

The warranty period extension method 1 year →2 years

The warranty period will be extended from 1 year to 2 years when you register customer information. ATAGO Logger NFC can also be downloaded at the same time.

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QR code

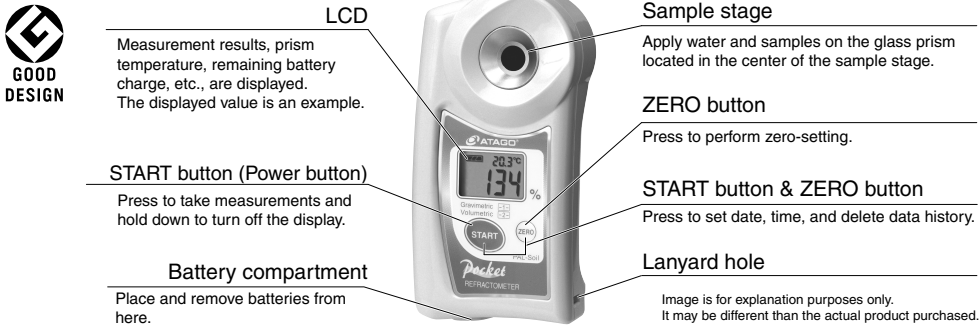
Digital Hand-held "Pocket" Soil Moisture Refractometer

PAL-Soil

Cat.No. 4571



Parts



Contents

The PAL-Soil contains the following items:

- ◆Main unit 1
- ◆Instruction Manual (this book) 1
- ◆Calibration Report 1
- ◆AAA alkaline batteries (LR03, AAA, 1.5V) 2
- ◆Beaker(100ml) 1
- ◆Plastic spoon 1

Introduction

Thank you for purchasing the instrument. Before operating, read this instruction manual carefully to understand its contents. Keep the manual with the instrument for future reference.

Safety Precautions

To use the PAL-Soil safely, the safety precautions described in this instruction manual must be observed. Failure to comply may result in injury and/or damage to property.

WARNING

- ◇ Ensure safety when handling hazardous materials. Observe precautionary measures and use protective equipment. Be aware of the hazards of such chemicals and emergency response guidelines.
- ◇ ATAGO may not be held liable for any injury or damage arising in connection with handling of hazardous materials during the use of the instrument.
- ◇ Do not drop the instrument or subject it to strong physical shock.
- ◇ Do not attempt to repair, modify, or disassemble the instrument.

CAUTION

- ◇ Carefully read this manual to have basic knowledge of the function of each component.
- ◇ ATAGO is not liable for any loss and damage caused by the measurement and use of this instrument.
- ◇ Some acids may corrode the glass prism and/or metal sample stage, which may cause erroneous measurements.
- ◇ **Do not use metal tools, such as a spoon, as they may scratch the prism, resulting in erroneous measurements.**
- ◇ Do not use water above 50°C to rinse the instrument.
- ◇ Only use the specified battery type. Observe proper polarities, properly aligning the anodes and cathodes.
- ◇ Store the instrument away from direct sunlight/heat sources and excessive amounts of dust/debris.
- ◇ Do not expose the instrument to a rapid change in ambient temperature.
- ◇ Do not subject the instrument to strong vibration.
- ◇ Do not subject the instrument to extreme cold temperature.
- ◇ Do not place the instrument under anything heavy.
- ◇ Loosen the battery compartment cover for air transportation.

ELI Function

<If the ELI* function indicates the [nnn] warning message when measuring a sample, shade the sample stage with your hand and repeat measurement. (Fig. A)>

Fig. A



If the PAL-Soil is subjected to intense light, such as direct sunlight or artificial lighting, when measuring a sample, the ELI function will display the [nnn] warning message immediately after the START or ZERO button is pressed. When this happens, shade the sample stage with your hand and press the START or ZERO button again.

— Note —

When intense light penetrates the prism of a digital refractometer, the light waves interfere with the sensor, which may lead to inaccurate measurements. To ensure accurate measurement results, the PAL-Soil is programmed with the ELI function which displays the [nnn] warning message when intense direct light is detected. Forming a habit of shading the sample stage with your hand and re-pressing the START button (when the warning message from the ELI function is displayed) will ensure accurate measurement results each time.

