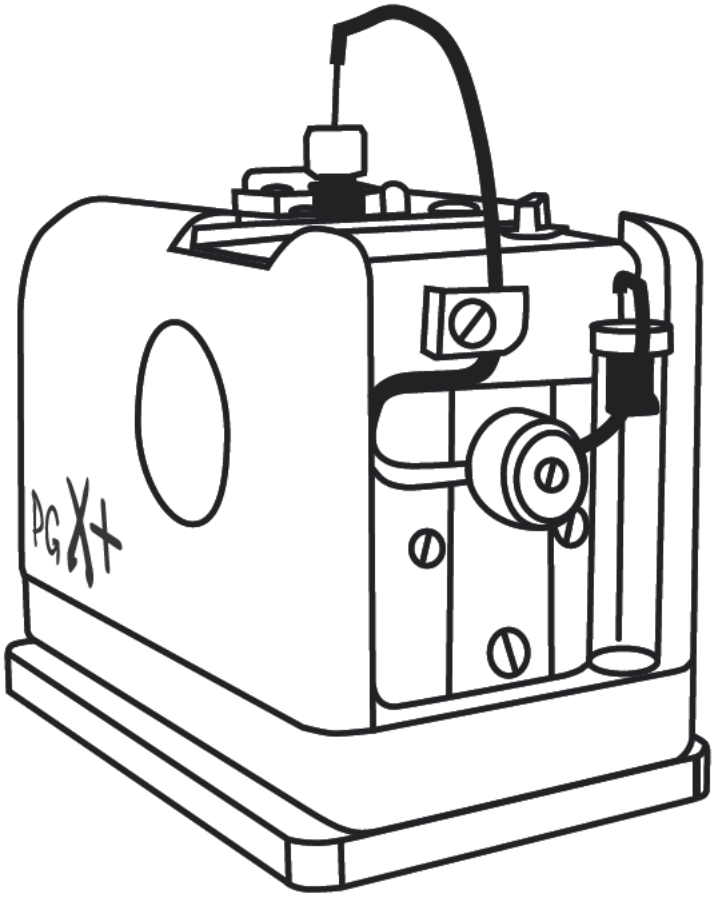
FIBRO system



PGX+
Pocket Goniometer
PG1000

Operating Instructions
(model 68-76 - 1219 - software version 1.0)

IMPORTANT! Before taking this instrument in use we strongly advise you to read this manual carefully.

www.fibrosystem.com

Fibro System is part of Industrial Physics Inks & Coating Division

CE Declaration of conformity

Fibro System declares under sole responsibility that the following product:

Model 68-76-00-0001 **PGX+ Pocket Goniometer**

complies to the following directives and harmonised standards:

2004/108/EC	Electromagnetic Compatibility Standards (EMC) EN 61326-1: 2013

This certificate is based on an evaluation of a sample of the above mentioned product

Issued on behalf of Fibro System,

Remco Wever
Managing Director

Date of issue: 19 November 2019

Fibro System
Molenbaan 19
2908 LL Capelle a/d IJssel
The Netherlands

+31 (0) 10 – 7900 100
info@fibro-system.com

www.fibro-system.com

Warranty Statement

The model 68-76 Pocket Goniometer PGX+ is manufactured, sold and distributed by Fibro System. We warrant this instrument to be free of defects in performance, materials and workmanship. We will replace free of charge and correct any defect in workmanship or performance without charge for labor within a period of twelve (12) months from the date of purchase.

Our obligation under terms of this warranty is effective only if the defect develops in a normal installation and under normal use and service and if the model 68-76 Pocket Goniometer PGX+, is returned intact to our plant with prior authorization and with all transportation charges prepaid, within twelve (12) months from the date of purchase.

Our obligation to repair without charge is effective only, if the model 68-76 Pocket Goniometer PGX+ has been properly installed and used in accordance with our written instructions. The complete terms regarding instrument warranty can be requested at Fibro System.

Shipping Instructions

To ensure freedom from damage in shipment, the 68-76 Pocket Goniometer PGX+ should always be repacked as it was when originally received including the eventual transport protections.

Before shipping, an authorization to return should be secured from Fibro System, by telephone, FAX or written letter. The best way to ship will also be advised at that time.

In all correspondence concerning this instrument, please quote the model- and serial number as given on the identification plate or as given on the info screen of the instrument.

Product End-of-Life Handling

The equipment may contain substances that could be harmful to the environment or human health. In order to avoid the release of such substances into the environment and harm to human health, we encourage you to recycle this product in an appropriate system that will ensure that most of the materials are reused or recycled appropriately. Please contact your local authorities for disposal or recycling information.

Unpacking

The 68-76 Pocket Goniometer PGX+ is delivered in a carrying case

Check the instrument for transport damage. If damaged, contact your insurance company and DO NOT throw away the packing as this is your evidence. The accessories are packed in separate boxes and / or envelopes.

It is recommended to conserve the original box and inserts in case the instrument needs to be transported. If the apparatus has to be returned to the factory, it is strongly suggested to use the original packaging (see warranty statement).

INDEX

1 OPERATOR SAFETY

Read this manual carefully before installation and use of this instrument.

1.1 General information

The design of this instrument is subject to continuous development. Consequently, this instrument may incorporate minor changes in detail from the information contained in this manual.

The instrument described in this manual is designed to be used by trained personnel only. Adjustment, maintenance and repair of the equipment should only be carried out by qualified personnel, who are aware of the hazards involved.

1.2 Safety precautions

For the correct and safe use of this instrument it is essential that both operating and service- personnel follow accepted safety procedures in addition to the safety precautions specified in this manual and statements and/or symbols on the instrument.

Whenever it is likely that safe operation is impaired or not possible, the instrument must be made inoperative and guarded against any unintended operation Fibro System or one of its representatives must then be informed for further instructions.

WARNING:
Electrical components inside the model 68-76 Pocket Goniometer PGX+ may carry enough electrical current to cause injury. Maintenance or trouble shooting of any electrical component inside the instrument may only be carried out by a Fibro System approved Technician.

ATTENTION:

Never remove any cover from the instrument before the instrument is switched off and the power cable disconnected!

The model 68-76 Pocket Goniometer PGX+ is designed to be used indoor and in dry conditions!

Cleaning the 68-76 Pocket Goniometer PGX+ can be done by using a soft dry cloth. Never use any excessive fluid to clean the instrument!

2 INTRODUCTION

The PGX+ measures contact angle (dynamic and static), surface tension, and surface energy. The PGX+ makes a drop in µl according to the size that is set. The drop is automatically released and 80 images per second are made. The instrument is used for paper & board, solar cell panels, windshields, metal cylinders and similar surfaces. For most tests deionized water is used, however using other liquids is also possible. Contact us if you want to use any other liquids.
During testing the instrument is connected to the special PC software. The software gives you an easy overview of the possible tests. During the test the data transferred to the computer. The pictures taken and the results can be stored and analyzed. Thanks to the direct feedback, adjustments to improve the results can easily be made.

Features:

- Easy to handle, small sized
- Registration with 80 frames/ second
- Automatic droplet creation and deposit
- Purity of liquids, Surface Tension, Static and Dynamic Contact Angle
- Multiple test fluids possible
- Runs on every Windows computer
- Power from USB connection
- No sample preparation
- Easy calibration

International Standards:

- TAPPI T458
- ASTM D-724
- ASTM D-5946

3 ABOUT THE PGX+

3.1 Instrument specifications

Camera

Image Capture Rate:	80 frames/second
Field of View:	7,0 x 5,2 mm
Sensor Resolution:	640 x 480 pixels
Pixel resolution:	11 µm

Droplet application

Droplet Volume:	0,1 – 10 µl
Modes:	Touch Down / Impact / Manual

Communication: USB 2.0

Operating conditions

Temperature:	10 - 35 °C
Humidity:	20 - 70%

Dimensions

Length:	90 mm
Width:	55 mm
Height:	90 mm
Net. Weight:	± 0.5 kg

3.2 PC specifications

Minimum specifications

- 1GB of RAM
- 20MB of free disk space
- 1024x768 screen resolution
- USB port

Recommended system

- Core i5 5th generation Intel (or compatible) processor
- 8GB of RAM
- 100MB of free disk space
- 1920x1080 screen resolution
- USB port
- Laser/Inkjet Printer

Operating systems

- Windows Vista, Windows 7, Windows 8, Windows 8.1 or Windows 10

3.3 Scope of supply

Your PGX+ instrument is delivered in a carrying case (see picture) including

- PGX+ software
- one millilitre syringe
- calibration plate
- glass bottle
- PGX+ Accessory kit with syringe tip, pump tubing and applicator tubing

NOTE:
Carefully check all small wrappings, boxes and envelopes in the large corrugated box to be sure all parts and supplies, as listed on the packing list, are present.

3.4 Consumables and accessoiries

Art. No.	*Description*
PG1023	Liquid Container Kit (with & w/o plug), 5+5 pcs
PG1171	Steel cannulus tip 0.5 mm (min order quantity 10 pcs)
PG1025	Applicator Tubing between Syringe and Tubing Dispenser, 5 pcs
PG1021	Pump Tubing (PTFE) suitable for most liquids, 5 pcs
PG1027	Pump Tubing (Silicone) suitable for Diiodomethane, 2 pcs
PG1010	Dosing unit

1	Calibration plate
2	PGX Instrument
3	Syringe
4	Accessory Kit
5	Glass bottle

4 SETUP SOFTWARE

The software GraphMaster allows to connect many different instruments, this instructions covers only the specific functions for the 68-76 Pocket Goniometer PGX+.

Please read the GraphMaster user's manual for more information.

The software is delivered on a CD or USB stick

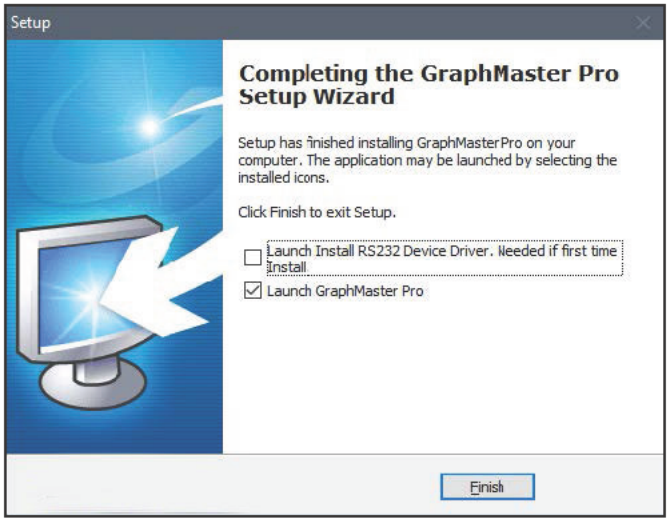
DO NOT download new camera drivers from Internet even when Windows may suggest this as program performance might then become unreliable!

DO NOT connect the PGX+ instrument to the USB port until requested by the program!

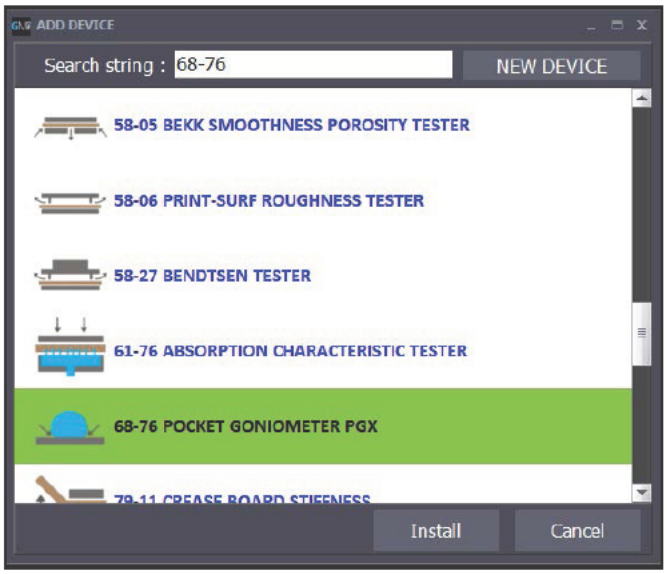
Otherwise Windows will attempt to search for other drivers and the result is unpredictable.

