Sigma 702

User Manual

Original instructions

Force Tensiometer

MANUAL23834-4

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1. Introduction

The Sigma tensiometer system is a high performance tensiometer for the measurement of surface or interfacial tension. The 702 is designed for measuring surface tensions and interfacial tensions between two liquids with Du Noüy ring or Wilhelmy plate. The density of a liquid can also be measured.

Inside this manual you will find information on how to use your Sigma tensiometer. You will also find brief reviews of the concepts involved in your measurements and some practical advice on the techniques involved. In order to obtain the maximum performance from your instrument you should read this manual and keep it available for reference.

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2. Safety

WARNING!
The safety requirements listed in this manual must be followed in order to avoid personal injury and damage to the instrument. If the equipment is used in a manner not listed in this manual, protection provided by the equipment may be impaired.

WARNING!
RISK OF ELECTRICAL SHOCK. Do not connect this instrument to electrical power if the enclosure is damaged or any of the covers or panels are removed. Make sure the voltage rating on the instrument matches the line voltage available. Make sure the power cord is not damaged and it is properly connected to the instrument and a power outlet with protective earthing. Make sure that the power cord is easily accessible after the equipment has been installed and set at its working position.

WARNING!
RISK OF ELECTRICAL SHOCK OR FIRE HAZARD. The instrument has been designed for indoor use only. Do not expose it to rain, snow or dust. During storage or transport the instrument should be kept dry. Temperatures below 0°C and above 70°C should be avoided. Do not operate at ambient temperatures below 15°C and above 30°C.

When handling flammable liquids, use a minimum sample volume that is required for successful measurement.

Ensure prevention of Electrostatic Discharge (ESD) when handling flammable liquids. Contact your local authorities for information on ESD prevention practices.

Do not heat flammable sample liquids to temperatures higher than T–25 °C where T is fire point of the sample liquid.

WARNING!
RISK OF INJURY. Do not configure the instrument with parts that are not supplied by Biolin Scientific and not intended to be used with Attension instruments. Do not install substitute parts that are not described in this manual. Do not perform any modifications to the product.

If dangerous liquids are used, adequate protection such as proper ventilation, safety glasses, etc., should be used: refer to the safety information from the supplier and general safety regulations in your country. Carry out appropriate decontamination if equipment is exposed to hazardous material.

WARNING!
RISK OF BURNS. Exercise caution when touching heated sample vessels (optional). The vessel surface will reach dangerous temperatures when heated. The vessels are marked with hot surface warning symbol.

Platinum Wilhelmy plate/rod is an excellent catalyst for oxidation of methanol vapor. This reaction is very exothermic. In experiments in which the Wilhelmy plate/rod is positioned above reagent-grade methanol this reaction may cause dangerous heating of the plate/rod. Be aware of this phenomenon and take appropriate precautions.

CAUTION!

Make sure that the power is switched off when making any electrical connections (apart from the USB cables). Connecting cables with power on may damage instrument electronics. To disconnect the instrument, after turning the instrument off, remove the power cord plug from the electric outlet.

3. Physical Description

This section describes the physical construction of the Sigma 702 tensiometer. All necessary hardware, software and accessories are included in the basic Sigma instrument making it possible to take the instrument into use directly from its shipping crate.

CAUTION!: The transportation lock of the balance must be unlocked before using the instrument. See section 3.1.2 for instructions.

3.1 Measurement Unit

The basic Measurement Unit consists of the following parts:

- Main body containing electronics, power supply and user interface
- Manually locked and calibrated super sensitive electro-magnetic balance
- Lifting stage with long movement range for large samples
- Membrane keyboard for manual system operations without PC control
- Led lights for non-heating illumination of the measuring chamber

3.1.1 Main Body

The Main Body consists of the Power supply and the Main Electronic Board.

3.1.2 Balance

The balance for your Sigma 702 tensiometer is located in the upper housing of the Measuring Unit. The balance is suitable for all kind of surface or interfacial tension measurements. One hook comes down from the balance. This is used for hanging the probe used for the measurement. The **travel lock** is located below the balance housing and looks like a small screw. Use this to lock the balance when the Measuring Unit is moved (even from table to table). **It is important to unlock the transportation lock before using the instrument.** To unlock, turn the screw so that it moves outwards from the balance housing.

3.1.3 Lifting System

The stage of your Sigma tensiometer is lifted by a stepper motor. The speed range for the movement of the sample stage is from 0.01 to 500 mm/min in increments of 0.01 mm/min. The maximum range of movement is 100 mm. There are safety switches which stop the upward and downward movement of your stage automatically at the highest and lowest positions of the stage.

3.1.4 Measuring stage

The measuring stage of your Sigma tensiometer has been designed so that it has a sufficient separation between balance housing (top) and measuring stage for improved stability.