* External Light Interference (ELI)

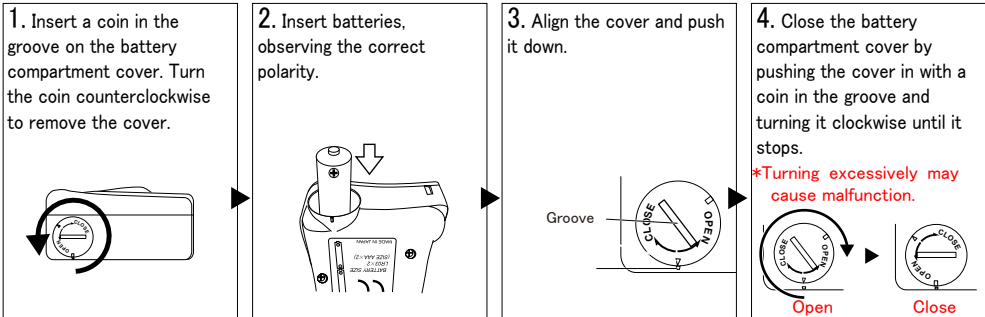
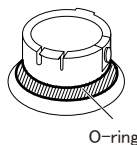
<International Protection Classification IP65>

Although the PAL-Soil is water resistant and may be cleaned under running water, it is not water proof. Do not submerge the instrument under water.

Inserting Batteries

[CAUTION]

- Fasten the battery compartment cover tightly to prevent water ingress or poor connection, which will cause erroneous measurements. Push the cover in firmly and turn.
- When the O-ring on the cover is dirty or damaged, the water resistance may be compromised.
- When the battery icon indicates the low power level (), replace both batteries with a brand new set of AAA alkaline batteries (1.5V).
- Static images may occasionally appear on LCD. Such retained pixel charges do not indicate a faulty display, consume the battery power, or affect the instrument's performance in any way.
- Check the expiration dates on batteries before purchase.
- Zero-set the instrument after the batteries are replaced.



Optional and Consumable Items

Optional

Part No.	Part Name	Remark	Quantity
RE-39450	Digital Balance (Digital Scale)	Measurement range 0.01 to 500.00	1

Items to Prepare

The following items are not included with the instrument.

■Glycerin

***Only use a premium quality reagent.**

*Purchase from a reagent manufacturer or supplier.

■Soil sampler or sand-pouring cylinder (for volumetric soil moisture measurement)

Choose one with a capacity of at least 50mL.

See reverse side for zero-setting, scale selection, and measurement procedures.

Gravimetric vs. Volumetric Soil Moisture, and Automatic Temperature Compensation

(1)What is gravimetric soil moisture?

As defined by ISO 16586:2003, soil quality is the water content % of soil expressed by mass (weight). It is the mass of water relative to the mass of oven-dried soil. Soil is dried in an 110°C±5°C oven. The PAL-Soil calculates the water content of soil by measuring a decline in the refractive index of glycerin after it is mixed with an equal amount of soil sample. It utilizes the water-absorbing properties of glycerin.

$$w = \frac{Ma-Mb}{Mb} \times 100 \quad \begin{matrix} \bullet w & = & \text{Gravimetric soil moisture (\%)} \\ \bullet Ma & = & \text{Mass of soil before drying in the oven} \end{matrix} \quad \begin{matrix} \bullet Mb & = & \text{Mass of soil after drying in the oven} \\ \bullet Ma-Mb & = & \text{Mass of water in soil} \end{matrix}$$

(2)What is volumetric soil moisture?

It is the water content % of soil expressed by volume. It is the volume of water relative to the total volume of a soil sample. A sand-pouring cylinder is commonly used. The PAL-Soil calculates the water content of soil by measuring a decline in the refractive index of glycerin after it is mixed with water at the 5:3 ratios. It utilizes the water-absorbing properties of glycerin.

$$\theta = \frac{Vw}{V} \times 100 \quad \begin{matrix} \bullet \theta & = & \text{Volumetric soil moisture (\%)} \\ \bullet Vw & = & \text{Volume of water} \\ \bullet V & = & \text{Total volume of soil sample} \end{matrix}$$

(3) Automatic Temperature Compensation

The PAL-Soil automatically compensates for the temperature of its prism. The feature functions correctly when the prism temperature is between 10 to 40°C. It will not function correctly when the temperature of the sample is drastically different from the temperature of the prism. Let hot or cold samples get acclimated to the ambient temperature before measuring.