Insert the CD to start the installation and follow the displayed instructions.

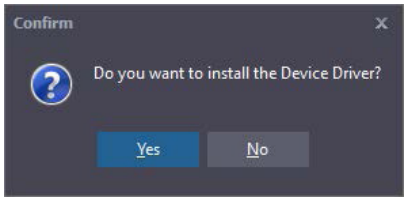
If the software will be used only to control the PGX+ the option "Install RS232 Device Driver" can be unchecked.



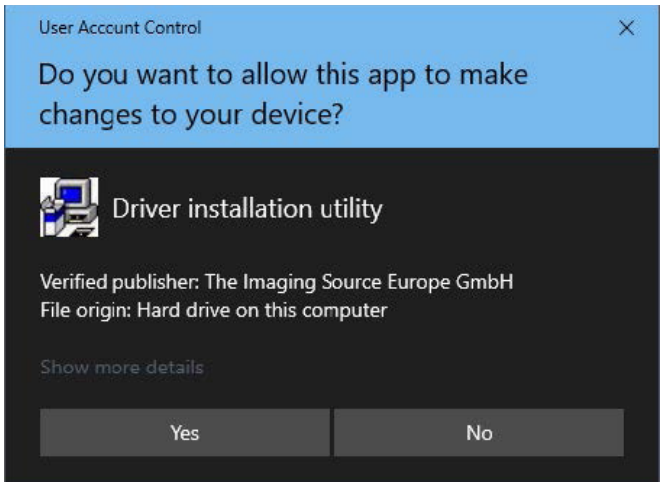
The first time the software is launched, you need to activate the 68-76 Pocket Goniometer PGX+.
Select the 68-76 Pocket Goniometer PGX+ and click Install



The first time the instrument is activated also the Device Driver must be installed.

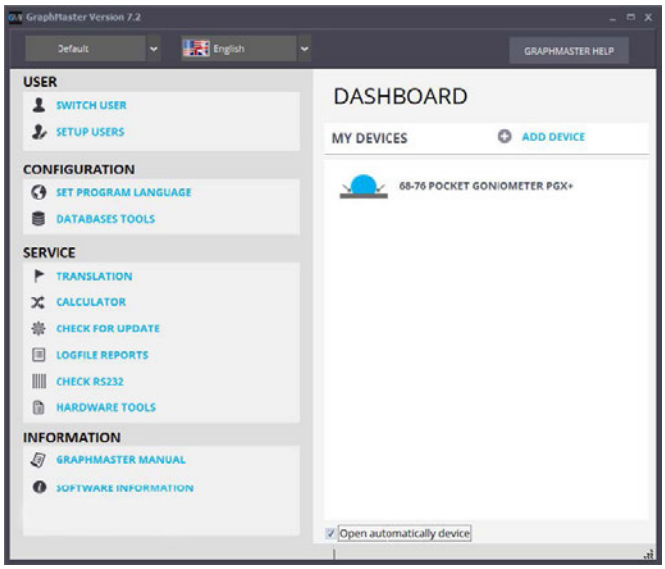


Confirm the security message.
Connect the PGX+ instrument to the USB port you wish to use and I follow the displayed instructions.

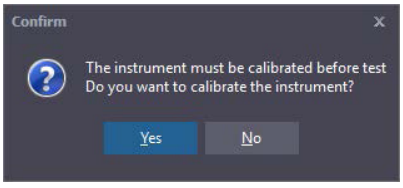


When the installation is terminated the new device 68-76 Pocked Goniometer PGX+ is ready to use.
Double click on the device to start the Test software

Note
If only one instrument is present the software GraphMaster Test will be launched automatically.



Before performing the test the instrument must be calibrated.
See Chapter Calibration.



5 CALIBRATION AND VALIDATION

Your PGX+ instrument has been carefully assembled and checked during production. It should not be necessary to do any further adjustments. For a correct performance, however, the instrument must be calibrated according to the procedure below. Without a correct calibration the instrument readings will be incorrect.

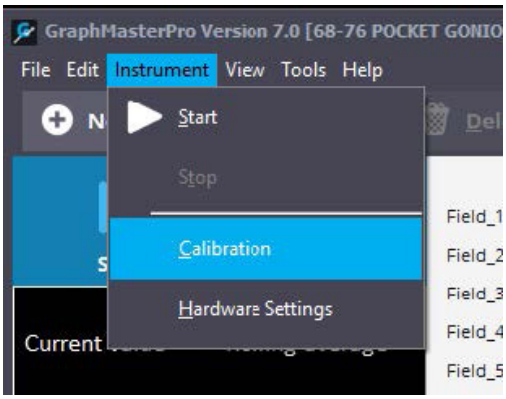
NOTE:
Before calibration, your instrument should be connected to the USB port for 30-60 minutes in room conditions. Make sure the drop applicator is installed to avoid stray light shining into the instrument as this may have an impact on the calibration.

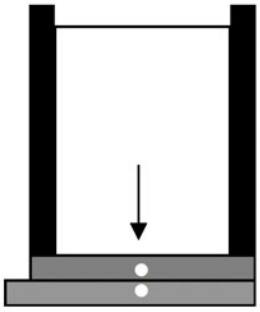
5.1 Calibration Procedure (Perspex plate)

a) The steel ball must have its top 2.6-3.0 mm above the Perspex surface. With a steel ball outside these dimensions calibration might fail.

b) Select "Calibrate" from the Instrument menu

c) Locate the reference mark at the edge of the instrument sole.The calibration plate has a similar mark indicating the "full sphere". Place the PGX+ instrument on top of the calibration plate with its reference mark positioned above the dot as indicated in the picture. Push gently on top of the instrument to make sure the instrument rests firmly against the calibration plate surface.





d) Click on the [Start] button to find the optimum Threshold setting.

e) Next the automatic scale factors are determined from the image. This is a high precision operation, which requires a clean sphere. If defects are detected an error message "Unable to find sphere" will appear. If debris is found at the sphere contour, remove the instrument from the calibration plate and clean the steel ball with a cotton swab dipped in Isopropanol. Select "Camera" and "Calibrate" to restart the calibration routine.

f) When the calibration routine has terminated, the results are displayed for the semi-sphere above the diameter with the following target numbers:

- Height (c-top) = 1,00 ± 0.02 mm
- Diameter = 2.00 ± 0.04 mm
- Volume = 2.09 ± 0.4 µl
- Contact Angle = 90.0 ± 1°

NOTE:
Accepted values will appear in green.

g) Click on [Save] to store the calibration data.

5.2 Validation Procedures

To verify a correct instrument reading it is much faster to "validate" the instrument using one of the two validation procedures described below. It is recommended to validate the instrument readings at regular intervals.

5.2.1 Standard Calibration plates (Perspex)

Select "Calibrate" from the Image Control Panel and place the PGX+ instrument on top of the full sphere and push the instrument gently against the calibration plate surface. This "artificial droplet" is now measured continuously. If the data are inside the tolerances, all numbers will be displayed in green. If one or more numbers are displayed in red, the instrument must be re-calibrated (Section 5).

NOTE:
An optional way to validate the instrument is to place the instrument on top of the calibration plate and perform a measurement in Static Mode. If these values are regularly stored, this information can be used for monitoring of the calibration/validations.

5.2.2 ISO Calibration plates (metal)

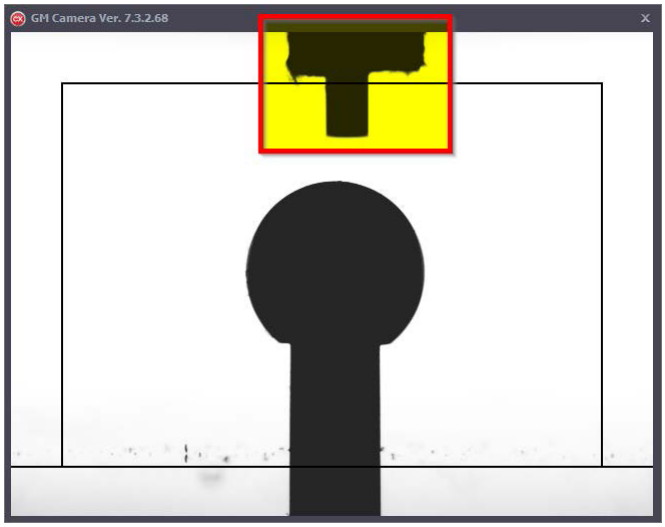
Select "Calibrate" from the Image Control Panel and place the PGX+ instrument on top of the semi- sphere and push the instrument gently against the calibration plate surface. This "artificial droplet" is now measured continuously. Enter the height of the reference found on the calibration plate. If the data are inside the tolerances, all numbers will be displayed in green. If one or more numbers are displayed in red, the instrument must be re-calibrated

6 SETTING UP THE INSTRUMENT

The 68-76 Pocket Goniometer PGX+ is powered directly from the USB cable, it is not require external power or batteries.

Warning:
The instrument must be connected to a port USB2.0 or higher.
Insert the Pump Dispensing Unit into the centre of the Applicator Tube.

NOTE:
The dispensing tip should now appear at the top of the live video image



6.1 Preparing a specimen

Determine and mark the machine direction of each sample where applicable. Be careful not to touch the areas to be tested, or contaminate them in any other way.

Determine and mark the "top" and "back" sides of each sample based on the side relevant for the application. The test areas must be free of folds, wrinkles, blemishes, watermarks and other defects not normally inherent in the sample.

Note: If the PGX+ instrument is used in the MD direction and then the CD direction, the ratio between BaseCD to BaseMD at an agreed time (e.g. one second) can be used to determine the anisotropy of a surface. For testing of anisotropic surfaces (e.g. newsprint) the PGX+ instrument should be oriented at a 45° angle to the machine direction when it is not necessary to determine the degree of anisotropic response.

Soft materials (e.g. tissues, textile, and film) or warping materials (e.g. newsprint, cigarette tipping paper) should be mounted on top of a flat backing material using a soft-sticky adhesive material.

A) Place the PGX+ instrument on top of the specimen.

B) Check to make sure the test surface appears horizontally in the image.

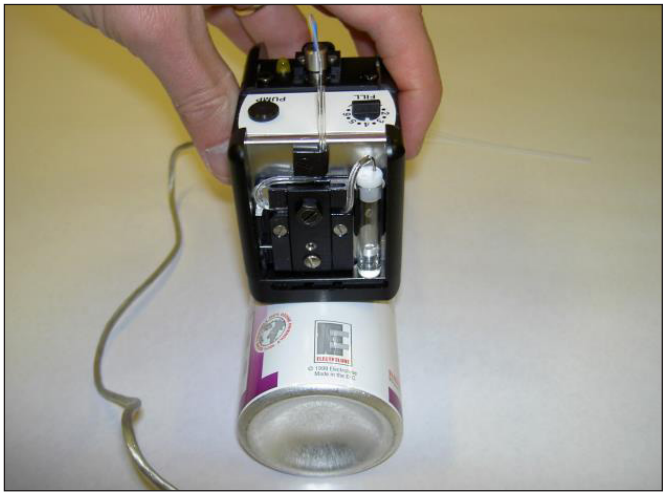
NOTE:
Soft and warping materials should be placed on a proper backing to hold it flat. A good backing is flat, stiff and coated with a soft-sticky surface, which does not pull lint from the specimen surface when removed.

