UV PROCESS SUPPLY, INC.

1. The Pocket Goniometer

is a battery operated instrument for laboratory and field applications related to gluing, printing and surface problems. It is an ideal tool to reveal contamination of a specimen as well as the effect of cleaning and surface treatments. A magnified image of the droplet is displayed on the built-in screen equipped with an adjustable protractor. An integral eyepiece provides additional magnification for improved accuracy.

The PocketGoniometer is ideal for introduction of the "static" contact angle concept. The contact angle approach is a robust method, established long time ago. By placing a liquid droplet on a specimen surface a contact angle q is formed at the contact area. By definition, a droplet which "beads up", is non-wetting and a contact angle higher than 90 degrees is displayed. When the droplet "wets out" across the surface, wetting is obtained and the contact angle is less than 90 degrees.

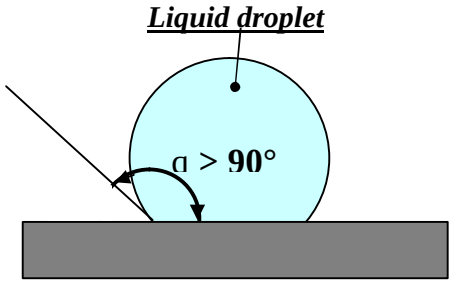

Figure 1.Contact angle

Applicable Standards: TAPPI T458, ASTM D724, SCAN –P 18

Contents

The PocketGoniometer contains the following:

- a longlife light source (expected life time of 70.000 hours)
- two installed batteries (1,5 Volts AAA-type)
- a High Quality triple lens system
- a specimen stage for strips and flat specimens
- an integrated display screen with a protractor and a scale
- an integrated eye-piece for increased magnification (x7)
- a syringe (stored inside instrument)
- a battery saving timer circuit

2. Setting up the PocketGoniometer

2.1 Filling the syringe

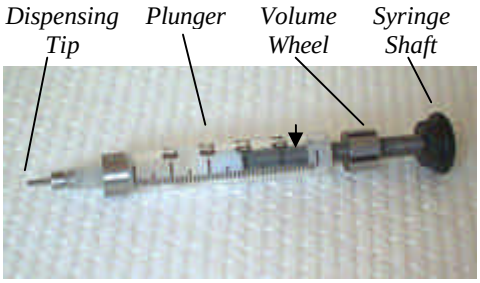

Figure 2. Syringe

Remove the syringe from its storage space by unscrewing the knob at the short end. Rotate the volume wheel until it is close to the knob at the end of the syringe shaft. Then push the syringe shaft into the syringe so the plunger is close to the dispensing tip. Insert the dispensing tip into the liquid used for the test (e.g. water) and pull the knob backward to fill the syringe. Hold the syringe vertically with the dispensing tip pointing upwards and tap gently on the syringe to bring the air bubbles to the top. Then push the knob forward to remove the air from the syringe. Repeat the process above to fill the syringe completely. After the syringe has been filled, turn the volume wheel until it touches the rear end of the syringe to prevent the plunger from moving forward.

NOTE: If different test liquids are to be used it is extremely important to avoid contamination as this will change the liquid properties resulting in an erroneous contact angle. To avoid tedious cleaning of the syringe each time a different liquid is used, it is recommended to use dedicated syringes for each liquid.

2.2 Activate the PocketGoniometer

Gently pull the two halves apart to switch on the light source and access the specimen stage. An integrated timer inside the instrument will switch off the light source automatically after about ten minutes to save battery power. The light can be switched on for another ten minutes by pressing the knob located next to the syringe compartment at the short end of the instrument.

2.3 Installing the specimen

Cut out a flat specimen and place it on top of the specimen stage. For instruments with a specimen holder, it is suitable to cut strips 15 mm wide, which can be inserted under the clamps. The specimen surface should always be viewed slightly from above and produce a reflected image on glossy materials. The specimen stage is designed to keep the specimen surface at the same height regardless of thickness.

Soft materials can be attached to the sample holder with a special pre-cut adhesive tape, which can be used for several specimens before replacement.