Storage and Maintenance

(1)Store this instrument in a dry and shaded area. A damp storage area may cause the optical system to blur or encourage molding. Extended exposure to direct sunlight may cause the casing to warp.

(2)**Clean the prism surface immediately after completing each measurement. Any sample left on the prism surface for an extended period of time will damage the prism. Clean the prism with water and then dry any excess moisture with a clean, dry tissue.**

Repair and Warranty

The PAL-Soil is warranted for one year after the date of purchase against any manufacturer defect in materials or workmanship. Since the PAL-Soil is a precise optical instrument, great care must be taken in the instrument's storage and use. If any mistreatment or misuse of the instrument is detected, the warranty will be voided and repair fees will be charged. Ask your supplier for more details.

Have the serial number of your PAL-Soil available when asking about repairs.

Specifications

Measurement range	Gravimetric soil moisture: 0~200% (Automatic Temperature Compensation) Volumetric soil moisture: 0~100% Temperature: 10.0~40.0°C
Resolution	Gravimetric soil moisture: 1%, Volumetric soil moisture: 1% Temperature: 0.1°C
Measurement accuracy	Gravimetric soil moisture: ±2% (Within the range of 0-40% gravimetric soil moisture) ±5% (Within the range of 41-100% gravimetric soil moisture) Temperature: ±1°C
Measurement temperature	10~40°C
Ambient temperature	10~40°C
Measuring time	3 seconds
Backlight	The backlight stays on for 30 seconds after any button is pressed.
Maximum number of data history	100
Output	NFC Forum Type 4 Tag ISO/IEC 14443 Type A Output category: Date Time, Gravimetric soil moisture [%], Volumetric soil moisture [%], Temp [degC] (e.g.) 2018/05/01 07:11:08, 134, ---, 20.5
Power supply	AAA alkaline battery × 2
Battery life	About 11,000 measurements (when an alkaline battery is used)
International Protection class	IP65 Water Resistant
Dimensions and weight	55(W) × 31(D) × 109(H)mm, 100g

ATAGO instruments are rigorously inspected to ensure each unit meets the highest standards of quality assurance.

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Key point

- Only use a premium quality reagent of glycerin.
- Use a balance with an accuracy indication of at least $\pm 0.1\text{g}$.
- The temperature of the tap water, the instrument, and the ambient temperature should all be the same before zero-setting can be performed. If not, allow the water temperature to adjust to the ambient temperature before pressing the ZERO button to Zero Set.

Zero Setting

[CAUTION]

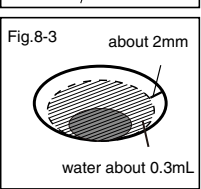
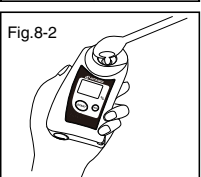
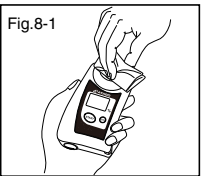
- Perform Zero Setting each day prior to using the PAL-Soil.
- The temperature of the tap water used for zero-setting should be the same as the ambient temperature. If not, allow the water temperature to adjust to the ambient temperature before pressing the ZERO button to Zero Set.
- If the ELI* function indicates the [nnn] warning message on the LCD screen while performing zero-setting, shade the sample stage with your hand and press the ZERO button again.
- When "AAA" is displayed, wipe the prism clean, apply water, and press the ZERO button again.

(1) Prepare tap water.

(2) Clean the prism surface (Fig. 8-1).

(3) Place approximately 0.3 mL of water onto the prism surface (Fig. 8-2, Fig. 8-3).

(4) Take a measurement. Zero-setting can be done in either scale.

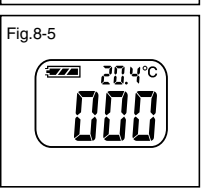
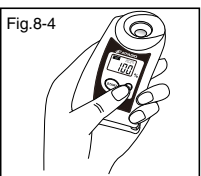


<When the screen is turned off>
Press the START button once, and either "-1-" or "-2-" is displayed. Press the START button again, and the measurement value is displayed.

<When "-1-" or "-2-" is displayed>
Press the START button once, and the measurement value is displayed.
If a measurement value is displayed on the screen, proceed to the next step.