6.2 Special specimens

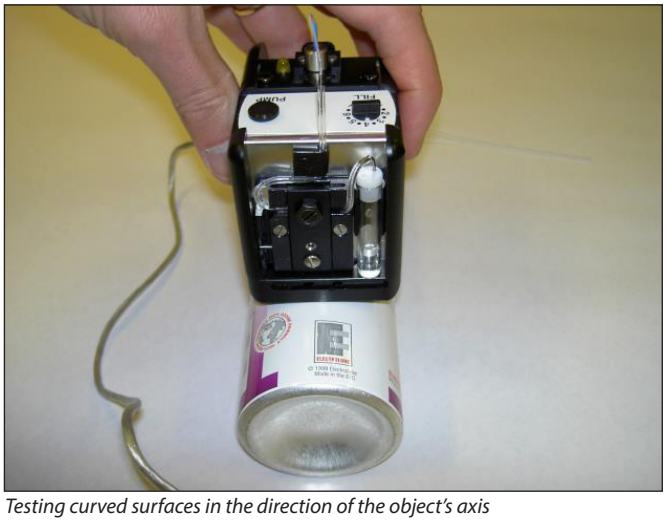
In certain applications, the test might require special arrangements like a fixture, into which the test specimen can be inserted. One example is a metal can or a round glass bottle where it will be necessary to position the droplet at the highest point of the curved surface.

NOTE:
Please note the groove at the centre of the instrument sole!
If the instrument is placed perpendicular across a test object with small radius (see picture) the test surface will appear higher in the image than normal. The instrument can then be placed in the direction of the object axis (see picture)).

We can also provide special PGX+ accessories for testing on electronic circuit boards and tablets. Contact your instrument supplier for additional information.



Testing curved surfaces perpendicular to the object axis



Testing curved surfaces in the direction of the object's axis

6.3 Pump dispenser

The test liquid is applied from the built-in micro-pump via the pump applicator unit. It is suggested the pump system is used for a single standard test liquid (e.g. water or fountain solution).

Use different tuning for each test liquid to avoid contamination!
To pump liquids of higher viscosity or to determine the wetting hysteresis (advanced/receding contact angles), it will be necessary to use the optional PG Dosing Unit.

The integrated micro pump is designed for a standard liquid (e.g. water) where the droplet size can be set in steps of 0,5 µL.

- Press the PUMP button to pump out a new droplet.
- If PUMP is pressed until the LED is lit, the droplet is slowly lowered towards the test surface, which is recommended for measurements in Static Mode;
- If PUMP is pressed momentarily, the LED will blink while the droplet is pumped out. It is then lifted a short distance from which it is dropped towards the surface. This approach is recommended for Dynamic Mode measurements.
- Press PUMP a second time during the pump sequence to inhibit application of the droplet.

The liquid system is filled in the following way:

a) Place the instrument on top of a flat surface

b) Locate the tiny air hole on top of the white container lid. Use the attached one millilitre syringe with the RED tip to fill the container with distilled water.
NOTE:
DO NOT use tap water, as this will leave residuals inside the liquid system!

c) Insert the RED dispensing tip into the air hole to fill the container. Check top of liquid container to see when liquid container is full (See picture)

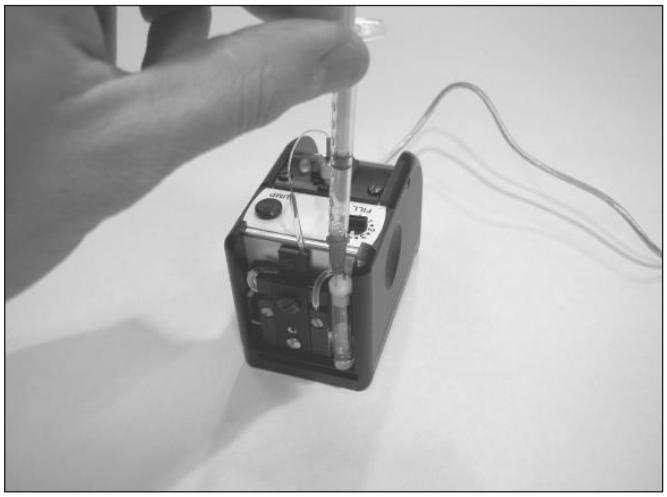
d) Check the pump lid screw is tightened. (see picture)

e) Fill the pump tubing like this:
- Set the volume selector to position FILL.
- Press PUMP and the pump will be activated to give 50 pump strokes before it stops.

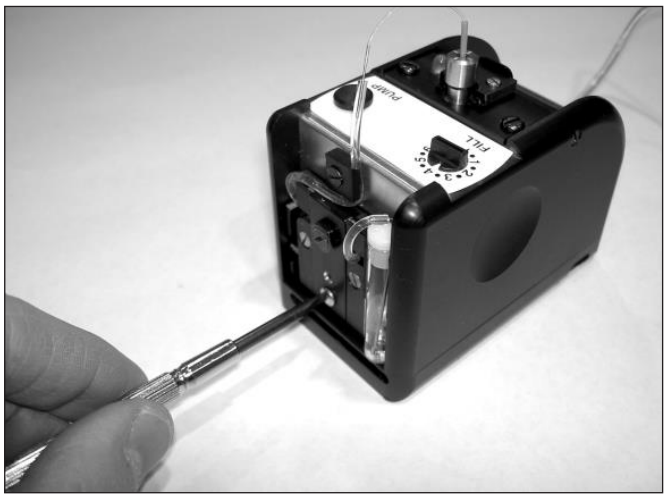
This volume (25 µL) may produce a small droplet at the dispensing tip. If not, press once more on the PUMP button to restart pump. When all air is removed and a droplet appears at the dispensing tip: press and hold the PUMP button until pump stops.

f) Set the volume selector to "4,0 µL", which is the default droplet size for testing (see chapter " Miscellaneous").

g) The instrument is now ready for a test (see Section 8.).



Filling the Liquid Container



Tighten the pump lid screw

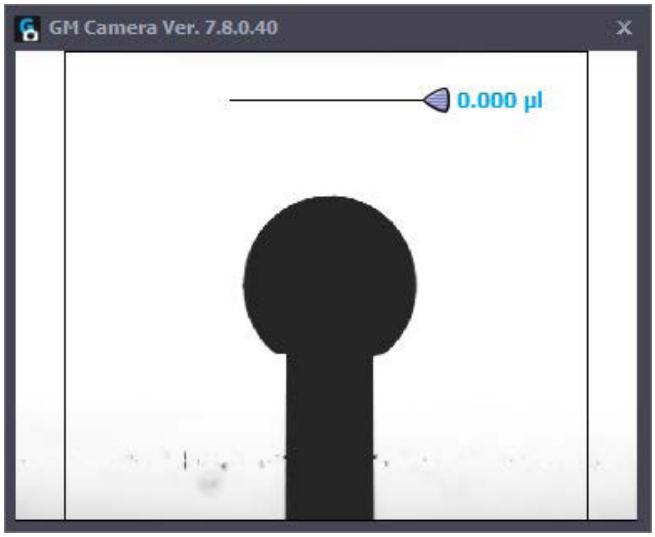
7 SOFTWARE FUNCTIONS

7.1 Graphmaster camera

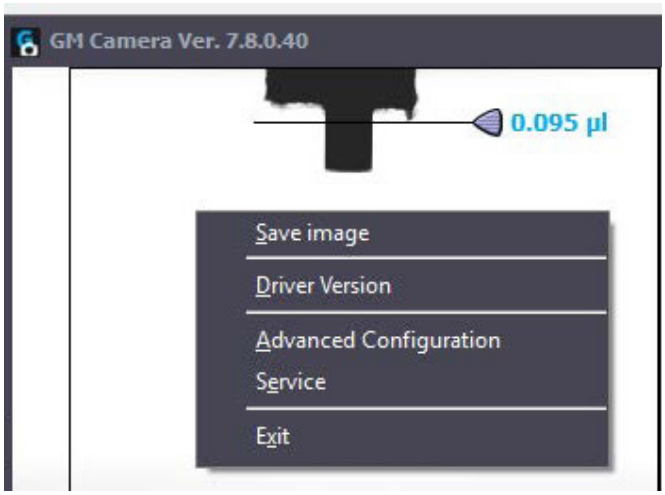
The Camera screen will always reside on top of the other screens, if not you can recall it from the taskbar.

Its size is adjustable to not interfere with other windows.

Double-click on the image to switch the live image between greyscale and binary (black/white) mode.



Click with the right button on the image to open the context menu

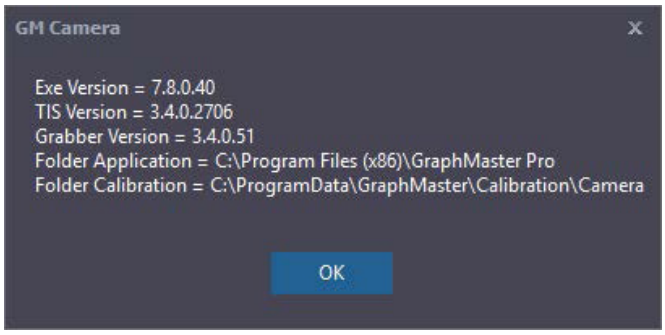


7.1.1 Save image

It allows to save the live image in a BMP file.

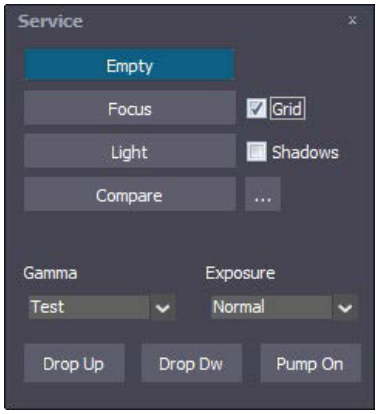
7.1.2 Driver version

It shows the information about the driver and module load.



7.1.3 Advanced configuration

7.1.4 Service



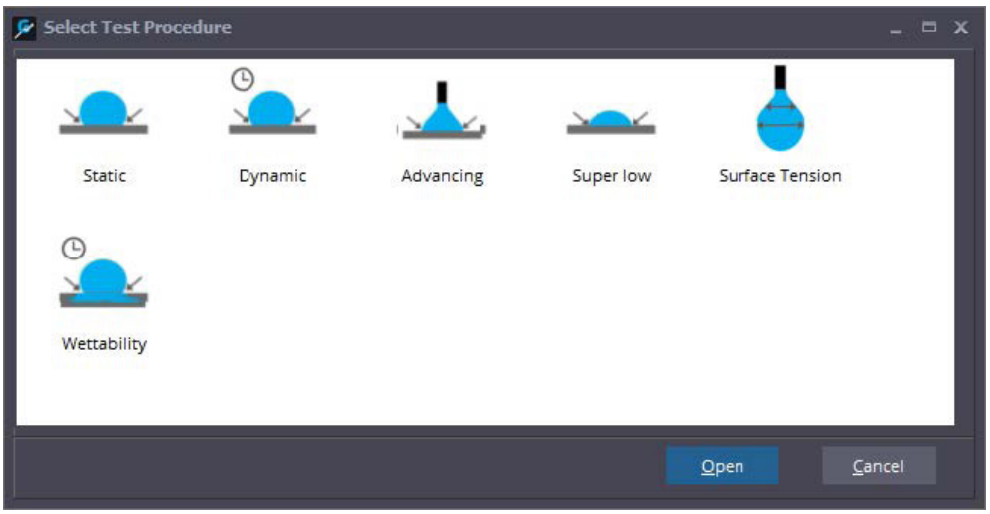
7.1.5 Exit

It allows to close the Camera window even if the software doesn't reply.

7.2 Graphmaster test

This manual covers only the functions specific for the 68-76 Pocket Goniometer, see the GraphMaster manual for all other information.

7.2.1 Select test procedure



Static
is designed to capture a single reading of the static contact angle at "equilibrium". This value can be measured on smooth, non-porous surfaces not penetrated by the test liquid. Typical examples are water droplets on hydrophobic release papers and polymer barriers (e.g. liquid container board).