3.1.5 LCD Display

The built-in LCD display is used to monitor the status of the Sigma 702. It guides the user to the next step in the measurement or calibration procedure and shows the results obtained.

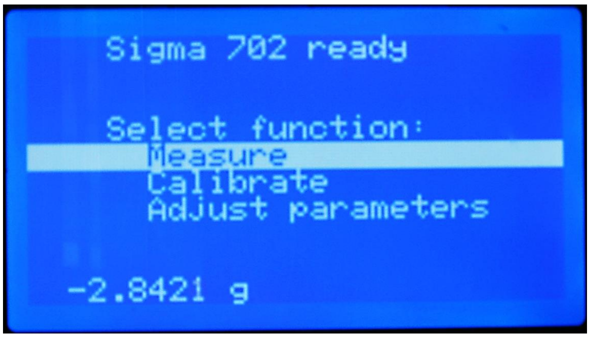


Figure 1: Startup screen

The bottom line of the display shows the balance reading, which is updated real-time. During measurement, the bottom line shows the surface tension or interfacial tension value calculated from the balance reading.

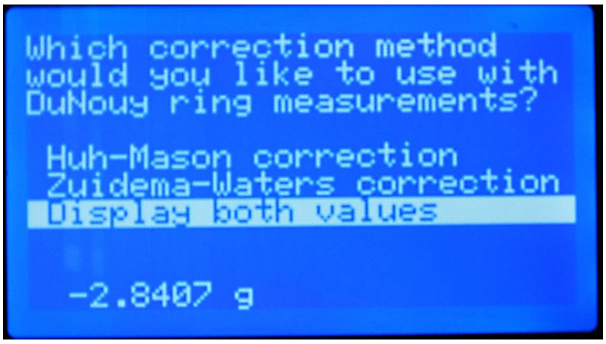


Figure 2: Adjusting measurement parameters

3.1.6 Manual Membrane Keyboard

The built-in Manual Membrane Keyboard allows the user to navigate through the menus of the user interface and to control sample stage movement and the stirrer.

Figure 3: The manual membrane keyboard controls

To control the distance between the probe and the vessel, use the triangular buttons on the left side of the keyboard. The upper triangle moves the stage up, the lower one moves it down. Press and hold down a button to keep the stage moving. To save time, it is advisable to bring the liquid surface close to the probe before starting measurement. The stage buttons are disabled during a measurement.

The button with two arrows in circular shape in the lower middle part of the keyboard is the stirrer button. Pressing it sets the stirrer on and off. The button is disabled during a measurement.

The blue buttons **OK**, ↑, ↓ and **Stop/Cancel** are used to navigate the menus on screen. Press ↑ and ↓ to move the highlight on the desired operation and OK to select it. Stop/Cancel can be used to return back to an upper menu level or to interrupt any operation.

3.2 Optional Accessories

Note: You need at least one of the probes described in sections 2.8.1 through 2.8.3 to perform measurements with Sigma 702.

3.2.1 Du Noüy Ring

A platinum-iridium ring (Du Noüy ring) can be purchased separately for use in surface tension and interfacial tension measurements. The ring should be cleaned regularly after use and treated carefully to avoid deformation.

A good way to store the ring is to immerse it in ethanol by first hanging it on a hook attached to a lid, which is then attached to a beaker filled half-full with ethanol. Then before using the ring again flush it with pure ethanol and water, or burn it with a Bunsen burner (ca. 1000ºC flame) for a short time (glowing yellow-red for a few seconds). In this way the ring will keep its form better and will not deform as easily as by putting it back to the transport case after each measurement.

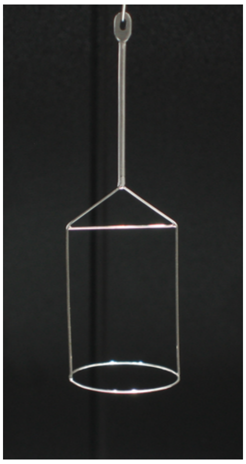


Figure 4: Du Noüy ring

3.2.2 Wilhelmy Plate

A thin platinum plate (Wilhelmy plate) can be purchased separately for surface tension measurement. The measurement with Wilhelmy plate is based on measuring the increase in the weight that the plate gets when it is wetted and water "hangs" from it (see figure 5). The force per wetted length is proportional to the surface tension. In this case, wetted length is the perimeter of the plate.

The Wilhelmy method is based on the assumption that the contact angle between the plate and the liquid is zero.

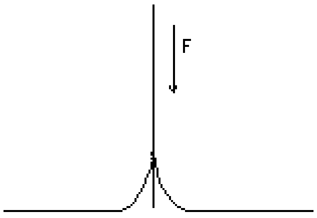


Figure 5. Water "hanging" from a Wilhelmy plate, increasing its weight.