(5) A measurement value or error message is displayed. Press the ZERO button. (Figure 8-4) After blinking "000" will be displayed on the LCD screen (Fig 8-5).

(6) When "000" is displayed, zero setting has been successfully completed. Dry the prism surface by wiping with a tissue. The PAL-Soil is ready to use.



- * Zero-setting can be performed in either scale.
- * The factory default scale selection is "-1-."

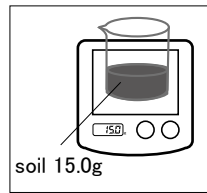
Measurement

[CAUTION]

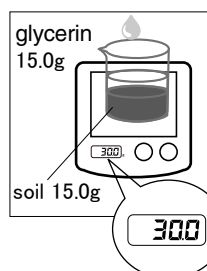
- Make sure that no small stones and other impurities are mixed in the soil sample.
- It is recommended to take multiple readings of one sample to ensure accurate, stable readings.
- Use a balance with an accuracy indication of at least $\pm 0.1\text{g}$.
- Do not use any metal tools when applying sample to the prism. Metal can damage the prism surface.
- The temperature of the sample should be the same as the ambient temperature. If the temperature is different, allow the sample temperature to adjust to the ambient temperature before pressing the START button to take a measurement.
- The instrument should not come in contact with any sample over 50°C . Warping of the outer casing may occur, which will diminish the water resistant feature of the instrument.
- Glycerin has water-absorbing properties and is sensitive to moisture in the air. Close the lid of the storage jar quickly and tightly.
- Glycerin has water-absorbing properties and is sensitive to moisture in the air. Minimize its exposure to the air before and after measuring.
- It is recommended to prepare bags of pre-measured glycerin in advance for outdoor measurement.

Gravimetric Measurement

(1) Prepare 15.0g of soil sample in the provided beaker.
* Use a balance with an accuracy indication of at least $\pm 0.1\text{g}$.

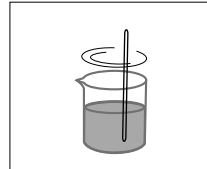


(2) Add 15.0g of glycerin to the soil so that the total weight will be 30.0g.
* Only use a premium quality reagent of glycerin.



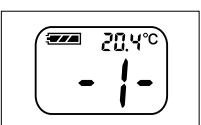
* As long as an equal amount of soil sample and glycerin is prepared, it does not have to be 15g of each. For example, 14.5g of glycerin for 14.5g of soil sample will also do. Please note that the smaller the amount of each sample is, the larger the relative error in weighing will be.

(3) Gently stir. Mix the soil evenly so that the moisture in soil is extracted into glycerin.



Use this homogeneous mixture for measurement.


(4) Select the scale "-1-".




<When the screen is turned off>
① Press the START button to turn on the power. The scale that was used for the previous measurement is selected. If "-1-" is selected, proceed to measurement.
② If "-2-" is selected, press the ZERO button to switch to "-1-." The scale switches between "-1-" and "-2-" every time the ZERO button is pressed.

<When the screen is turned on>
① Hold the START button down. The scale changes from "-1-" to "-2-," or vice versa, when the START button is held down.
② Select the scale "-1-." Release the button when "-1-" comes on.
* If the START button is held down after the scale switches to "-1-," the display will turn off.
③ "-1-" will blink, and then a measurement value or error message will be displayed. The scale selection is now complete.


(5) Clean the prism surface thoroughly.



(6) Apply a sample.

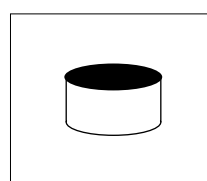


(7) Press the START button. The selected scale number blinks, and the measurement value is displayed. Replace the sample and press the START button to continue measuring in the same scale.



Volumetric Measurement

(1) Measure out 50mL of soil, using a sand-pouring cylinder or soil sampler.



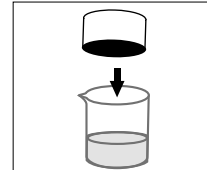
(2) Measure out 30mL of glycerin and place it in a beaker.
* Only use a premium quality reagent of glycerin.

Measure glycerin in one of the 2 ways:

<Method 1>
Measure 30mL of glycerin with a graduated cylinder. Place the glycerin in a beaker.
* Glycerin is viscous and may not pour out of the cylinder easily. Make sure to transfer it all to the beaker.

