1 Maintenance and calibration

The **VariPol** polarimeter is designed for continuous operation, regular maintenance and calibration is recommended to maintain the precision of your device and increase its service life.

1.1 Maintenance

1.1.1 Customer Maintenance

We recommend cleaning the device at regular intervals from the outside. The period of this cleaning depends on the contamination and the useful life of the instrument. At least a purge once a quarter is recommended

1.1.2 Technician Expectations

Cleaning, checking and calibration by a certified S+H technician is recommended once a year. This ensures the proper functioning and measurement accuracy of your device.

1.2 Maintenance

1.2.1 Customer Maintenance

To extend the life of your high-quality Varipol, we recommend regular cleaning of the instrument from the outside. The period of this cleaning depends on the contamination and the useful life of the instrument. At least a purge once a quarter is recommended.

- ✓ To do this, turn off your device first.
- ✓ Then remove the power plug from your device.
- ✓ If necessary, remove a polarimeter tube still in the sample chamber and close it from the instrument as well.
- ✓ For external cleaning of the device and display, it is best to use a soft, lint-free cloth and a cleaning solution suitable for plastic surfaces.
- ✓ A suitable cleaning foam from the spray can as well as corresponding cleaning cloths can be obtained from Schmidt + Haensch, please ask our sales department (sales@schmidt-haensch.de) or see the article description and the order code in the spare parts directory.
- ✓ If you do not have the recommended cleaning materials at hand, use a light soap solution and a soft, lint-free cloth. Do not use solvents of any kind, as they can destroy the instrument and the surfaces. It is also strongly discouraged to use sponges or other harder cleaning items, as they could crush theart.
- ✓ Use the soft, slightly damp cloth to gently wipe the housing all around.
- ✓ Make sure that the cloth used is only damp and not too wet so that no liquid can penetrate into the device. Take special care that no moisture penetrates into the rear ports. Then use a dry, soft cloth to remove liquid residues from the sample holder.
- ✓ Inside your sample room is the sample room holder for your polarimeter tubes. This is made of stainless steel, manufactured with high precision and resistant to most solvents by means of a special surface coating.
- ✓ Make sure at all times that there is no contamination on the surface of your sample holder, otherwise an optimal temperature transition to your used polarimeter tube is not ensured. This can lead to inaccurate measurement results. Furthermore, a poor transition can also affect the response time of your measurements.
- ✓ To clean the metal surface of your sample, we recommend a mixture of isopropanol and water in conjunction with a soft sponge.
- ✓ Even if the sample chamber is almost completely sealed, make sure that no liquid can enter the instrument through a sponge that is too wet.
- ✓ Then use a dry, soft cloth to remove liquid residues from the sample holder.
- ✓ After cleaning your device externally, reconnect the power cord and turn your device back in.
- ✓ The Varipol automatically performs a self-test and will then switch to the operating mode you are familiar with.

- ✓ Before further use, please wait until your instrument has reached the set sample room temperature again.
- ✓ Before taking further measurements, we recommend checking your Varipol using a certified quartz plate. Please see chapter 1.3 Calibration.

1.2.2 Technician Expectations

Cleaning, checking and calibration by a certified S+H technician is recommended once a year. This ensures the proper functioning and measurement accuracy of your device.

The scope of this technical expectation includes:

- ✓ Journey
- ✓ cleaning of the polarimeter inside and outside,
- ✓ Verification of the optical components of the polarimeter,
- ✓ Control and adjustment of the beam path,
- ✓ Review of all functions,

- ✓ If necessary, replacement of wear parts / components:
    - Dust filter mat*
    - Light protection brushes (sample room)*
    - Dust protection glasses (sample room)*
    - Interference filter*
    - Cover glasses, sealing rings (tubes)*
- ✓ Software upgrade to the latest version,
- ✓ Verification of the measured values by means of
    - PTB – certified quartz plates,
    - DKD – certified temperature measuring device,
- ✓ In case of measurement deviations, recalibration of the polarimeter,
- ✓ Recording of the measured values for the creation of a new calibration protocol,
- ✓ Preparation of the maintenance log,
- ✓ On request, attach an calibration sticker with maintenance interval,
- ✓ Departure

We would be happy to make you a separate offer for this technical expectation or offer you a maintenance contract.