A Wilhelmy plate can be cleaned by washing it with pure ethanol and de-ionized water. The plate should also be burned glowing red with a Bunsen burner for a few seconds in order to burn all remaining organic contaminants.

WARNING!
RISK OF BURNS. Platinum Wilhelmy plate/rod is an excellent catalyst for oxidation of methanol vapor. This reaction is very exothermic. In experiments in which the Wilhelmy plate/rod is positioned above reagent-grade methanol this reaction may cause dangerous heating of the plate/rod. Be aware of this phenomenon and take appropriate precautions.

3.2.3 Density Probe

A density probe (a glass ball with a wire hook attached to it) can be purchased separately for use for density measurement with Sigma 702. The hook of the probe is mounted to the hook that hangs from the balance housing.

The density measurement system of Sigma 702 must be calibrated for each density probe used.

3.2.4 Thermostatic Vessel

A thermostatic vessel is used for controlling the temperature of the sample liquid. It has two water jackets that conduct water from an external bath/circulator heating or cooling. A glass vessel should be used inside the thermostatic vessel. Sample vessels with a diameter of 70mm or less fit in the thermostatic vessel. Note: The necessary external bath/circulator is not included.

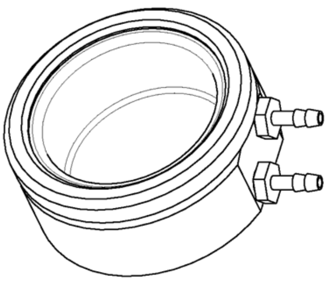


Figure 6: Thermostatic vessel

3.3 Cleaning procedure

In all measurements done with Sigma 702, the cleanliness of the used probes and beakers is extremely important for reliable and reproducible results. The best cleaning procedure depends on the samples used. Here is a typical cleaning procedure when water or oil is used.

Cleaning of the glass beaker

Rinse **three times** with n-heptane (only after preceding tests with oil), afterwards with 2-propanol (also in case of unused beakers and after water testing). Rinse with hot tap water and afterwards thoroughly with deionized water/bi-distilled water. Please see water requirements below.

Laboratory dish washer with integrated deionized water with the required quality may be used if providing the required cleanliness. Be sure that all washing agents are removed completely before drying.

Cleaning of the platinum probe

Rinse **three times** with n-heptane; afterwards with deionized water and **heat it in the oxidizing flame** for approx. 5 s in an ethanol or natural gas burner to **red** heat.

Water used for the reference test

Bi-distilled or deionized water from a glass bottle with a surface tension of >70 mN/m at max. 25°C should be used. HPLC-grade water may be used if suitable.

Note: For pure water the following relationship between surface tension of water and temperature exists:

$$\frac{\Delta\sigma}{\Delta T} = 0{,}15 \frac{mN}{m \times {}^{\circ}C}$$

σ = surface tension (mN/m)

T = temperature (K)

Cleaning the instrument

The exterior of the instrument can be cleaned with a damp cloth. Ensure that the surfaces are dried immediately after cleaning. If liquid is accidentally spilled on the instrument, wipe the instrument using a dry, clean cloth.

3.4 Maintenance

Only persons authorized by Biolin Scientific are allowed to perform maintenance and repairs on the instrument. In case repair is needed, contact Biolin Scientific directly.

4. Technical Specifications

Sigma 702	Electro-magnetic balance
Maximum load Weighing resolution* Force resolution ST Resolution with standard probe Taring Calibration Locking	5 g 0.01 mg 0.01 mN 0.01 mN/m Automatic Manual Manual

*Actual resolution of the balance.

Voltage and current

Input voltage	100 – 240 Vac
Frequency	50 – 60 Hz
Input current	100 – 160 mA
Fuses	T1.0A 5x20 mm

Environmental conditions

Ambient temperature	15 – 30 °C
Ambient pressure	700 to 1060 hPa
Ambient humidity	20 – 80% (non-condensing)

5. Measurement

5.1 Preparations for measurement

Before beginning a measurement, please go through the following checks and preparatory operations:

- Check that the transportation lock of the balance is fully open.
- Turn Sigma 702 on at least half an hour before starting a measurement or calibration.
- Calibrate the instrument if necessary (see section 5).
- Check the condition of the measurement equipment you are going to use: A correct, non-deformed shape is important for Du Noüy ring and Wilhelmy plate.