2.4 Installing the syringe

Hold the syringe with the dispensing tip pointing upwards. Tap gently on the syringe to bring air bubbles inside the liquid to the top. Push the plunger slightly to remove the air at the dispensing tip. Rotate the wheel for droplet size forward until it barely touches the end of the syringe. Then press at the end of the shaft and a small droplet should appear at the dispensing tip. Screw the syringe tip into the hole in the dispensing bridge until it appears at the top of the displayed image.

NOTE: Make sure the dispensing tip is not damaged by the specimen stage or touches the specimen surface. DO NOT use excessive force when tightening the syringe!

2.5 Drop application

The volume wheel for droplet size setting has five marker lines corresponding to 10 µl for a full turn. Put one finger on top of the syringe shaft and apply a light pressure. Then rotate the wheel (counter clockwise seen from above) until the droplet contacts the surface. Upon contact, two different situations may occur, which can be described as

Figure 3. Installing the syringe

(a) "Released" droplet, which immediately transferred to the specimen upon contact with the surface. This is the situation we would like to have right now.

(b) "Trapped" droplet, which made contact with the specimen surface but did not release completely from the dispensing tip. Then unscrew the syringe a few turns until the droplet releases from the dispensing tip. Do not reduce the droplet size with the volume wheel as this generates a too low contact angle. This lower "receding" contact angle can be used to characterise the wetting hysteresis as described in section 4.2.

2.6 The displayed image

A magnified image of the released droplet should now be displayed on the projection screen. It is necessary the contact point between the droplet and the substrate is in view. The image should also be viewed slightly from above so a "reflected image" of the contacting point can be used when taking a reading.

For big droplets it might not be possible to see the two sides of the droplet simultaneously. In this case it will be necessary to slide the specimen sideways or simply reduce the droplet size when this is acceptable.

2.7 Taking a reading

Figure 4 shows a low contact angle <90° as the liquid droplet wets out across the specimen surface. Locate the "point of reflection" at the edge of the contour (marked by a circle). Then estimate the tangent at this contact point (indicated by the white line).

Figure 4. Low contact angle <90°

On top of the projection screen, there is a protractor disk with parallel straight lines (Fig. 5). Rotate this disk until the lines are parallel to the tangent at the contact point. The black centre line will now point at the contact angle value on the scale.

Please note: When taking a reading the black centre line must be aligned with the corresponding grid line under it to avoid parallax errors!

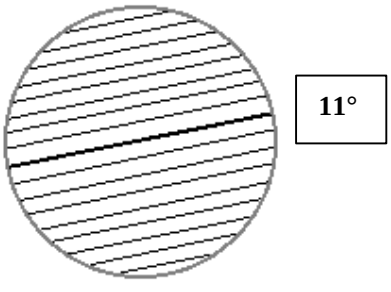

Fig. 5. Protractor at 11°

Figure 6 shows a high contact angle >90° as the liquid droplet beads up on the specimen surface. Locate the "point of reflection" at the edge of the contour (marked by a circle). Then estimate the tangent at this contact point (indicated by the white line).

Please note: The tangential line must not go inside the contour of the droplet!

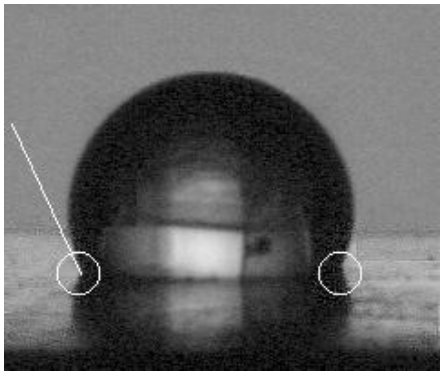

Fig 6. High contact angle >90°

Rotate the protractor disk until the lines are parallel to the tangent at the contact point. The black centre line shows the contact angle on the scale.
Please note: When taking a reading the black centre line must be aligned with the corresponding grid line under it to avoid parallax error!

NOTE: The scale displays values from 180 degrees down to zero. When the contact angle is measured on the left-hand side of the droplet image, the reading is correct. When the reading is made on the right-hand side of the droplet, however, the correct value is the complement angle (e.g. a reading of 122 degrees means 180-122= 58 degrees).