*Required spare parts or materials will be charged additionally by proof.

1.3 Calibration

1.3.1 Polar Interior

A polarizing filter looks like a simple gray filter. But if you hold two such filters one behind the other, there is a position in which no more light comes through the combination of the filters. If one of the filters is then rotated by 90°, the light from the first filter passes unhindered through the second. Physicists say that only light of a polarization plane can pass through a polarization filter. If the pass-through planes of the two filters in series are perpendicular to each other, no more light comes through the pairing. Some materials such as quartz or sucrose solutions are called optically active because they can rotate the polarization plane. Polarimeters are measuring devices that determine this rotation by optically active samples. In a polarimeter, two polarizing filters are arranged one behind the other so that no light passes through. When an optically active sample is placed between these filters, some light comes through again because the polarization plane has been rotated. If one of the filters is now rotated in such a way that no light passes through again, the rotation through the sample is measured directly. The actual measured value of a polarimeter is therefore an angle.

A very simple polarimeter consists of at least the following components:

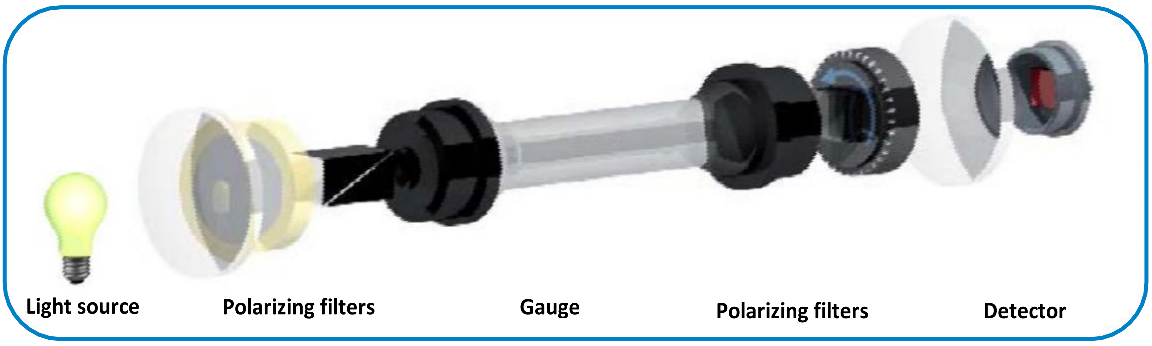

Figure 1: Structure of a polarimeter

In practice, such a simple setup may not work, since it is impossible to find the darkest point with sufficient accuracy. Therefore, a Faraday modulator is used in our automatic polarimeters. Faraday modulators use the property of some substances to become optically active by magnetic fields. If a rod of such a material is placed in a coil connected to alternating current, this rod will have a periodically changing optical activity. If such a modulator is placed between two polarization filters, the intensity of the light will therefore also change periodically. From this signal one can determine when the oscillation occurs around the compensation point. This method of Faraday modulation is particularly accurate and insensitive to errors.

For dissolved substances measured in sample tubes, the measured angle of rotation depends on the

Type of sample

Concentration of the sample

Length of the tube

Temperature

Color of light (wavelength)

The corresponding formula was found by the French physicist Jean B. Biot in the 19th century . BIOT's law states:

$$c = \frac{\alpha}{\frac{[\alpha]_D^{20} \cdot 10000}{l}}$$

with

c : concentration (g / 100 cm^3 solution)

α : Rotation (angular degree)

$[\alpha]_D^{20}$: Specificsche Drehung

l : length of the sample tube (in mm)

The **specific rotation** depends on temperature and wavelength; for some samples, also on the concentration itself. Note that the unit of concentration g / 100 cm is ^{3}, and not in g / 100 g.