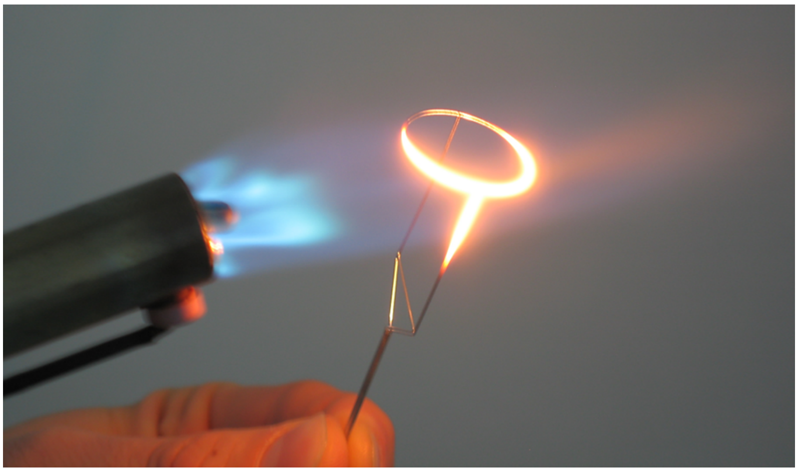


Figure 7: Cleaning a Du Noüy ring with a Bunsen burner.

5.2 Measuring surface tension with a Du Noüy ring

1. Check the instructions in section 5.1 and make necessary preparations.

2. Mount the cleaned Du Noüy ring in the tensiometer hook.

3. If there is any doubt, check that the correct ring type is selected and also other measurement settings are as preferred via **Adjust parameters** in the main menu. You can find the ring type setting by selecting:

Adjust parameters -> **Du Noüy ring parameters** -> **Ring type**

using the arrow buttons (↑ and ↓) and **OK** button, and **Stop/Cancel** to return back to the main menu. For information about choosing between Huh-Mason and Zuidema-Waters correction methods, see section 4.2.1.

4. Pour the liquid to be measured in to the cleaned glass sample container. A liquid depth of at least 11 mm is recommended.

5. Select **Measure** from the menu selection and press the **OK** button. In the following menu, select **Surface tension / ring** and press the **OK** button.

6. You will now be asked, which **density difference** value to use. When measuring surface tension, the density difference is $\rho_{liquid} - \rho_{air}$.

7. You are asked to set the number of measurement points you want the device to make. One point means a single measurement pull through the surface. If you specify a greater number of measurement points, the instrument will perform the specified number of measurements and will show the average value and standard deviation at the conclusion of the measurement. The values of individual measurement samples can be seen by collecting data to PC by using a USB connection and the PC software described in section 5.6 or by using an optional printer to collect the data. However, the curve drawn on display during measurement helps you to detect any possible anomalies among the sample measurement rounds.

8. Press **OK** to begin measurement and wait until it is finished. A curve is plotted during measurement, showing the surface tension value calculated from the balance reading at each instant. If your measurement consists of many measurement points, each of them gets a curve of its own. However, the curves usually follow the same trajectory quite closely.

9. When finished, the measurement result is displayed on screen and the stage starts moving to draw the probe out of the liquid. Please note that either Huh-Mason correction or Zuidema-Water correction is applied, depending on your settings. You can also have the result displayed with both corrections.

The result is calculated from the highest value of the measurement curve. In the case of several measurement points, the result is calculated as the average of results from the individual measurement points, and the sample standard deviation value is displayed.

10. After measurement, clean the Du Noüy ring and the glass sample container.

5.2.1 Choosing a correction method: Huh-Mason or Zuidema-Waters

Briefly: When measuring surface tension or interfacial tension with Sigma 702 and a Du Noüy ring, either of two possible methods can be used for correction factor calculation: Huh-Mason or Zuidema-Waters. Generally, Huh-Mason is regarded as the more accurate one whereas Zuidema-Waters is an older method and may be used, e.g., for compatibility with earlier results. Huh-Mason is set as the default in Sigma 702.

Background: The starting point for calculating surface tension from balance reading is the following formula:

$$\sigma_{basic} = \frac{F_{meniscus}}{4\pi \cdot r_{ring}},$$

where σ_{basic} stands for the surface tension of the liquid being measured, $F_{meniscus}$ is the maximum lifting force that the meniscus hanging from the ring can withstand, and r_{ring} is the radius of the Du Noüy ring. The term $4\pi \cdot r$ amounts to the *wetted length* of the ring–the inner circumference plus the outer circumference.

While giving results to the right direction, the basic formula does not correctly take into account the effect of ring wire curvature on shape of the meniscus and thus the result. Therefore, a correction factor is usually applied (automatically in Sigma 702 tensiometers). The most commonly used methods for correction factor calculation are Huh-Mason and Zuidema-Waters, named after their authors.

The precise correction factors for Huh-Mason correction are looked up and interpolated from a numeric table that cannot be conveniently represented here.

The calculation formula for the Zuidema-Waters correction factor ($F_{correction}$), however, goes as follows:

$$F_{correction} = 0.7250 + \sqrt{\frac{1.452P}{C^2(D-d)} + 0.04534 - \frac{1.679 r_{wire}}{r_{ring}}},$$

where P equals the force when the film ruptures in mN/m, D is the density of the heavy-phase at 25°C in g/ml, d is the density of the light-phase liquid (air if surface tension is measured) as g/ml, C is the circumference of the ring in mm, r_{ring} is the radius of the ring in mm, r_{wire} is the radius of the wire of the ring.