Dynamic
captures a video sequence during the interaction between the liquid and the surface. Here the dynamic wetting (contact angle), liquid penetration (volume) and spreading are measured as a function of time.

Advancing
is designed to characterize the "wetting hysteresis" as a liquid droplet advances across a dry surface and then retracts from a wet surface. This measurement requires a reversible pump flow, which is not possible to do with the micro pump built into the PGX+ Measuring Head.

SuperLow
is designed for measurement of very low static contact angles below 10 degrees related to super clean surfaces.

Surface Tension
enables testing of the purity of the test liquid. A sufficiently big pendant droplet is pumped out at the dispensing tip and the surface tension is determined from the droplet shape.

Wettability
is a dynamic test with specific calculation for wettability.

7.2.2 Camera settings

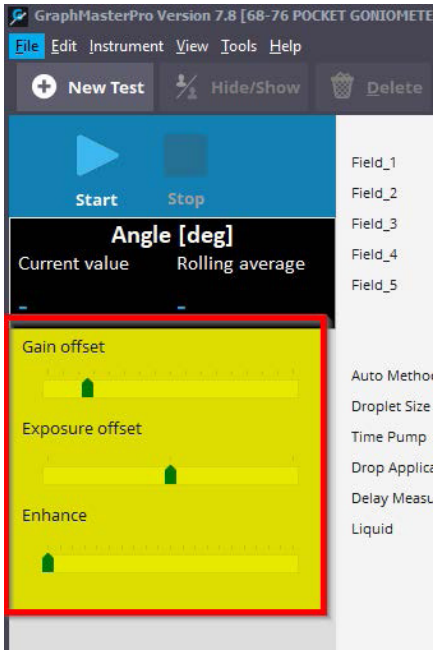
Gain offset
This feature modifies the live camera image in real time. This way the full dynamic range is always available even when the test substrate appears "too dark" or "too bright" due to variations in light reflectance.

Double click on the label "Gain Offset" to restore the default value (24).

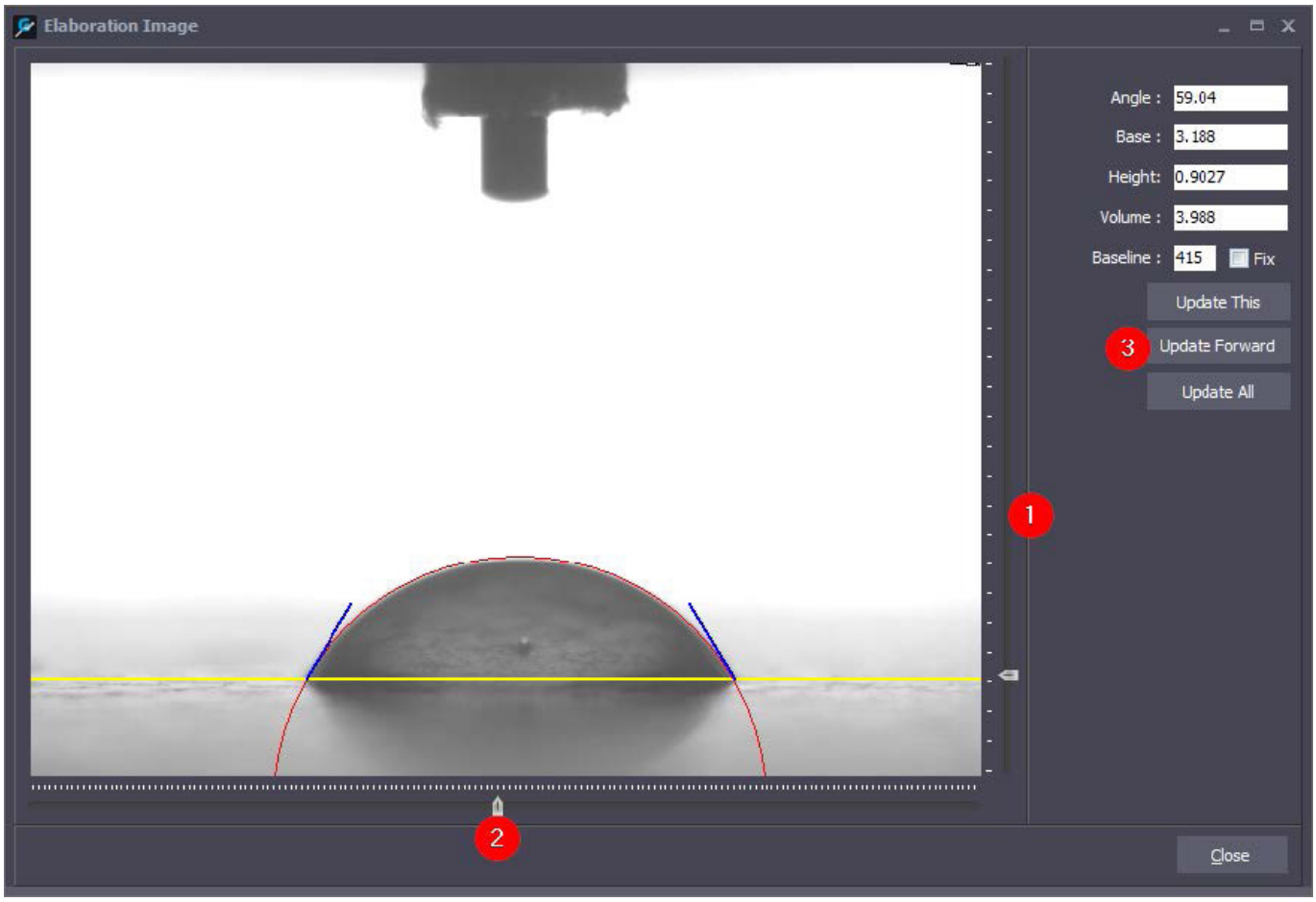
Exposure offset
This feature modifies the live camera image in real time. This way the full dynamic range is always available even when the test substrate appears "too dark" or "too bright" due to variations in light reflectance.
Double click on the label "Exposure Offset" to restore the default value (0).

Enhance
This feature brings out the droplet image even in situations where the droplet base is partially hidden on a dark, light-absorbing surface.
When a water droplet is applied on a surface of low reflectance (e.g. dark, rough craft liner), the droplet base will appear against a dark background. If the light level is increased, or the parameter camera Offset Gain and/or Offset Exposure are adjusted to distinguish the droplet base from its background, the droplet top can become too bright against the illuminated background. This is where the image enhancing routine will be very helpful.

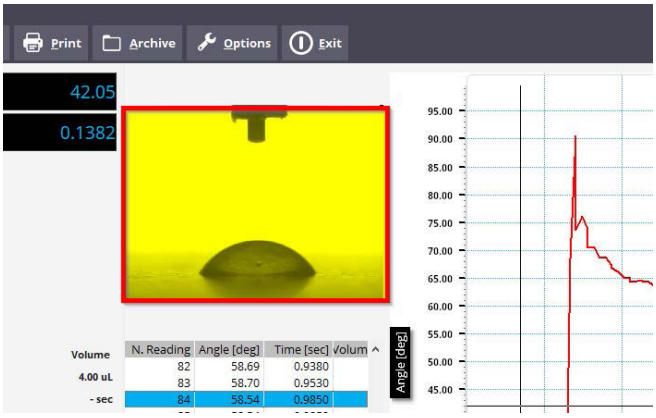
- Double click on the label "Enhance" to restore the default value (0).
- Place the instrument on the test surface and apply a liquid droplet on the surface.
- Double-click in the video image to switch from greyscale to a binary image if necessary.
- Adjust the Camera Gain control until the top of the droplet is completed. Then use the Enhance control to create a solid black contour all the way down to the base of the droplet.



7.2.3 Elaboration image



The windows is open with a double click on the image from the main page



Elaboration Image allows to change the points where the measurement are done.

Adjust the position of an incorrect Base line
When the automatic base line is set incorrectly, keep press Shift and use the "Page Up" and "Page Down" keys or pick up the base line handle (1) with the mouse and slide it to the correct position.

Adjust the position of droplet contour
When the automatic contour is set incorrectly, keep press Shift and use the cursor to move the contour to the correct position.

Adjust the dimension of droplet contour
When the automatic contour is incorrectly, keep press Shift and use the "+" and "-"keys to change the dimension of the contour to the correct dimension.

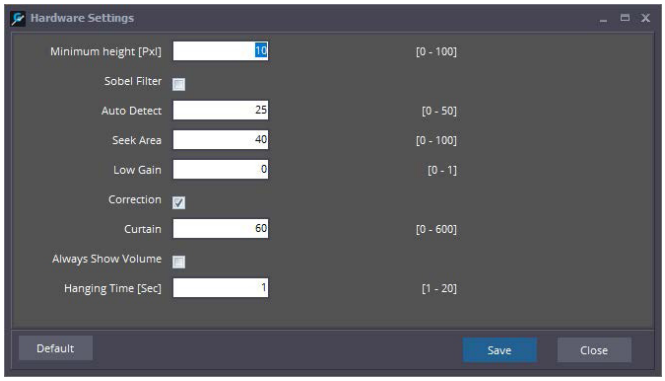
These images will then be recalculated with the new base line setting.

Update the values
Once the contact angle is measured in the correct position, press one of the buttons (3) to re-calculate the measurement with the new settings.
The dimension and position of the contour is used only for the selected image, the baseline position can be used to recalculate all the images or only the forward images.

Fix baseline position
If the option "Fix" is selected the new baseline position will be used for all the future tests.

Use the slider below the image (2) to shift to another image.

7.2.4 Hardware settings



Hardware Setting allows to customize the software

Minimum height
Defines the minimum height of a droplet (reduce for smooth surfaces)
Default value = 10

Sobel Filter
Enable the Sobel filter to improve measurements on rough surface but it can increase the stability of the readings.
Default = false

Auto Detect
Defines the distance to the trigger line in Dynamic Mode
Default = 25

Seek Area
Seek Range for Advancing/ Receding function
Default = 40

Low Gain
Use a low gain in the SuperLow method
Default = false

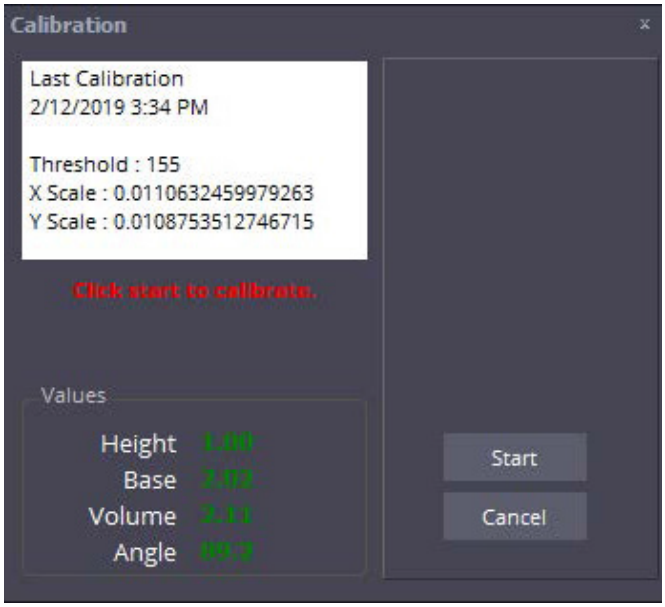
Correction
Correction method in surface tension procedure.
Default = true

Curtain
The curtain allows to avoid to analyze the top part of the image.
The value is expressed in pixel.
Default = 60

Always Show Volume
It shows always the volume of the droplet.
Default = false

Hanging Time
Delay from the end of the pumping operation and the release of the droplet.
Default = 1