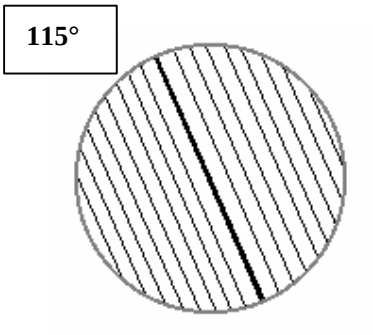

Fig 7. Protractor at 115°

To increase the accuracy of these readings, there is an integral eyepiece offering additional 7x magnification. Release two of the screws holding the bezel and insert the eyepiece foot under the bezel. Then secure the two screws again.

Figure 8. Removable eyepiece

3. Static and Dynamic contact angles

The terminology around contact angles can be slightly confusing.
It is therefore important to know the different types of contact angle and how they are measured.

3.1 Static Contact Angle

The static contact angle is measured at “equilibrium” conditions and is only valid for solid, non-sorptive surfaces. Section 4.1 contains a description on how to measure the static contact angle at equilibrium with the PocketGoniometer.

3.2 Dynamic Contact Angle (“surface hysteresis”)

The interaction between a liquid droplet and a specimen surface is not always described by a single value. In fact, there is a range of contact angles that may appear as a result. The reason is a relatively high contact angle may appear as the liquid advances across the dry surface. When the liquid is removed from a wetted surface, a lower contact angle appears as the droplet is receding. This type of *dynamic contact angle* is referred to as “surface hysteresis” described by the advancing and receding contact angles. The purpose of this characterisation is to determine the wetting/de-wetting characteristics of a surface.
Section 4.2 contains a description on how to measure the surface hysteresis with the PocketGoniometer.

3.3 Dynamic Contact Angle (“function of time”)

When the liquid penetrates into the substrate, the contact angle will change continuously. This “dynamic” contact angle is described as a function of time, where requested data are reported at selected times. To test dynamic contact angles as a function of time, you can use the PocketGoniometer model PG-3 or the fully automatic DAT 1100-series of instruments.

4. Test Applications

The contact angle can be measured in different ways depending on the test application. This section describes the principal applications and how to perform these tests with your Pocket Goniometer model PG-1.

4.1 Static Contact Angle

This approach is valid for smooth, solid surfaces where the test liquid does not penetrate into the substrate. For liquids with high viscosity (e.g. glycerine) the contact angle reading is taken when the liquid droplet is not spreading any further (at ”equilibrium” conditions).

(a) Cut a specimen and install it on the specimen stage
(b) The specimen surface should be viewed slightly from above.
(c) Fill the syringe with the preferred test liquid
(d) Insert the syringe into the dispensing bridge and screw the syringe downwards until it appears at the top of the displayed image.
(e) Pump out a droplet big enough to make contact with the specimen surface
(f) Upon contact the droplet is usually “released” from the dispensing tip, in which case you continue to take a reading. When the droplet is “trapped” and not releasing from the dispensing tip, turn the wheel for volume setting in a clock-wise direction (seen from above) until the droplet releases from the dispensing tip.
(g) Rotate the protractor disk until the parallel lines match the tangent to the droplet at the base of the droplet (the contact point between the liquid droplet and the surface). Take a reading where the black centre line points at the scale. To increase the accuracy of this reading, there is an integral eyepiece offering additional magnification (7x).

NOTE: The scale displays values from 180 degrees down to zero. When the contact angle is measured on the left-hand side of the droplet image, the reading is correct. When the reading is made on the right-hand side of the droplet, however, the correct value is the complement angle (e.g. 122 degrees means 180-122= 58 degrees).

4.2 Dynamic Surface Hysteresis

This approach is valid for smooth, solid surfaces where the test liquid does not penetrate into the substrate. For liquids with high viscosity (e.g. glycerine) the contact angle reading is taken when the liquid droplet is not spreading any further (at ”equilibrium” conditions).

PLEASE NOTE: the approach described below is commonly used in the industry. Extreme care must be taken as contaminants on the specimen surface may change the properties of the probing test liquid leading to erroneous test data. At the end of this section a faster approach is described, where the risk for surface contamination is reduced.