When the basic result σ_{basic} and the correction factor $F_{correction}$ are known, the final result is their product:

$$\sigma_{corrected} = \sigma_{basic} \cdot F_{correction}$$

Sources:

C. Huh and S.G. Mason, Colloid & Polymer Sci. 253 (1975) 566-580.

H.H. Zuidema and G.W. Water, Industrial and Engineering Chemistry 13 (1941) 312-313

5.3 Measuring interfacial tension with a Du Noüy ring

5.3.1 Push Mode and normal (pull) mode

An interfacial measurement is performed by pulling the Du Noüy ring from a polar liquid over the interface to a non-polar liquid. Often, the polar liquid is heavier than the non-polar one, so the ring is pulled upwards -- that is the normal mode. If, however, the non-polar liquid is heavier and falls to the bottom of the sample vessel, the measurement must be performed in Push Mode, i.e. by pushing the ring from the light-phase liquid downwards to the heavy-phase liquid.

When measuring in Push Mode, an extra weight must be attached to the Du Noüy ring in order to prevent the ring from getting tilted or rising away from the hook as the interface exerts an upward force towards the descending ring. The weight must be mounted on the ring before starting any measurement in Push Mode.

5.3.2 Measurement steps

1. Check the instructions in section 5.1 and make necessary preparations.

2. Mount the cleaned Du Noüy ring in the tensiometer hook.

3. If there is any doubt, check that the correct ring type is selected and also other measurement settings are as preferred via **Adjust parameters** in the main menu. You can find the ring typesetting by selecting:

Adjust parameters -> **Du Noüy ring parameters** -> **Ring type**

using the arrow buttons (↑ and ↓) and **OK** button, and **Stop/Cancel** to

return back to the main menu. For information about choosing between Huh-Mason and Zuidema-Waters correction methods, see section 5.2.1.

4. Pour the heavy-phase liquid into the glass sample container. A liquid depth of at least 14 mm is recommended for normal pull-mode measurement. In push mode, the depth requirement varies depending on the properties of the liquids measured but about 20 mm should be sufficient. See section 4.3.1 for information about Push Mode and normal (pull) mode.

5. Select **Measure** from the menu selection and press the **OK** button. In the following menu, select **Interfacial tension / ring** and press the **OK** button.

6. You will now be asked, which **density difference** value to use. When measuring interfacial tension between two liquids phases, the difference is $\rho_{heavy-phase} - \rho_{light-phase}$. The density difference may be input using the arrow and OK buttons on the keypad.

In the same screen you can toggle **Push Mode**. Please note that Push Mode must be set on or off before making any selection that would move you to the next screen. See section 4.3.1 for information about Push Mode.

7. You are asked to set the number of measurement points you want the device to make. One point means a single measurement pull through the surface. If you specify a greater number of measurement points, the instrument will perform the specified number of measurements and will show the average value and standard deviation at the conclusion of the measurement. The values of individual measurement samples can be seen by collecting data to PC by using a USB connection and the PC software described in section 5.6 or by using an optional printer to collect the data. However, the curve drawn on display during measurement helps you to detect any possible anomalies among the sample measurement rounds.

8. When you press OK to continue, Sigma will instruct you to move the liquid sample close to the probe or immerse the ring to liquid, depending on your selections.

If you make a pull mode measurement, you will be asked to immerse the ring into the heavy-phase liquid and then pour the light-phase liquid. That way you can perform the measurement without first contaminating the ring in the light-phase liquid.

If Push Mode is used, an additional weight (called Push Mode weight) must be mounted on the ring before starting a measurement.

9. Press **OK** to begin measurement and wait until it is finished. A curve is plotted during measurement, showing the interfacial tension value calculated from the balance reading at each instant. The highest value encountered will be displayed as the result of the measurement.

If you chose several measurement points, the result will be the average of the points, in which case the standard deviation is also displayed.

10. When finished, the interfacial tension will be displayed on screen and the stage starts moving to draw the probe out of the liquid.