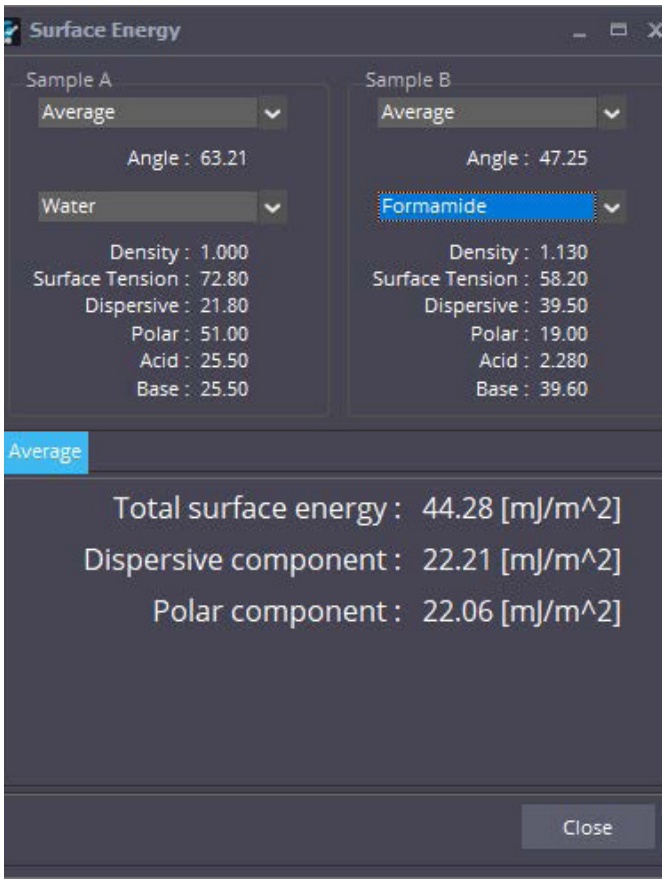
7.2.5 Calibration



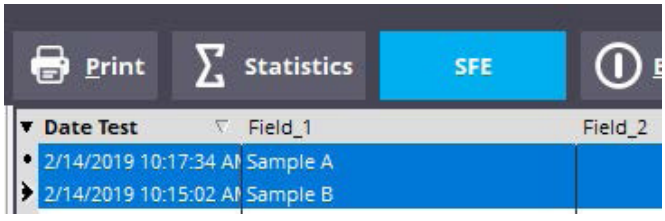
7.3 Graphmaster database

7.3.1 Surface energy

The Surface Energy functions is available only for the Static and Dynamic mode.

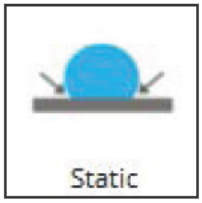


The function is enabled only when 2 or 3 records are selected.



8 TEST METHODS

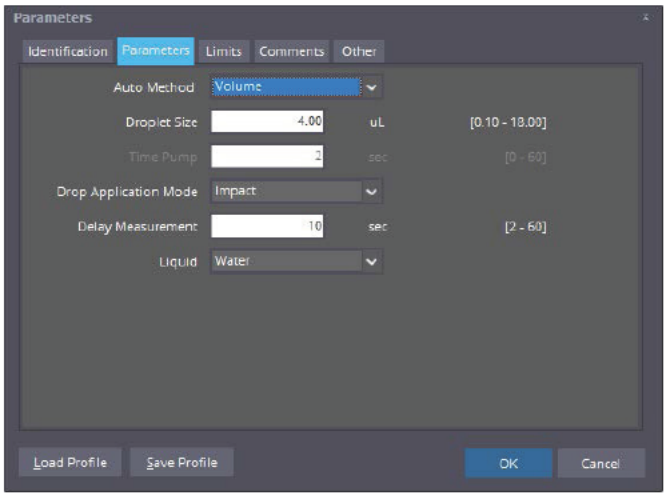
8.1 Static Mode



This mode captures single readings of the static contact angle at "equilibrium".
Please note static contact angle measurements are only valid on smooth, non-porous surfaces not penetrated by the test liquid. Typical examples are water droplets on hydrophobic release papers and polymer barriers (e.g. liquid container board).
When a test liquid of higher viscosity is used, the reading must not be taken until the droplet has stopped spreading on the substrate surface.

A test surface is usually characterized from an average of 6-10 test droplets and one or more additional surfaces can be tested in the same test run for comparison in the same diagram.
Static contact angle is primarily used to determine the wetting characteristics of a substrate to check surface treatment, cleanliness and/or contamination effects.
The purpose of this test is to determine the highest possible contact angle at "equilibrium".

8.1.1 Parameters



Auto Method

Off	Manual test
Volume	Automatic test with droplet size control
Time	Automatic test with time control

Droplet Size

Enable only if the Auto Method is selected to Volume

Time Pump

Enable only if the Auto Method is selected to Time

Drop Application Mode

Impact	The pendant droplet is lifted and dropped with a small impact.
Touch Down	The pendant droplet is lowered towards the surface.

Delay Measurement

The measurement is suspended until the set time has expired.
Disable when the Auto Method is selected to Off.

Liquid

It has no influence in the results.

For corona treated polymers water can be used as the single liquid to determine SFE in accordance with ASTM D5946.

8.1.2 Results

Test	Angle [deg]	Base [mm]	Height [mm]	Volume [uL]	Surface Energy [mN/m]
16	46.29	3.430	0.7330	3.592	48.32
17	45.72	3.374	0.7112	3.368	48.52
18	45.45	3.396	0.7113	3.410	48.62
19	45.45	3.396	0.7113	3.411	48.62
20	45.46	3.396	0.7114	3.411	48.62
Average	45.72	3.399	0.7166	3.448	48.52
SD	0.5765	0.05783	0.02189	0.2339	0.2087
CV%	1.26	1.70	3.06	6.78	0.43
Max	47.30	3.596	0.7873	4.252	49.01
Min	44.37	3.275	0.6676	2.967	47.95

Angle

Contact angle

Base

Base droplet

Height

Height droplet

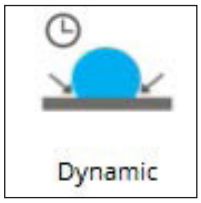
Volume

Volume droplet

Surface Energy

Surface energy calculate in according of the standard ASTM D5946.

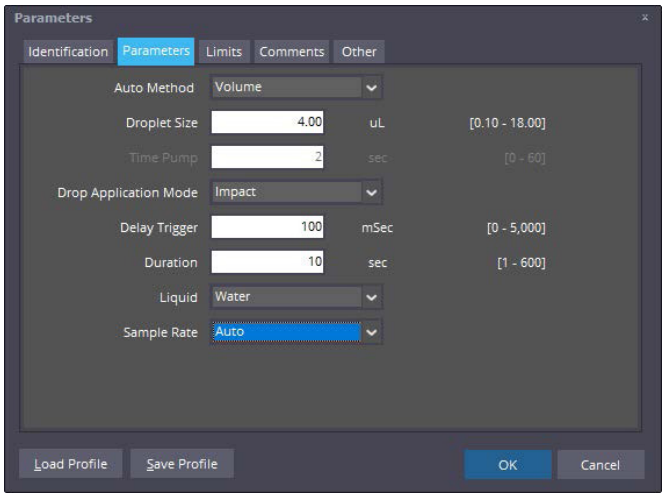
8.2 Dynamic mode



This mode captures a video sequence showing the dynamic interaction between the liquid and the surface. Here the dynamic wetting (contact angle), liquid penetration (volume) and spreading is measured as a function of time. After a droplet has been pumped out at the dispensing tip, a new test is started when the Measure button is pressed. The droplet must then be applied on the specimen surface within 30 seconds.

In Dynamic Mode the droplet cannot be applied "slowly onto the surface" as in Static Mode.
Such a slow application would make the initial interaction during the first second impossible to measure. Instead the droplet is gently transferred to the surface from a very short "free-fall" distance.

8.2.1 Parameters



Auto Method

Off	Manual test
Volume	Automatic test with droplet size control
Time	Automatic test with time control

Droplet Size

Enable only if the Auto Method is selected to Volume

Time Pump

Enable only if the Auto Method is selected to Time

Drop Application Mode

Impact	The pendant droplet is lifted and dropped with a small impact.
Touch Down	The pendant droplet is lowered towards the surface.

Delay Trigger

The measurement is suspended until the set time has expired.
Disable when the Auto Method is selected to Off.

Duration

Duration test.

Liquid

It has no influence in the results.

Sample Rate

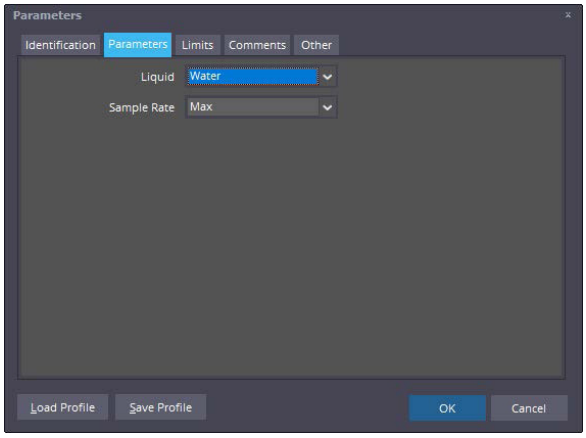
It's the number of frame per second that the camera will collect.

8.3 Advancing mode

This mode captures a video sequence showing the dynamic interaction between a liquid and a surface as the liquid spreads over the dry surface ("wets") and then retracts from the wet surface ("de-wets"). This interaction, described as "wetting hysteresis", is characterized by the highest ("advancing") and lowest ("receding") contact angles. This test is based on a reversible pump flow. The optional PG Dosing Unit is a programmable dispenser suitable for this task, but any stand-alone pump with reversible flow can be used for the test. With a little practice it is even possible to use a regular handheld syringe to run this test manually.

In some applications it is of interest to characterize the "wetting hysteresis" of a surface.
The purpose is to determine the "highest" contact angle as the liquid spreads across the dry surface and the "lowest" contact angle as the liquid retracts from the wet area on the surface. These two contact angles, referred to as the advancing/receding contact angles describe the "wetting hysteresis".

8.3.1 Parameters



Liquid

It has no influence in the results.

Sample Rate

It's the number of frame per second that the camera will collect.

8.3.2 Automatic measurement using a reversible pump

The dispensing tip must be equipped with a fine capillary tube inserted into the PTFE tubing (P/N 860309). In addition, the distance between the dispensing tip and the test surface must be short enough to make sure the droplet remains in contact with the tip during the test sequence, as the test otherwise will be terminated.

Click on Measure to start a new test.

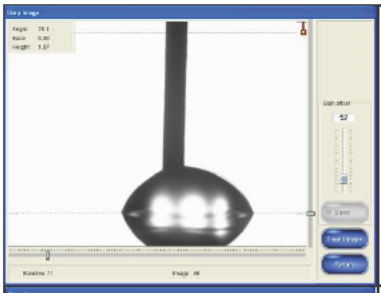
Pump out a droplet, which must contact the surface within 30 seconds to trigger the test.

The pump should now pump out liquid until the droplet has spread sufficiently across the dry surface (the "advancing" phase). Next the pump flow should be reversed so the liquid retracts from the wet surface (the "receding" phase).

The test is automatically aborted when the contact is lost between the tip and the surface.

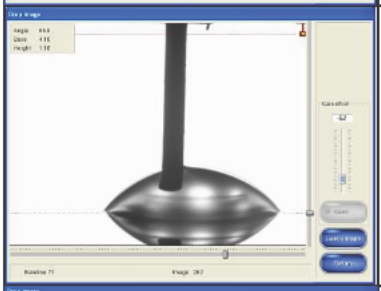
8.3.3 Automatic measurement without using a reversible pump

When a reversible pump is not available a liquid droplet can be applied manually from a syringe with the tubing inserted directly into the drop applicator. Alternatively, a pendant droplet of suitable size can be pumped out and the droplet is slowly pushed towards the surface after the test has been initiated. As the dispensing tip is pushed well into the sessile drop, its base will expand across the surface creating an advancing contact angle. As the dispensing tip is slowly retracted from the sessile drop, its volume will shrink and a receding contact angle will appear on the condition the droplet base is reduced.



