturnia probe measurements are calibrated to moisture levels (VWC) using Agurotech's automated, soil-specific calibration technology. This enables the Saturnia sensor to accurately measure moisture across all soil types. By analyzing a combination of VWC and EC levels, we can identify the soil type. Our system applies customized calibration for different soil levels and types. Users of the application can enhance calibration accuracy by providing additional soil details, such as organic matter content and the percentages of clay, silt, and sand. Furthermore, users can supply crop-specific information, including sowing date, planting method, and variety. This data helps to determine the optimal moisture range needed to support yield optimization tailored to their specific crop and soil conditions.

7.5 Maintenance requirements

The Saturnia probe is designed for minimal maintenance. The only requirement is to charge or replace the battery when it is depleted, typically after 3-5 years.

8. Interfacing and Communication

Saturnia's data can be accessed through an API or the Agurotech application. API documentation is available upon request. The app primarily focuses on irrigation management, offering irrigation advice based on sensor measurements, soil types, crops, agricultural models, and local weather conditions. Detailed features and specifications of the app are provided in a separate product sheet. Access to the application is granted via an authorized email address. The app is available for download on both the App Store and Google Play or can be accessed through a web application.

- App Store: https://apps.apple.com/us/app/agurotech/id1593705670
- Google Play: https://play.google.com/store/apps/details?id=com.agurotech.app

9. Application Examples

- The Saturnia probe is used in fertigation projects to provide precise and real-time data on soil moisture levels, electrical conductivity, and temperature, enabling accurate monitoring and management of irrigation and fertigation practices. By integrating this data with agricultural models and local weather conditions nutrient delivery are optimized, ensuring efficient water and fertilizer use, which enhances crop health and yields.

- The Saturnia probe and subscription is used by farmers to optimize yield or save water for their high yielding crops, such as potatoes, onions, tomatoes, flower bulbs, fruits and vegetables.

- The Saturnia probe is used to determine irrigation schedules for fruit trees and vineyards.

10. Complimentary Products

Agurotech's Saturnia probes can be combined with other Agurotech hardware products such weather stations, rain meter solutions, crop freezing sensors and software based offerings such as plant disease advice and spray planning. Data and insights from each of these systems are available through the same Agurotech application.

Agurotech Saturnia Sensor Manual