11. Clean the Du Noüy ring and the glass sample container.

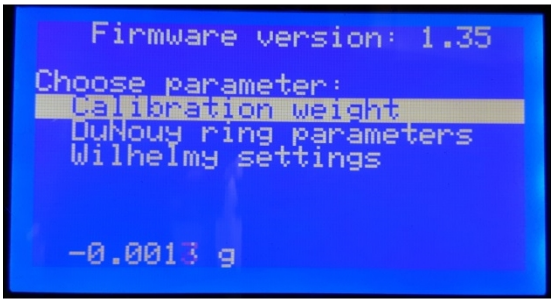
5.4 Surface tension measurement with a Wilhelmy Plate

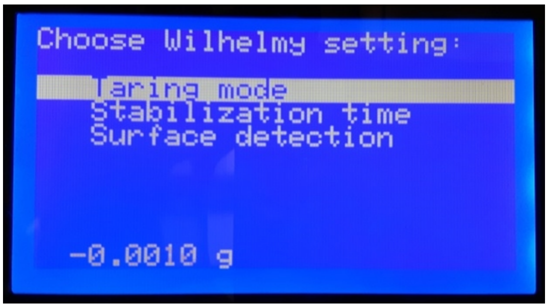
5.4.1 Steps for measurement

1. Check the instructions in section 5.1 and make necessary preparations.

2. Mount the purified Wilhelmy plate in the tensiometer hook. See to it that no liquid drop hangs from the bottom of the plate.

3. Check that the correct Wilhelmy measurement parameters are set. The settings can be found by selecting **Adjust parameters** -> **Wilhelmy settings**.





- For taring mode, you can choose between **Wet Taring** and **Dry Taring**, of which Wet Taring is the default. See section 5.4.2 for information about Wet Taring and Dry Taring.

- **Stabilization time** specifies how long to wait after the Wilhelmy plate is brought to the correct depth before taking measurement. 4 seconds is the default, but with viscous liquids it may take longer to reach a satisfactory state of equilibrium.

- **Surface detection** specifies the surface recognition threshold. The liquid surface is recognized by seeing a sharp rise in force when the plate touches the liquid surface. Here the needed force level can be specified. 2 mN/m in recommended to avoid false surface recognition due to vibrations and air currents.

4. Pour the liquid to be measured into the glass sample container.

5. Select **Measure** from the menu selection and press the **OK** button. In the following menu, select **Surface tension / plate** and press the **OK** button.

6. Set the number of measurement points you wish to make. If you choose more than one point, the average of the measurement points and their standard deviation (STD) is displayed at the conclusion of the measurement. The results of individual samples can be seen via the USB receiver

software (see section 6.6) or by using an optional printer. The standard deviation reading on the display after measurement will help you to detect any problems in the measurement sequence.

7. Sigma will instruct you to move the liquid sample close to the probe. This is particularly important in Wilhelmy Plate measurement, since the plate approaches the surface rather slowly in order the get an accurate reading of the surface position.

When the plate is close to the surface, press **OK** to begin the measurement. Wait until the measurement has completed and write down the results (unless you use a PC data connection or the optional printer to collect results automatically.)

8. Clean the Wilhelmy plate and the glass sample container.

5.4.2 Taring modes: Wet Taring and Dry Taring

With Wet Taring, the zero level for the balance is set equal to the balance reading of a wet plate hanging on the balance hook. With Dry Taring, the zero level equals the balance reading of a dry plate hanging from the balance hook.

Certain practical differences arise from the different objectives of Wet Taring and Dry Taring: As the plate with Dry Taring should not touch water before taring, only one taring can be performed for a multi-round measurement. With Wet Taring, however, taring is repeated before every measurement round. Surface level is determined only once, regardless of the taring mode.

The measurement sequence with Wet Taring:

- At first, the plate descends (i.e. stage ascends) slowly in order that the liquid surface level may be accurately determined. Next, the plate is dipped into the depth of about 5 mm, and lifted up.
- For each measurement round, the following is repeated: The plate waits in the air while the balance is tared and then it is dipped to the depth of about 5 mm, after which it is brought to the liquid surface level and waits a while as the weight on the balance hook is measured read, and the plate is lifted up again.

The measurement sequence with Dry Taring:

- At first the plate waits in the air, taring is performed. Then it descends slowly toward the liquid surface, determining surface level.
- For each measurement round: The plate is lifted up from the liquid surface, descends to the depth of about 5 mm, moves to the surface level and determines the weight (force) of the item hanging from the balance hook.

Wet taring is usually recommended, but Dry Taring allows the user to control the wetness of the plate when taring if performed at beginning of measurement. The taring modes have no difference in the interpretation of balance readings during taring and measurement phases.

If the user wishes to have a slightly wetted plate for taring, he/she may manually perform the desired amount of wetting and then perform measurement with Dry Taring selected. In this case, however, care should be taken that no drop of liquid is hanging from the plate, since that would cause inaccuracy in the instruments' ability to detect the surface level.

5.5 Density measurement

NOTE! Density measurement is sensitive to vibrations. In order to ensure accurate measurements the instrument should be placed on a vibration free table in an area where local air currents are at a minimum

5.5.1 Density of a liquid

The density of a liquid can be measured using the glass ball probe supplied with the instrument. The steps for performing the density measurement are as follows.

1. Check the instructions in section 5.1 and make necessary preparations.

2. Place a sample container with sample liquid on the stage and carefully mount a clean and dry density measurement probe on the balance hook.