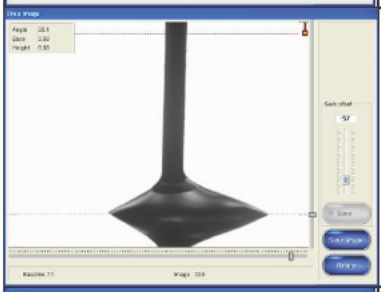
The initial contact phase

Immediately upon contact between the droplet and the specimen surface, the dispensing tip inside the applied droplet may "lift" the droplet upwards, which then creates a too high contact angle reading.



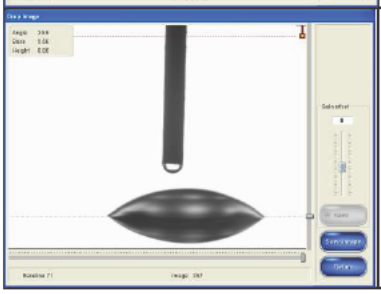
The advancing phase ("wetting")

When the droplet volume increases and spreads across the dry surface, a stable contact angle reading is obtained. This is referred to as the "advancing" contact angle.



The receding phase ("de-wetting")

Once the "advancing" angle has been determined, the liquid flow is reversed until the droplet begins to retract from the wet area. The lowest contact angle obtained during this phase is referred to as the "receding" contact angle.

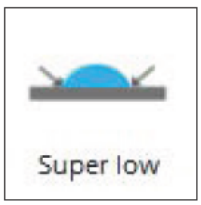


The release point

As the droplet is no longer in contact with the dispensing tip, the test is aborted and the final contact angle at equilibrium is measured. This angle should be higher than the receding

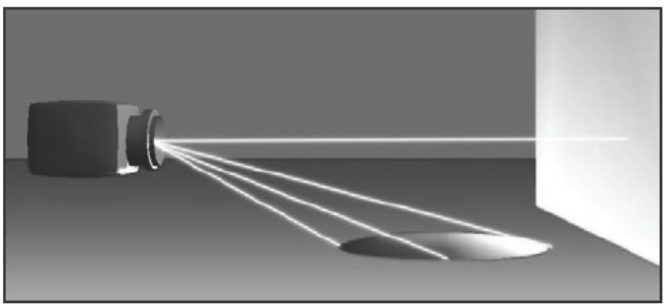
8.4 Superlow contact angles mode

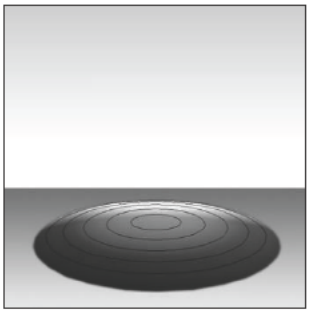
This mode is designed for measurement of very low static contact angles below 10 degrees related to super clean surfaces.

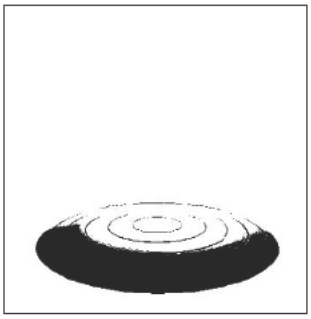


A camera view horizontal to the test surface will still view the base of the droplet at an angle of 3-6 degrees. Light reflected from the back of the droplet, then makes the top of the droplet "invisible".

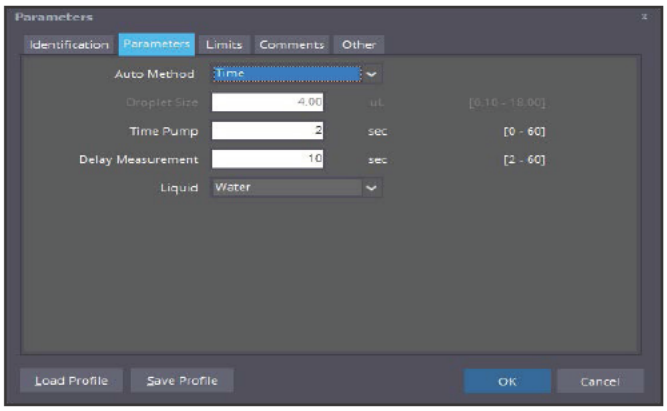
If the greyscale image is thresholded, the top of the droplet will vanish. As the camera cannot detect the top, it is impossible to determine its position automatically.
This image can still be evaluated using the procedure described below.







8.4.1 Parameters



Auto Method

Volume — Automatic test with droplet size control

Time — Automatic test with time control

Droplet Size

Enable only if the Auto Method is selected to Volume

Time Pump

Enable only if the Auto Method is selected to Time

Duration

Liquid

It has no influence in the results.

8.4.2 Volume determination

The value of a super low contact angle can only be automatically determined if the volume of the applied droplet is known. On these surfaces, even a very small water droplet of a single pump stroke (0,5 µL) may spread outside the camera view. This is why the volume often must be reduced with the volume adjustment knob located on the pump unit.
Kindly note the live camera image is enhanced using background correction.

Fill the liquid system and make sure there are no remaining air bubbles in the liquid.

Insert a 0,50 mm steel cannulas into the free end of the PTFE dispensing tip.

Adjust the end of the cannulas in a position where the droplet barely transfers to the test

Adjust the reference line on the screen to the end of the cannula.

Click the MEASURE button to take a measurement using the actual droplet size which is automatically transferred to the program.

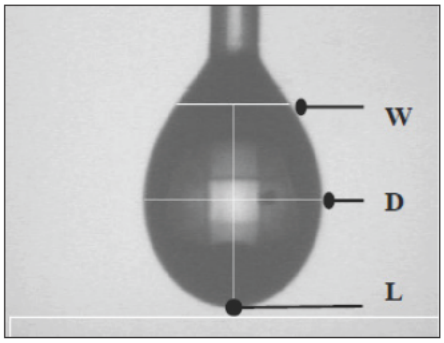
8.4.3 Automatic measurement of Super Low Contact Angles

Once the applied droplet volume has been determined an automatic test of Super Low angles can be carried out. Place the instrument on a clean test surface free from debris and water droplets and press START to continue. These program functions are similar to Static Mode operation.

8.5 Surface tenson

The instrument must be placed on a stable, horizontal table to give correct results. A sufficiently big pendant droplet must be pumped out at the dispensing tip to determine the surface tension from the droplet shape (Bashforth - Adams). The critical dimensions are calculated from a polynomial curve fitting at sub-pixel resolution with an accuracy of 10-6 mm, which offers an accuracy of ± 0,2 dyne/cm.

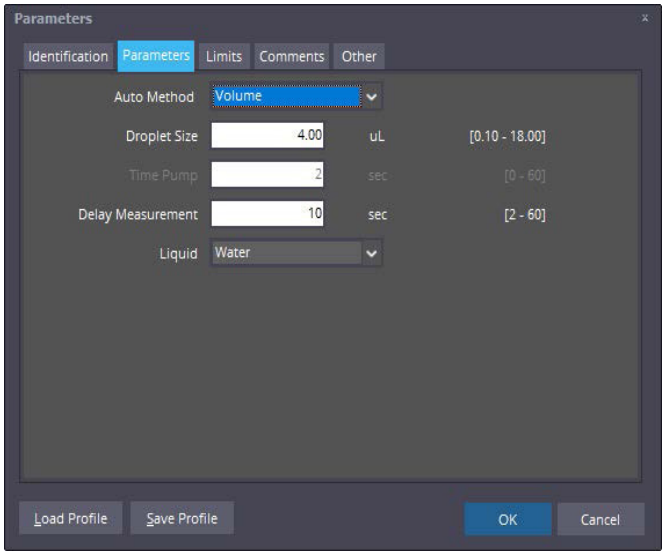
A "too small" pendant droplet at the dispensing tip will give a too high reading. When the droplet size is gradually increased, gravity will influence the droplet shape and the surface tension will gradually decrease. At a certain droplet size the droplet becomes unstable, wobbling from side to side, which may give an erroneous result. The correct droplet size is the volume used immediately before the droplet begins to wobble.



The algorithm used determines the maximum diameter "D" and the lowest point "L" of the droplet contour. The droplet width "W" is then established at a distance "D" above the point "L". The parameters "D" and "W" are finally used to calculate the liquid's surface tension from the droplet shape.

Please note the surface tension value is a function of the density of the liquid. This correction is done automatically if the Density field is updated before the measurement is done.

8.5.1 Parameters



Auto Method

Off	Manual test
Volume	Automatic test with droplet size control
Time	Automatic test with time control

Droplet Size

Enable only if the Auto Method is selected to Volume

Time Pump

Enable only if the Auto Method is selected to Time

Duration

Liquid

The characteristic of the liquid are used in the formula.

8.6 Wettability

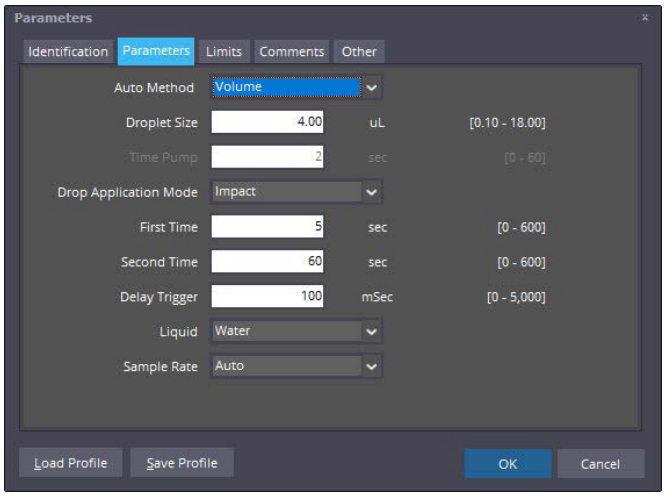
This mode captures a video sequence showing the dynamic interaction between the liquid and the surface as the dynamic mode.
The method measures the contact angle at two points and calculate the wettability with the function:

Wettability= (Angle1-Angle2)/(Time2-Time1)

Where the Time1 and Time2 are the two times enter as parameters and the Angle1 and Angle2 are the angle measures at the prefix times.

The end test will be the values of the second time.

8.6.1 Parameters



Auto Method

Off	Manual test
Volume	Automatic test with droplet size control
Time	Automatic test with time control

Droplet Size

Enable only if the Auto Method is selected to Volume

Time Pump

Enable only if the Auto Method is selected to Time

Drop Application Mode

Impact	The pendant droplet is lifted and dropped with a small impact.
Touch Down	The pendant droplet is lowered towards the surface.

Delay Trigger

The measurement is suspended until the set time has expired.
Disable when the Auto Method is selected to Off.

First Time

Second Time

Liquid

It has no influence in the results.

Sample Rate

It's the number of frame per second that the camera will collect.

8.7 Manual testing in static and dynamic mode

In some special situations, it might be necessary to make a manual determination of the droplet.
One example is when the captured droplet image is too bright and therefore does not have a solid contour resulting in a "zero result".
Another example is when the droplet base is hidden against a too dark surface and the base line is then incorrectly set. In these situations the captured image sequence can still be used for a semi-automatic or manual approach described later in this section.

Double-click on a data point in the diagram or a line in the Results Window to bring up the corresponding image as shown in Figure 9.9.