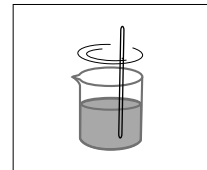
<Method 2>
The weight of 30mL of glycerin is set to 37.8g.
* The density of premium quality glycerin reagent is $1.26\text{g}/\text{cm}^3 = 1.26\text{g}/\text{mL}$. Therefore, 30mL equals to 37.8g.
* Use a balance with an accuracy indication of at least $\pm 0.1\text{g}$.

(3) Transfer the soil that was measured out in (1) to the beaker that contains glycerin.



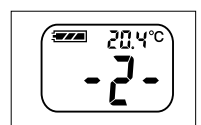
* As long as 5-part soil sample and 3-part glycerin are mixed together, any amount will do. For example, 100mL of soil sample and 60mL of glycerin can be used.

(4) Gently stir. Mix the soil evenly so that the moisture in soil is extracted into glycerin.



Use this homogeneous mixture for measurement.


(5) Select the scale "-2-".



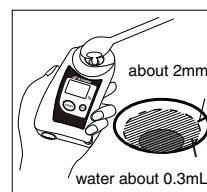
<When the screen is turned off>
① Press the START button to turn on the power. The scale that was used for the previous measurement is selected. If "-2-" is selected, proceed to measurement.
② If "-1-" is selected, press the ZERO button to switch to "-2-." The scale switches between "-1-" and "-2-" every time the ZERO button is pressed.

<When the screen is turned on>
① Hold the START button down. The scale changes from "-2-" to "-1-," or vice versa, when the START button is held down.
② Select the scale "-2-." Release the button when "-2-" comes on.
* If the START button is held down after the scale switches to "-2-," the display will turn off.
③ "-2-" will blink, and then a measurement value or error message will be displayed. The scale selection is now complete.

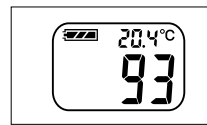
(6) Clean the prism surface thoroughly.



(7) Apply a sample.



(8) Press the START button. The selected scale number blinks, and the measurement value is displayed. Replace the sample and press the START button to continue measuring in the same scale.

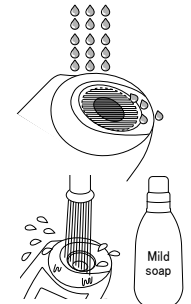


How to Turn the Power Off

The measurement value remains displayed for 2 minutes. To manually turn off the screen, hold the START button down to change the scale once, and keep holding it down. Although the scale selection changes by doing so, the selection of the scale that was used for measurement last time will be retained until next time the power is turned on.

Cleaning Method

[Caution]
Do not scratch the prism.
The instrument is water-resistant, not waterproof, and should not be submerged.

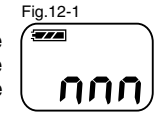


1. Rinse the sample with tap water.
2. Clean the prism and sample stage using a mild soap and thoroughly rinse with water.
3. Dry the area with tissues thoroughly.


Error Messages

Improper operation of the PAL-Soil will result in one of the following error messages:

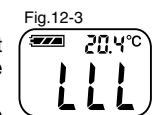
"nnn" Error (Fig.12-1)
Intense light is detected at the prism. Shade the sample stage with your hand and measure again.



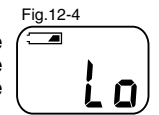
"AAA" Error (Fig.12-2)
There is no or an insufficient amount of water on the prism surface while performing zero setting.
A substance other than water is used to perform zero setting.



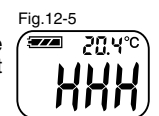
"LLL" Error (Fig.12-3)
There is an insufficient amount of sample on the prism surface to perform measurements.
Indicates when the sample measured has a measurement value below the measurement range.




Battery Error (Fig.12-4)
The following error message will be displayed when the battery power is low, replace with new batteries.




"HHH" Error (Fig.12-5)
The sample's measured value is out of the measurement range.



Measurement Temperature Error (Fig. 12-6 & 12-7)
The prism temperature is below the temperature range.



The prism temperature is above the temperature range.



"EEE" Malfunctioning Error (Fig.12-8)
With the instrument turned off, remove and reinsert the battery. In the case of a low battery, replace the batteries with new AAA alkaline batteries. If the instrument continues to display the error message, the instrument will need to be repaired. Please contact your Authorized ATAGO Distributor for information on repair.