3. Select **Measure**->**Liquid Density** from the main menu of Sigma 702 and follow the instructions displayed.

4. Wait for the completion of the measurement and write down the density reading.

5. Clean the density probe and the glass sample container. Instructions for cleaning are given in section 4.1.

5.5.2 Density of a solid object

The density of a solid object weighing no more than 4 or 5 grams can also be measured using the Sigma 702 instrument. The accuracy of the measurement depends e.g. on the wettability of the object and the shape of the object (glassy or porous).

In solid object measurement, calculations must be done manually. In these instructions, it is assumed that you use a thin, lightweight wire to hang the solid object from the balance hook.

1. Check the instructions in section 5.1 and make necessary preparations.
2. Put a cup of pure water on the sample stage.
3. Check that the object whose density is to be measured is clean and dry.
4. Write down the balance reading before hanging the object on the balance hook. Call this value m_0 -- it should be close to 0. If the wire has any significant weight, measure m_0 with the wire hanging from the hook. This will compensate for the weight of the wire.
5. Carefully hang the object on the balance hook and check the balance reading. We call this m_{in_air}.
6. Drive the sample stage up, so that the object is immersed into water. When fully immersed, write down the balance reading—this is called m_{in_water}.

Now, the following 3 properties of the object can be calculated (continuing to next page):

- Mass: $m = m_{in\_air} - m_0$

- Volume: $V = (m_{in\_air} - m_{in\_water}) / \rho_{water}$, where ρ_{water} is the density of the water used in this experiment.

- Density: $\rho = \frac{m}{V} = \frac{m_{in\_air} - m_0}{m_{in\_air} - m_{in\_water}} \rho_{water}$

5.6 Collecting data to a PC

A USB cable can be used to connect your Sigma 702 and a PC for data collection using a program called Attension Data Receiver. The program is included in the software USB drive that comes with the instrument. Data collection is easy, since Sigma 702 sends the result of every measurement to PC automatically. Attension Data Receiver can be installed by copying the program to a directory and installing the necessary USB device driver.

The data receiver displays one line for each measurement result it receives, with fields for time stamp, measurement result and the method used. With multi-sample measurements, a line is output for every sample, while the field "Info type" specifies whether a particular line is about one sample out of many or an ordinary measurement.

The lines displayed on screen can be copy-pasted to another program (such as spreadsheet) for storage or analysis, and the output is also appended to a log file whose name can be set by the user.

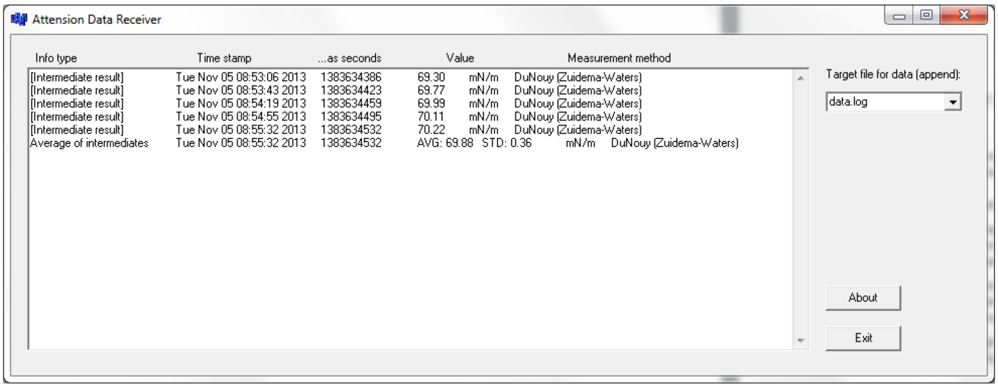


Figure 8: Attension Data Receiver to transfer measurement results to PC, including the intermediate results of a multi-round measurement.

5.7 Using the optional printer

The optional printer can be used when you want to print your measurement results. Connect the serial cable supplied with the printer between Sigma 702 back panel and the printer. Connect the printer power cord to a mains outlet and power on the Sigma 702. The printer will automatically print your measurement results after a measurement is completed.

6. Calibration of Sigma 702

In Sigma 702 there are two things to be calibrated: the electromagnetic balance and the density measurement probe volume. When both calibrations are performed, it is important to calibrate the balance first.

6.1 Calibration of the electromagnetic balance

Calibration of the electromagnetic balance is necessary whenever you start using Sigma 702 after a longer break and whenever the instrument has been moved, even if it is just from one table to the next. If you are in doubt, it is advisable to calibrate, as the process is simple.

Due to the excellent linearity of the balance, only two-point calibration is needed. First point is at zero weight and the second point is in the middle of the typical weighing range of the Sigma 702 tests.

A certified calibration weight (approximately 1.7g) is delivered with the instrument. The weight will be hung on the hook of your Sigma balance at a certain stage of the calibration procedure.