Common procedure:

(a) Cut a specimen and install it on the specimen stage
(b) The specimen surface should be viewed slightly from above
(c) Fill the syringe with the preferred test liquid
(d) Insert the syringe into the dispensing bridge and screw the syringe into the dispensing bridge. The dispensing tip *must not be in contact with the surface.*
(e) Pump out a droplet big enough to make contact with the specimen surface. Increase the droplet volume *while the dispensing tip is inside the droplet*. The droplet should not spread outside the field of view and the purpose is to capture a situation where the contact angle is “as high as possible”.
(f) Use the protractor disk to take a reading from the “advancing” contact angle, which describes the wetting of a dry specimen surface.
(g) Turn the wheel for volume setting in a clock-wise direction (seen from above) to reverse the flow of liquid *while the dispensing tip is inside the droplet*. As the droplet recedes a lower contact angle will appear. The purpose is now to capture a situation where the contact angle is “as low as possible”.
(h) Use the protractor disk to take a reading from this “receding” contact angle, which describes the de-wetting of a wet specimen surface.

Improved procedure:

(a) Use a 15 mm wide specimen strip installed under the stage clamps.
(b) Apply a droplet big enough to keep the dispensing tip well inside the droplet.
(c) Pull the specimen strip to the right side until the droplet slides across the surface.
(d) Take a reading of the advancing contact angle on the left hand side of the droplet.
(e) Pull the specimen strip in the opposite direction until the droplet slides again.
(f) Take a reading of the receding contact angle on the left hand side of the droplet.

NOTE: The scale displays values from 180 degrees down to zero. When the contact angle is measured on the left-hand side of the droplet image, the reading is correct. When the reading is made on the right-hand side of the droplet, however, the correct value is the complement angle (e.g. 122 degrees means 180-122= 58 degrees).

5. Sample Preparation

(a) Determine and mark the machine direction of each sample. Be careful not to touch the areas to be tested, or contaminate them in any other way.
(b) Determine and mark the "top" and "back" sides of each sample based on the side, which is relevant for the application.
(c) When the specimen thickness is not greater than 1.0 mm, cut three clean about 100-200 mm long specimen strips of 15.0 ± 1.0 mm at 45° to the machine direction. To determine the anisotropy of the surface one strip should be cut in the machine direction, one in cross direction and one strip at 45° to the machine direction. The strips must be free of folds, wrinkles, blemishes, watermarks and other defects not normally inherent in the specimen.

6. Test Liquids

Water is the most commonly used test liquid because it is easy and safe to handle. It is still important to know there is many different types of water (e.g. tap water, distilled water, reagent water) and the water must be checked too.

Other test liquids than water can be used in this system as long as they can be pumped out from the dispensing tip and form a "liquid droplet" on the specimen surface. When more than one test liquid is used, it is recommended contamination is avoided by the use of one dedicated syringe for each test liquid.

The properties of a probing liquid can be validated from known contact angles on reference materials with known surface properties.

7. Trouble shooting & Maintenance

7.1 Light source does not switch on

As the light source has an expected lifetime of more than five years continuous use, you should not expect "the lamp is gone". Here is what to check:

- Close the instrument, wait a few seconds and then open up again
- Batteries are out of power?
- If you replaced the batteries, check they are inserted as indicated
- Electronic failure (attached diagram)

7.2 The displayed image is not sharp

- Check the disk image is sharp.
- Move the contact point to the centre of the image
- Contact your supplier for adjustment of the lens

7.3 The protractor disc does not rotate

- Release the four screws holding the bezel
- Remove the disc as described in the service instructions and wipe it clean with a moist cloth. Do not use solvents!

7.4 No droplet or droplets of varying size appear at the dispensing tip

- Check for air bubbles inside the syringe

8. Technical Specifications

Specimen thickness	0 - 2 mm
Dimensions (LxWxH)	160 x 55 x 38 (50)
Weight (including batteries)	250 grams

9. Spare Parts

PG Syringe kit
PG Reflecting mirror kit

10. Certificates and Warranties

CE-certificate