8.7.1 Adjust the image contrast

Double-click the image to select binary mode and slide the handle Gain offset up or down to make the binary image brighter or darker. Try to find a position where the contour is continuous and the base of the droplet separated from the background. This will activate the button Save, with its light indicator. Right-click on this button to assign a new mode (Fig 9.8). If the button already has the appropriate selection (e.g. "All images"), simply click the button to change the contrast settings for selected images. These images will then be recalculated using the new gain setting. Use the slider below the image to step between images and check the results.

If a suitable contrast setting cannot be found using the Gain offset control, it will be necessary to use the Enhance function.. (see section 8.9.1

8.7.2 Adjust the position of an incorrect baseline

When the automatic base line is set incorrectly, pick up the base line handle (BL) in Figure 9.9 with the mouse and slide it to the correct position. This will activate the button Save data with its light indicator. Right-click on the button to assign a new mode. If the button already has the appropriate mode (e.g. "All images"), simply click the button to move the base line for selected images. These images will then be recalculated with the new base line setting.

8.7.3 Exclude fragments above droplet

When the automatic analysis picks up fragments of the dispensing tip, slide the top line handle (TL) below the fragments that could disturb the measurement. This will activate the button Save data and the changed setting will update all images in the measurement. The new top line setting will also update the region setting of the corresponding test button on the Image Control Panel.

8.7.4 Make a manual measurement

Select the greyscale view and click the button Manual to open the zoom window (Figure 9.10).
Click with the cursor at the contact point between the droplet base and the test surface.
Click again at the contact point on the opposite side and once at the top of the droplet.
The manual results will now appear in the top left-hand corner of the image together with the original data. To save the manual results instead of the original results, click on "Save data", which will also store the manually selected points superimposed in the image. To select three new points along the contour, click on "Reset". To close the Zoom window, click on "Close".

Save Image stores a copy of the image with the manual results superimposed.

Use the slider below the image to shift to another image.

8.8 Surface 'free' energy (SFE)

As this surface property cannot be measured directly; it is calculated from contact angle measurements using different, properly characterized liquids. Depending on the substrate, one or more liquids are used. Please note SFE calculations are subject to the following constraints:

- No penetration of test liquid into surface (check that volume remains constant over time)
- No chemical reaction between test liquid and surface (check contact angle is constant over time)
- Surface must by sufficiently smooth

Here the operator starts by selecting a Calculation Model from the following options:

- ASTM D5946
- Polar/Dispersive
- Acid/Base

The first option, ASTM D5946 is the "Standard Test Method for Corona-Treated Polymer Films using Water Contact Angle Measurements" (copyright ASTM International) where the water contact angle is converted into a dyne value. For this option only the topmost liquid field (Water) is activated and used for the SFE calculations.

The second option 'Polar/Dispersive' uses contact angle readings from two selected test liquids to determine the SFE of a substrate. Here the two first liquid fields (Water and DIM) are activated.
For these calculations, the Harmonic approach (Wu) is used as the first option as this is considered 'more accurate'. This approach can, however, end up in negative roots, so there is not always a solution to these equations. In this situation the program changes to the Geometric approach (Owens-Wendt), which always gives a solution. The SFE report indicates which method was eventually used (Harmonic or Geometric) for the calculation. It is possible to force the Geometric method if the parameter SFEMETHOD is changed from H to G (see section 11).

The third option 'Acid/Base' (Lewis) uses three liquids to calculate the surface energy from an equation system. Here all three liquid fields are activated (Water, DIM and Formamide).
Please note the calculated results depend on the liquid combination used.

To select an input data file, use the associated Browse button.
For Water, the browse button will present files with a wgs extension only as these should contain results from water contact angles. In a similar way the other two browse buttons (if active) can be used to select other result files measured with DIM or Formamide. As soon as the result file for Water has been selected, the first part of the file name is used for the field 'Sample ID' (e.g. 45901).

The program will automatically search for associated result fields. The condition is, however, that all files must use the same ID as a file name (e.g. 45901.wgs and 45901.dgs). The operator can still overwrite information displayed in the contact angle fields, in which case the Sample ID window will be erased. As soon as the input fields (one, two or three) have been completed, the program will automatically calculate the SFE results. When manual data is typed into the input fields, it is necessary to click on 'Calculate' to determine the SFE values. The SFE results are displayed in the Results Window at the bottom of the screen.

The Save button will store a copy of the report in the default directory (e.g. \fibro\pg) with the extension sfe (e.g. 45901.sfe). When the file has been stored the 'Save' button becomes inactive until a new result is calculated.

For corona treated polymers water can be used as the single liquid to determine SFE in accordance with ASTM D5946-0. The SFE result is then presented directly in the Static window when the ASTM parameter in the Options Menu is set to "ON"(see Section 9.11).

For determination of SFE using other liquids please see Section 11 of this User's Manual.

Please note SFE calculations can only be done from static contact angle test results!

8.9 Options screen

8.9.1 Enhance Mode

When a water droplet is applied on a surface of low reflectance (e.g. dark, rough craft liner), the droplet base will appear against a dark background. If the light level is increased, or the parameter CameraGain /Threshold is adjusted to distinguish the droplet base from its background, the droplet top can become too bright against the illuminated background. This is where the image enhancing routine will be very helpful. The enhancing routine is available in Static Mode, Dynamic Mode and Advancing/Receding Mode. Please note the image enhancing function remains in operation also when a new test mode is selected (e.g. changing from Static to Dynamic Mode).

a) Double click on the labels Offset Gain, Offset Exposure and Enhance to start with the default settings.

b) Place the instrument on the test surface and apply a liquid droplet on the surface.

c) Double-click in the video image to switch from greyscale to a binary image if necessary.

Adjust the Camera Gain control until the top of the droplet is completed. Then use the Enhance control to create a solid black contour all the way down to the base of the droplet.

8.9.2 Base Line determination

A water droplet applied on a reflecting background will appear as a dark 'saucer' when the contact angle is below 90 degrees. A high contact angle above 90 degrees will appear as a 'black snowman' with a waist against the white background. Similarly a contact angle of 90 degrees will result in a black circular shape. All these droplet silhouettes will be analyzed automatically and the program will assign a base line at the interface between the droplet and the test surface. The determined base line is displayed as a dotted line in the captured image. The base line can be adjusted manually as described.
By definition, the base line is the lowest section of the droplet resting on top of the test surface.

8.9.3 Camera Gain and Threshold

The default value for Camera Gain and Threshold is established during calibration. This light level determines if a pixel is black or white in the binary image. These values can be modified by the operator to manage unusually bright or dark test surfaces as part of a test profile stored under a button on the Options screen

8.9.4 Field of View limitations

The measurement of very low contact angles is limited by the horizontal field of view.
A standard PGX+ instrument has a horizontal view of approximately 6.5 mm. Droplets of 0.5 µL will reach a width of 3.7 mm at a contact angle of six degrees. At an angle of 2.5 degrees this droplet will have a width of five mm. In comparison a 0.25 µL droplet will reach a width of 4.6 mm at a contact angle of 1.5 degrees. As we cannot expect the droplet to be perfectly centered in the image, a useful width is some 4.5 mm at the droplet base. This means 0.5µL droplets can be measured down to 3 degrees. Similarly, a 0.25 µL droplet can be measured down to a contact angle of 1.5 degrees. For even lower contact angles, the droplet volume has to be decreased further.

9 APPLICATION

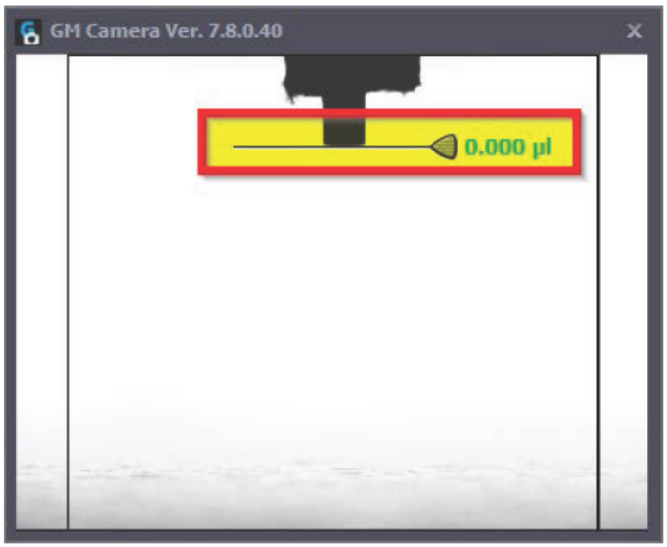
9.1 Manual application

Select the requested droplet size and press the PUMP button until the LED is lit.
The droplet is now pumped out and then slowly lowered towards the test surface.
To inhibit automatic drop application, press PUMP a second time while pumping is in progress.
The droplet can then be applied manually by pressing on top of the applicator.

9.2 Automatic application

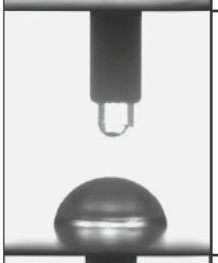
There are two ways to activate the automatic application.

From the instrument selecting the requested droplet size with the selector and press the PUMP button.
If the PUMP button is pressed until the LED is lit the droplet is pumped out and then slowly lowered towards the test surface.
If the PUMP button is pressed and release immediately the droplet is pumped out and transferred to the surface from a very short "free-fall" distance.



If the parameter Auto Method is selected to Volume or Time the automatic application is activated automatically by the software when the test start.
If the method selected is Volume the reference line on the screen to the end of the cannula must be adjusted.

After droplet has been applied, three different situations may occur, which can be described as

	A "pendant" droplet hanging at the dispensing tip To transfer droplet, apply a slightly bigger droplet or move the dispensing tip closer to the test surface.
	A "released" droplet, which is immediately transferred to the specimen upon contact with the surface.
	A "trapped" droplet, which is in contact with the specimen surface but has not released from the dispensing tip. Move instrument to a new test position and try using a smaller droplet size or increase distance between dispensing tip and specimen surface.

described as "wetting hysteresis", is characterised by the highest ("advancing") and lowest ("receding") contact angles. This test is based on a reversible pump flow. The optional PG Dosing Unit is a programmable dispenser suitable for this task, but any stand-alone pump with reversible flow can be used for the test. With a little practice it is even possible to use a regular handheld syringe to run this test manually.

10 TROUBLE SHOOTING

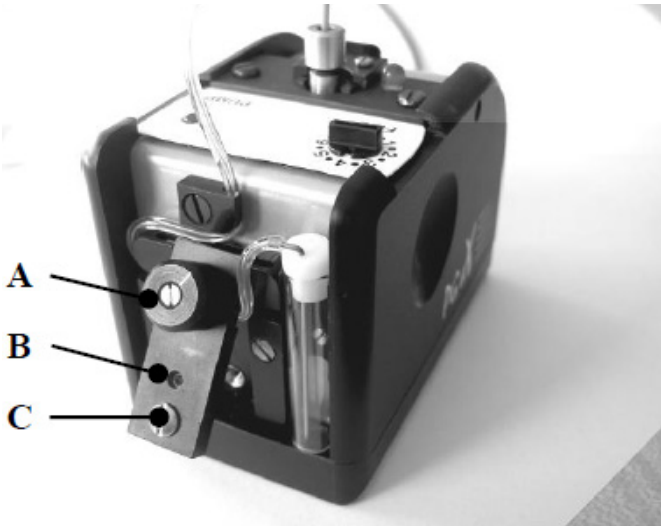
Camera "not found" or missing live image or "too dark" image
It is necessary to use the camera drivers supplied with your instrument!
If you have downloaded "later drivers" from the Internet, the results will become unpredictable and Windows might even refuse re-loading of your original drivers once "later versions" have been installed. If this situation occurs, please contact your instrument supplier for assistance.