As an example, let us show the specific rotation of an aqueous solution of sucrose at 20 °C and a wavelength of 589.44 Nm (this is the centre of gravity of the two yellow lines of sodium light) produced by the ICUMSA ("International Commission for Uniform Methods of Sugar Analysis")set was set to $[\alpha]_D^{20}$ = 66.588 ± 0.002

Thus, taking 26 g per 100^{cm3} and a measuring tube of 200 mm, the rotation of

α = **34.626° ± 0.001°**

as you can see by simply inserting it into the formula. This sucrose solution is called normal solution and its rotation 100.00 °Z (sugar degree). The International Sugar Scale (ISS) is divided linearly, i.e. a rotation von 17.313° corresponds to 50.00 °Z.

1.3.2 Effect on polarimetric measurement

The following are some of the effects that can affect the polarimetric measurements. Due to these effects, it can happen that the device gives incorrect results after delivery. Therefore, please calibrate the device before first use.

1.3.2.1 Wavelength effects

Four standard wavelengths are used in the polarimeters of the sugar industry. At these wavelengths, the following specific Turns $[\alpha]_D^{20}$, sowle Turns the Standardalsolution in A 200 Mm Tube:

Description	**Wavelength**	$[\alpha]_D^{20}$	α
Mercury-green	546.23 nm	78.4178	40.777°
Sodium-yellow	589.44 nm	66.5885	34.626°
HeNe Laser	632.99 nm	57.2144	29.751°
NIR	882.60 nm	28.5306	14.836°

Detailed definitions of the International Sugar Scale can be found in "Specification and Standard SPS 1 (1998): Polarimetry and the International Sugar Scale" of the ICUMSA Methods Book. In this example, the influence of wavelength on rotation becomes visible. Even a shift of 0.03 nm leads to a change in rotation by 0.01%. Therefore, light sources with narrow half-widths must be used. Mostly halogen lamps with interference filters are used. These filters can be manufactured with a sufficiently narrow bandwidth, but their central wavelength is not one hundred percent stable in the long term. To determine the current wavelength at which a polarimeter operates, it must be tested with a precisely known sample. Quartz control plates have proven themselves well. With their rotation in the device you know the wavelength of the device.

1.3.2.2 **Temperature effects**

Another influence is the temperature. The reading of a quartzplate increases with temperature:

Reading (T) = Reading (20.0°C)(1.0 + 0.000144(T - 20.0))

The same plate that shows 40,000° at 20 °C rotates 40,006° at 21 °C and 40,029° at 25 °C.

In contrast, the rotation of a solution decreases with temperature, T. Using the example of a sugar solution, this has the following effect:

Correct reading:
() = Reading () (1.0 - 0.000471 α α · · (T - 20.0))
39.906° = 40.000° (1.0 - 0.000471 (25°C - 20°C))

The same solution that shows 40,000° at 20 °C rotates 39,981° at 21 °C and 39,906 ° at 25 °C.

Please note that there are three temperature influences on the reading of solutions. On the one hand, the volumetric flasks, which are filled to 100 cm³, are calibrated for 20 °C. The length of the measuring tube also depends on the temperature. In addition, the optical activity of the solution changes with temperature. Of these three influences, only the last one is taken into account in the formula above. The examples show that when calibrating a polarimeter, the temperature must be taken into account. If a calibration is performed with a quartz in a laboratory at 22 °C and then a normal solution is measured without taking the temperature into account, the solution will show only 99.88 °Z instead of 100.00 °Z!

1.3.3 Customer calibration

The continuous cooperation between the company Schmidt + Haensch with various institutes and other pharmaceutical companies has shown that a very simple measure can avoid major problems under certain circumstances. Therefore, we recommend at this point the introduction of a so-called "laboratory - devices - book", if not already available.

This book is used to document and record the recommended, daily checks and thus to be able to find any deviations very quickly and easily.