6.1.1 Calibration procedure

When calibrating for the first time with your calibration weight, you first need to adjust the calibration weight setting in your Sigma 702. Select **Adjust parameters** from the main menu. From the parameter menu, select **Calibration weight**. The calibration weight stored in the instrument is displayed on screen, allowing you to change the digits by using three buttons: **Arrow Up** (↑), **Arrow Down** (↓), and **OK**. The cursor bar under a digit shows which digit is activated. Use **Arrow Up** and **Arrow Down** to change the activated digit and **OK** to move on to the next digit. When the last digit is done, the new value is stored. If you need to cancel the operation, press **Stop/Cancel** to interrupt the weight adjustment.

To begin the calibration procedure, select **Calibrate** from the main menu and **Calibrate balance** from the menu that opens. Now the following instruction will appear on the display:

Please make sure that the balance hook is empty. Wait until the balance reading is stable and press OK.

When the reading is stable, press the **OK** button. After a moment, the following instruction will appear on the display:

Please hang a calibration weight of [mass of your weight] on the hook and wait until the reading is stable. Then press OK.

Make sure that the number of grams displayed equals the weight of your calibration weight. Hang the calibration weight on the balance hook and wait until the reading has become stable, then click the **OK** button. A *Wait* message will appear on the display at this point as the balance is calibrated. When calibration has been completed following message will appear on the display:

Calibration completed.

New calibration has taken effect and Sigma is ready for use.

6.1.2 Calibration result verification

To verify the calibration result, the balance performance can be tested. Add the measurement probe you are normally using into the hook. Then add the calibration weight to the hook. The added weight the Sigma 702 shows should be within ± 1 mg from the nominal value of the calibration weight. If this is not true, a recalibration is required.

Please notice that the system should be on at least 30 minutes before performing calibration or tests.

6.2 Calibration of the density measurement system

The calibration value of the density measurement system of Sigma 702 is dependent on the properties of the density probe used, particularly the volume. Therefore, the calibration of the density measurement system must be performed whenever a new density probe is introduced, even if the type of the new probe is the same as before.

1. Turn on the Sigma 702 instrument. The instrument should be turned on at least half an hour before starting a measurement.

2. Calibrate the balance if there is any possibility that the previous calibration is not accurate anymore (see section 6.1).

3. Clean the density measurement probe and let it dry before starting the density measurement.

4. Take a clean sample container and pour pure water into it. A depth of 2 cm is sufficient. Place it on the sample stage and carefully hang the probe on the balance hook.

5. Select Calibrate->Calibrate density probe from the main menu of Sigma 702 and follow the instructions displayed.

6. Wait for the completion of the calibration.

7. Troubleshooting

Problem	Possible solutions
I get incorrect surface tension readings.	Make sure that you are using pure water and that the sample and the sample cup are clean. Make sure that the Du Noüy ring or Wilhelmy plate has been cleaned properly and is not deformed. Flame cleaning is required in a typical case for good results. Recalibrate the balance.
Interfacial tension measurement between water and a heavy non-polar liquid fails.	If the non-polar liquid is denser than water so that it falls below water, then the interfacial tension between them is measured by pushing the ring from water downwards through the interface. (See section 5.1.)
When I start a measurement, the sample stage just keeps rising until the probe hits the bottom of the cup.	Make sure that the transportation lock is fully open, so that the bar of the balance can move freely.
Calibration of the balance fails.	Make sure that the transportation lock is fully open.
Density probe is not fully immersed in sample during measurement.	Minimize vibrations around the instrument to prevent accidental triggering. Placing the instrument on a vibration free table in an area where local air currents are at a minimum is advised.

8. Contact and support

If any problems arise please feel free to contact a local distributor or Attension directly.

Attension can be contacted from the following address:

Attension

Tietäjäntie 2

FIN-02130 Espoo

Finland

Tel. +358-(0)9-5497 3300

Fax +358-(0)9-5497 3333

E-mail: info@attension.com (sales requests)

support@attension.com (technical support and maintenance)

Website: http://www.biolinscientific.com/attension

Local distributors are listed at our website, **www.biolinscientific.com**

Biolin Scientific
[Progress Together]

9. EC Declaration of conformity

EC DECLARATION OF CONFORMITY

We,

Biolin Scientific Oy, Tietäjäntie 2, Espoo, Finland

as the manufacturer declare under our sole responsibility that the following products

Attension T700

Attension T701

Attension T702

Attension T702-D

Attension T702ET

Attension T702ET-D

are in conformity with the following European Directives

Low Voltage Directive 2014/35/EU

EMC Directive 2014/30/EU

RoHS Directive 2011/65/EU

The following harmonised European standards have been applied

EN 61010-1:2010

EN 61326-1:2013

Espoo, Finland

19.12.2018

Sten Brandt

Supply Chain Director

Biolin Scientific Oy