If you have installed the PG program with the original camera drivers, please check the following:

a) Check the PGX+ instrument is connected to the selected USB port. If not connected, connect instrument cable and press OK

b) If your instrument is connected, unplug the instrument from the USB port, wait a few seconds and then re-connect the instrument again. The correct driver should now be selected automatically.

The micro-pump does not run although LED indicator on top of pump is lit
a) Turn the volume adjustment knob (A) counter clockwise until pump starts to run.
b) If pump still does not run, release the lid screw firmly again.
c) Then tighten the hex screw (B) for one turn.
d) Finally tighten the pump lid screw (C) firmly again.
e) Check pump volume is correct .



The micro-pump runs but does not produce a droplet
a) Make sure liquid system is filled as described in section 6.3.
b) If pump runs but liquid does not appear at the dispensing tip, make sure the pump lid screw (C)) is firmly tightened.
c) If still no liquid is pumped, release stop screw (B) ½ a turn and then tighten the pump lid screw (C) firmly again.
d) Repeat (c) above until liquid is pumped inside tubing (use pump position FILL).

The pendant droplet continues to build up after pump has stopped
The pump tubing must be completely shut after the pumping has stopped. If not, liquid will continue to flow through the pump tubing. See Appendix D of this manual to adjust the pump function.

The droplet climbs up on the outside of the dispensing tip
The outside of the dispensing tip is wet or is not clean.
Dip a cotton swab in an evaporating solvent (e.g. alcohol) and wipe the tip clean on the outside.
Some liquids of very low surface tension (e.g. organic solvents) might still tend to wet the outside of the dispensing tip due to the tip material.
To reduce this it might be necessary to use PTFE tubing with a large cross section and a small inner diameter (P/N 860315, Ø1.5x0.2 mm) without inserting a metal needle at the tip.

Droplet forms nicely at the dispensing tip but does not release from the tip in Dynamic test mode
Increase the droplet size to overcome the adhesion between the liquid droplet and the dispensing tip.

The Dynamic test gives no test result at all
The dynamic test is triggered by the drop application. Possible errors are:

a) The image capturing might start "too early".
If the pendant drop is too close to the surface it might trigger the image capturing before the droplet is dropped. Increase the distance to the surface slightly.

b) The Dynamic test might have "timed out"
After the test button has been pressed the scanning process will time out after 30 seconds. Pump out a droplet before the program button is activated and apply the droplet during the 30-second period.

Test results appear to be incorrect or "zero"
When a captured image cannot be evaluated automatically, the result is a line of zeroes.
The automatic analysis will fail if the captured image is of poor quality because of incorrect settings. Some examples could be a droplet contour that is broken, the droplet base is hidden in the background or the image is too bright and the droplet cannot be detected.
The captured image is still available and can be displayed if the incorrect result line is double-clicked (see Section 8.7 Manual testing in Static/Dynamic Mode)

Bundled operating systems
We have come across occasional problems with modified operating systems delivered with certain computers. As a result the displayed image might not appear or it will freeze up on the screen. Kindly note we can take no responsibility for the use of modified operating systems, as these are completely outside our control. Install a licensed Microsoft version on your computer, re-install the PG software and the problem should be gone.

Jumping image
With a limited number of notebook computers, the live image displayed is occasionally unstable. These errors usually occur from interfering accessories (e.g. a built in web camera) or a low refresh rate of the screen in combination with the capacity of the USB port. Use the "Performance Check" in the Help Screen, to check the image capture rate available. If performance is poor, try to switch off background tasks that are not necessary to run in parallel with the PG program. You may also try to increase the refresh rate of the display screen and reduce the resolution of the display screen.

NOTE:
Please note this error is NOT related to your instrument or the PG software itself!

USB port voltage supply
Use of USB ports has become very popular and sometimes a USB port is expanded using a passive hub. Unfortunately this may affect the power available at the port when different accessories are plugged in/out (e.g. memory stick, mouse, hard disks). If you would like to connect the PGX+ instrument to a hub, please make sure the hub is of an "active" type with its own power supply to avoid possible errors.

11 MISCELLANEOUS

11.1 Instrument storage

The liquid system (dispenser, tubing and liquid container) should never be left with a liquid for a long time as this may clog the system. The procedures below are recommended when your PGX+ is to be stored for some time or shipped to another location.

When using the PGX+ with liquids other than water (e.g. solvents, inks) it is necessary to clean the liquid system after the test has been finished. If the instrument will be stored for some time it is also recommended to empty the liquid system in the following way:

a) Release the pump lid screw to access the pump tubing
b) Lift out the liquid container, remove the plug and the empty container
c) Blow liquid container dry with air
d) Connect syringe with the RED tip to the dispensing tip and pump air through the tubing until dry
e) Push the plug back into liquid container top and re-install the container
f) Put the pump tubing in position
g) Re-install the pump lid and secure the pump lid screw gently

NOTE:
DO NOT tighten the pump lid screw completely when stored!

11.2 Transportation

Before shipping, the instrument should be prepared as described in above section.
Please note it is important to empty even a water-based system completely if shipping might include airfreight at high altitude as this might cause freezing damages.

Always ship the instrument in a complete case with all instrument accessories.

Make sure the case is shipped in sufficient padding to avoid damaging the instrument case and its contents.

11.3 Droplets

11.3.1 Recommended droplet sizes

The default droplet size is 4,0 µl, which has been used as the recommended size in contact angle testing for historical reasons. In general the contact angle is not affected by the droplet size as long as the droplet is not affected by the gravity. For water (having a high surface tension) the contact angle will be stable as long as the full droplet remains in view.

The droplet size may still have an input on the reading, as a bigger droplet will cover a larger test area and might easier pick up contaminants on an inhomogeneous test surface.

For absorbent surfaces it might be easier to track the penetration of liquid into the substrate if a slightly bigger droplet is used for the test. On the other hand, a bigger droplet may spread outside the field of view or cause the test surface to warp leading to erroneous test results.

If the specimen warps when the liquid droplet is applied, it might be necessary to attach the specimen strip to a flat surface with a suitable adhesive.

11.3.2 Detection of the droplet in Dynamic Mode

The distance between the pendant droplet and the specimen surface is necessary for the droplet to form and release from the dispensing tip before the droplet touches the surface.

The impact on the contact angle from a falling droplet of 4.0 µl is very small. This can be verified if a solid, non-absorbent surface is tested for the static contact angle with 6-8 droplets. When the same specimen is tested with the dynamic approach the contact angles should match the average result from the static test.

Smaller droplets will require a bigger falling distance to release from the dispensing tip.
A droplet of 2.0 µl falling from a two-mm distance will still give the same contact angle reading.

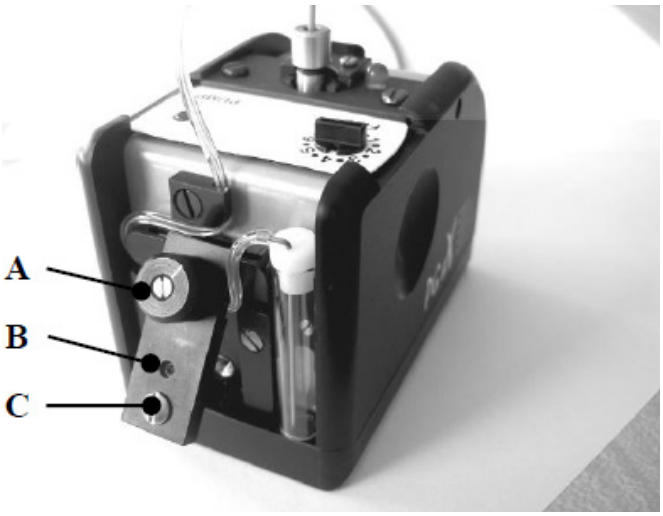
Bigger droplets will give lower contact angles for bigger falling distances. This principle can be used to determine the "receding" contact angle describing the de-wetting properties of a surface.

11.4 Pump

11.4.1 Replacement of Pump Tubing

a) Remove the pump tubing from its holder
b) Open up the pump lid screw (C) and lift up the pump lid.
c) Disconnect the old pump tubing from the liquid container and the cannulus connected to the droplet dispenser.
d) Install the new tubing between the liquid container and the tubing connected to the dispenser.
e) Insert the pump tubing into its track and make sure the pump tubing goes straight through the pump unit when the liquid container is installed into the pump.
f) Re-install the pump lid and secure the pump lid screw (C) firmly.
g) Refill the liquid container.
h) Fill the pump tubing like this:
- Set the volume selector to position FILL.
- Press PUMP and the pump will give 50 pump strokes and stop. This volume may produce a small droplet at the dispensing tip. Press once more on the PUMP button to restart the pump. When a droplet without air bubbles appears at the dispensing tip, press and hold the PUMP button until pump stops.

i) Set the volume selector on top of the instrument to "4.0 µL", which is the default droplet size for testing.
j) Slide the instrument sideways to a new test position.
k) Use "Static" mode to measure the average volume from six droplets on a flat glass surface.
The volume readings may vary around the average but must not show a trend indicating air bubbles in the liquid system. When the average becomes stable it should not vary more than 0,2 µl from the average. If the average is outside ± 0.2 µL compared to the target of 4,0 µL the droplet volume can be adjusted with the volume adjustment knob (A) on the pump unit.
l) Leave instrument for 10-15 seconds and check no droplet is building up at the dispensing tip. If a droplet builds up, the pump tubing is not firmly shut. Adjust as follows:
- Release the hex screw (B) ½ turn.
- Tighten screw (C) firmly.
- Repeat if droplet is still appearing at dispensing tip.



11.4.2 Adjustment of Pump Volume

The micro pump delivers droplets in steps of 0,5 µl and for a target volume of 4,0 µl the pump will make eight pump movements. The Static Mode can be used to measure the average volume from six droplets applied on a non-absorbent specimen surface (e.g. a metal foil or a glass plate). The volume readings will vary around an average and should not show an increasing trend indicating air bubbles in the liquid system.

Two numbers describe the pump performance where

- "repeatability" is the variation in droplet volumes around the average of six volume determinations;
- "deviation" is the difference between the target volume (e.g. 4,0 µl) and the average from the six volume determinations (e.g. 4,1 µL).

The "repeatability" is a function of the pump and cannot be adjusted. This value should not exceed 5% (corresponding to ±0,2 µl at a target of 4,0 µl).

The "deviation" is a function of the physical dimensions of the pump tubing. This value should not exceed 5% (corresponding to ±0,2 µl at a target of 4,0 µl). If the average volume from six droplets is outside 5% from the target, the droplet size can be adjusted with the procedure described below.

a) Locate the volume adjustment knob located on the pump lid (A in picture).
b) When the droplet volume is too high, turn knob in a counter clockwise direction. When the droplet volume is too low, turn the knob in a clockwise direction.
c) Take a new set of readings in Static Mode and check the average volume from six droplets. If necessary repeat step (b) above.

11.4.3 Small droplets below 0.5 µl

The micro pump delivers droplets in steps of 0,5 µl but to measure SuperLow contact angles it might be necessary to use even smaller droplets. Turn the volume adjustment knob (A in picture) counter clockwise for a smaller volume. Apply a few droplets on a smooth, reflecting glass surface and determine the set volume in Static Mode.

In SuperLow Mode enter the determined volume into the Volume field (default 0.25 µl) before the measurement is carried out.

NOTE:
Remember to reset the volume adjustment knob (A) to 0.5 µl when leaving SuperLow Mode.

11.5 Conversion chart

Water Contact Angle	*SFE (dyne/cm)*
51-53	46
54-56	45
57-59	44
60-62	43
63-65	42
66-68	41
69-71	40
72-73	39
74-76	38
77-79	37
80-81	36
82-84	35
85-87	34
88-89	33
90-92	32
93-95	31
96-97	30
98-100	29

Adapted, with permission, from D5946-01 Standard Test Method for Corona-Treated Polymer Films using Water Contact Angle Measurements, copyright ASTM International.