- ✓ We recommend checking your Varipol once a day before using the device regularly.
- ✓ The calibration of the instrument should, if possible, be carried out in an air-conditioned environment under constant ambient conditions. For example, at high outside temperatures, e.g. 40°C and high humidity >60%, condensation could occur in the sample chamber, which could impair the measurement accuracy.
- ✓ Remove all tubes, quartz plates, cuvettes or similar from your sample chamber and also disconnect the cable connection between them and your Varipol.
- ✓ Close the sliding doors above your sample room to exclude possible influences from extraneous light.
- ✓ Before calibration, make sure your instrument is turned on and the sample room temperature is set to **20.00 °C.**
- ✓ If this is not the case, turn on your device and set the test room temperature to 20.00°C.
- ✓ Wait until the sample chamber temperature reaches 20.00 °C.
- ✓ Now perform a so-called "zeroing" of your polarimeters.
- ✓ To do this, press the tests "zero" in your measurement mode.
- ✓ The recommended measurement mode is "Standard".

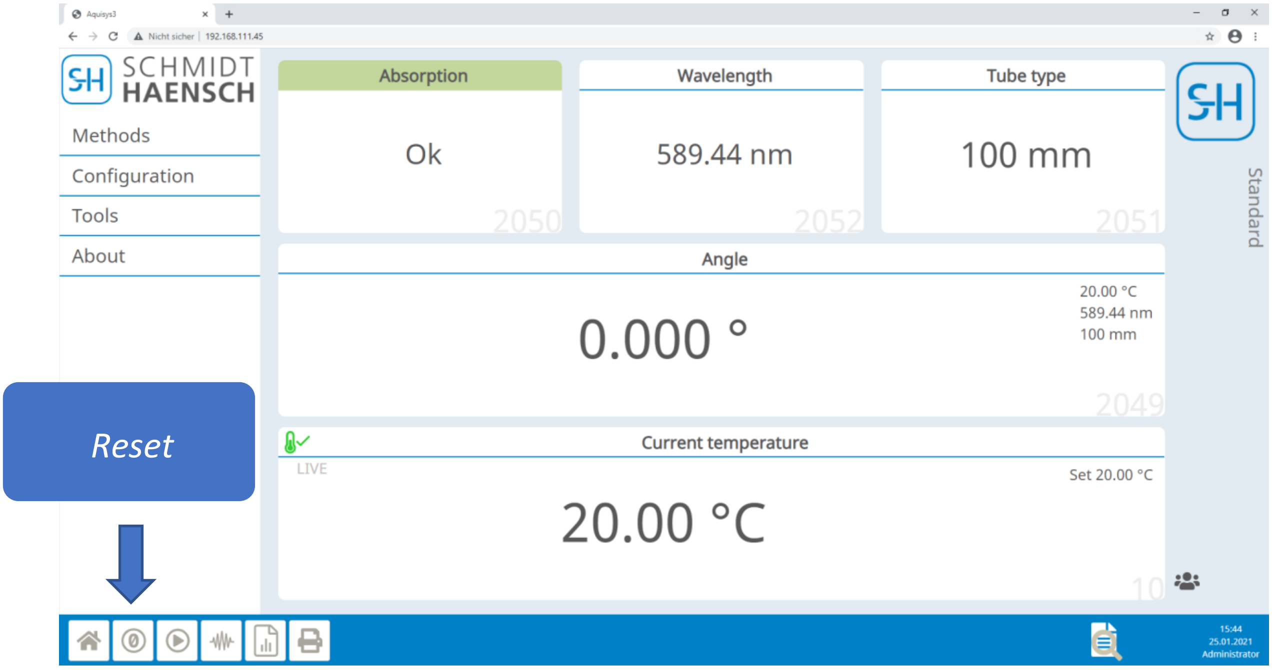

Figure 2: Standard method after zero setting with empty sample space

- ✓ The device will ask you again to empty the sample room or fill the polarimeter tube with distilled water.
- ✓ Make sure that the sample chamber is emptied at this point and that no quartz plate, etc. is connected to the instrument.
- ✓ After you have successfully performed the "zeroing" with empty sample space, your angular degree reading should show 0.000°. (see Fig. 2)
- ✓ Now place your certified quartz plate in the sample chamber and connect the cable to the socket provided for this purpose on the back of the instrument.
- ✓ When connecting the cable, you will notice a temperature jump in your actual value display of the temperature. This is completely normal, since at the moment of connecting the quartz plate, the control is switched from the sample chamber to the quartz plate.
- ✓ Close the sliding doors above the sample rough to avoid possible influences of extraneous lighton the measurement.
- ✓ Wait until the temperature display (now for your quartz plate) is exactly 20.00 °C again.
- ✓ Now press the Start button to start a measurement.

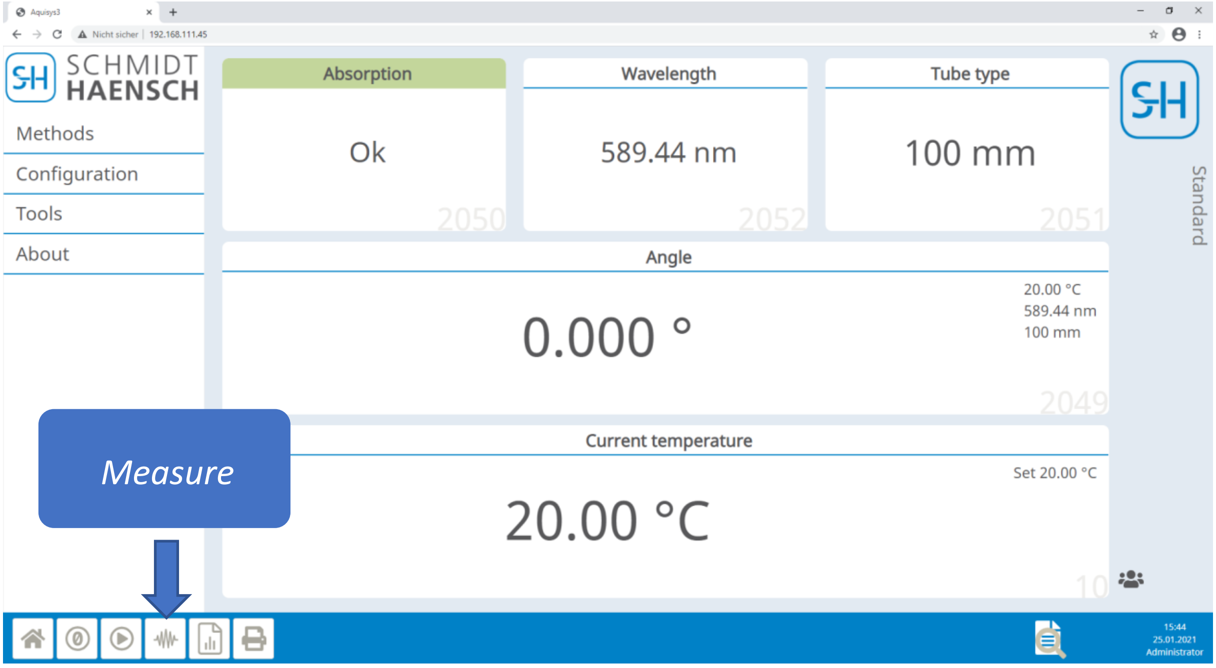

Figure 3: Start standard method measurement

- ✓ After successful measurement, compare the displayed measured value with the value in your certificate of the quartz plate. Please note that the certificate indicates measured values for different wavelengths. Your Varipol can also be equipped with different wavelengths. As a result, it may be necessary to repeat the calibration process for the second, installed wavelength in the same way.
- ✓ Enter your measured value with the temperature, the ambient temperature and the date and time, if necessary stating your name in your "Laboratory – Equipment – Book".
- ✓ These daily entries enable you to react quickly and easily to any changes and to recognize deviations and tendencies in good time.
- ✓ Compare any measurement deviations with the specifications given in your user manual for your device type.
- ✓ If you find that the deviations are outside the permitted tolerances, proceed as follows.
    - Repeat the entire process again, including "set zero" with the sample space empty before measurement.
    - If your results again detect identical, too large deviations, you have the possibility to adjust the measured values by correcting the wavelength.
    - On the Left On the side of your Varipol you will find two small feedthroughs behind which the adjustment options for the interference filters are hidden to correct the wavelength.

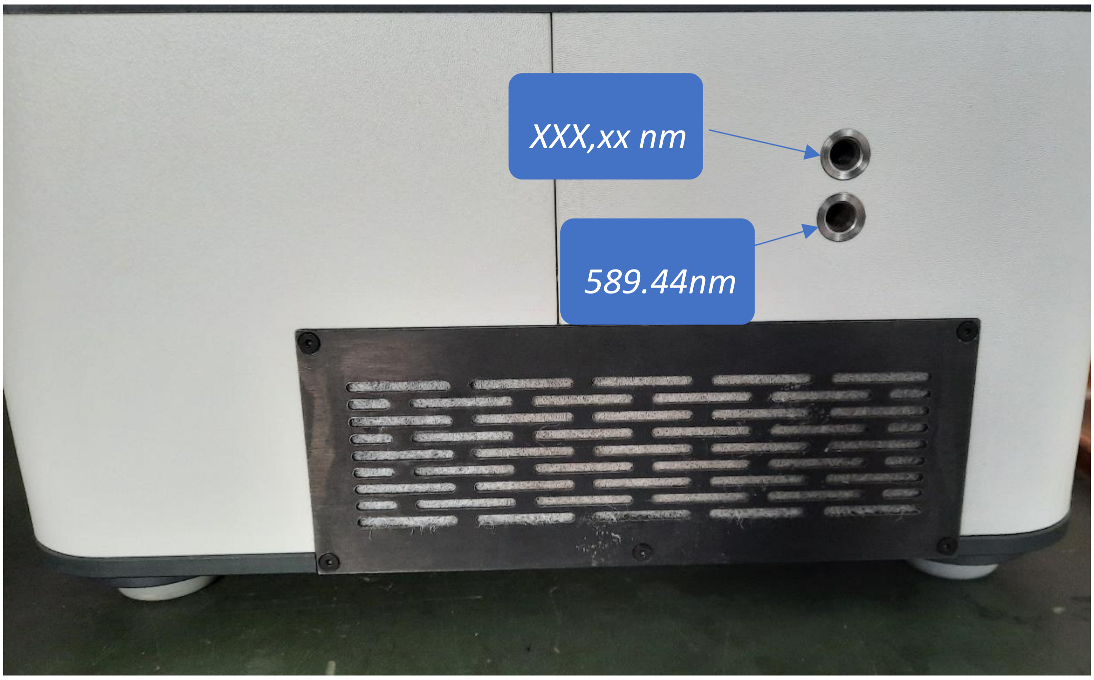

Figure 4: Setting the Wavelength

- By means of a 2mm Allen key, which you insert into the corresponding opening of the wavelength you are using, you can correct the wavelength and thus set your measured values according to the specifications of your certified quartz plate.
- In order to be able to detect a change in your measured values, you must start a measurement again after each change in the setting (see Fig. 3).
- When you have reached the desired measured value, equivalent to the specified value in your quartz plate certificate, remove the quartz plate from the sample chamber, close it again and start a measurement again.
- If you receive 0.000° as a measured value for the empty measurement carried out in this way, place the quartz plate again in your sample room and start a measurement again after reaching 20.00°C for your quartz plate. If you again receive the measured value for your quartz plate equivalent to the quartz plate certificate, the "recalibration" of the wavelength is successfully completed and your Varipol is ready for operation again.
- However, if you do not receive 0.000° as a measured value for the empty measurement carried out in this way, reset your Varipol again by pressing the "zero button" (Fig. 2).

- Then place the quartz plate again in the sample chamber and wait until the 20.00°C for the quartz plate is reached again.
- Start a measurement again and, if necessary, correct the measured value again by correcting the wavelength.
- You may need to repeat this process several times to achieve optimal recalibration of your Varipol.

✓ Do not forget to note the re-calibration of your device carried out in this way in your "Laboratory – Equipment – Book".

✓ Significantly larger deviations than those stated in the specifications indicate a need for maintenance, please contact Schmidt + Haensch - Service in this case.

✓ service@schmidt-haensch.de
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