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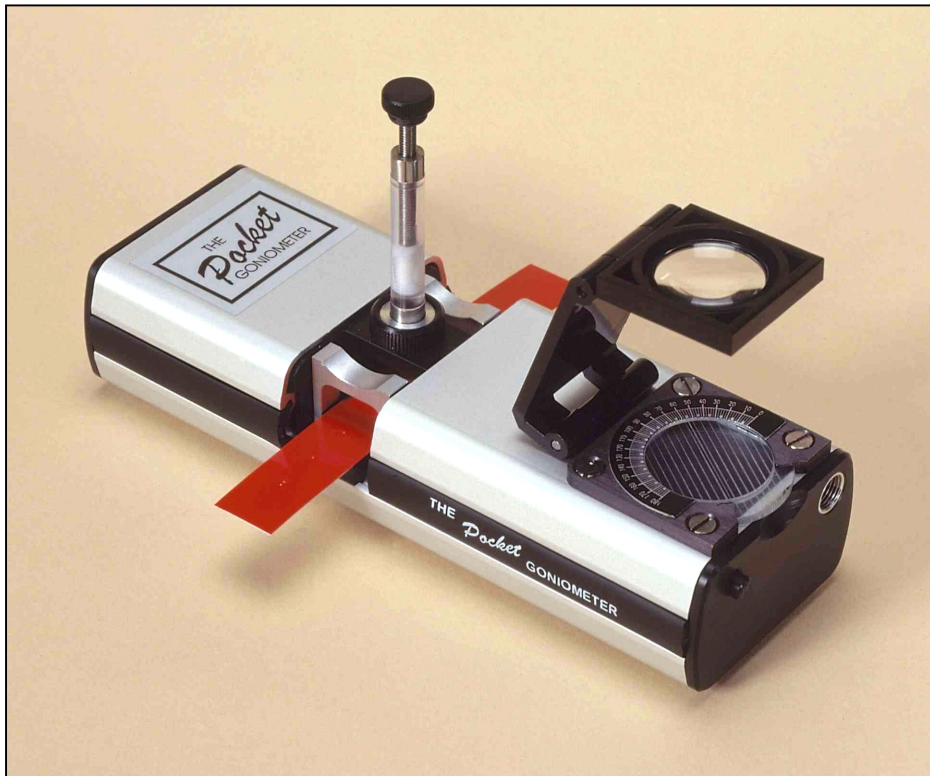
INSTRUCTIONS

GARDCO DISTRIBUTED PRODUCTS



The *Pocket*Goniometer

Model PG-1



User's Manual

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1. The PocketGoniometer model PG-1

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.

This model 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 θ 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.

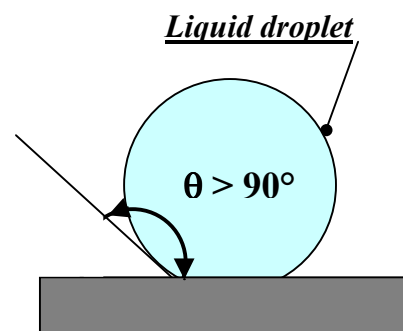


Fig. 1.1 The contact angle

Applicable Standards: TAPPI T458, ASTM D724, ASTM D5946, SCAN –P 18

1.1 Unpacking your instrument

The PocketGoniometer is delivered in a case including

- a Removable eyepiece
- a Training Tool with three semi-spheres (86°, 77°, 61°)
- a Carrier Strip kit with Special Tape (50pcs)
- an Accessory Kit

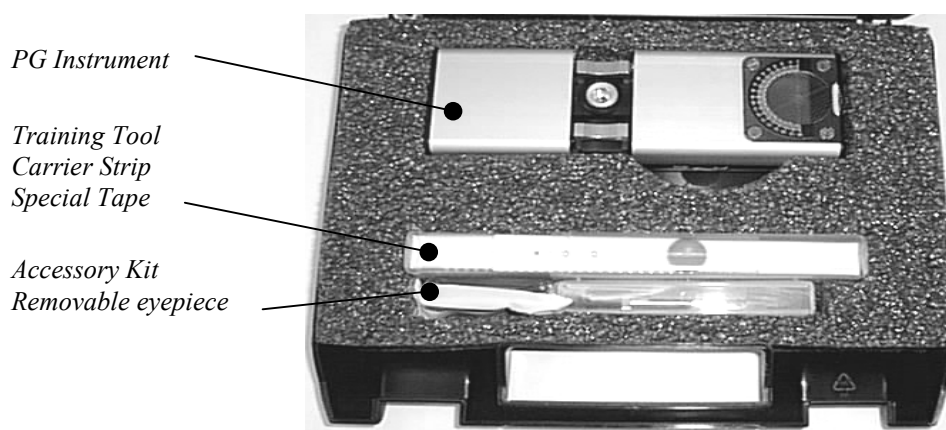


Fig 1.2 PG-1 Instrument case and accessories

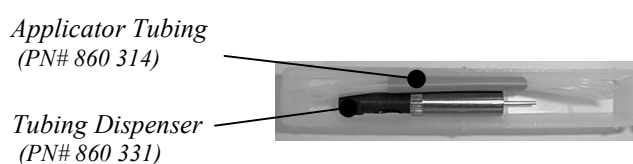


Fig. 1.3 PG-1 Accessory Kit

2. Setting up the PocketGoniometer

2.1 Activating the PocketGoniometer

Push the light button located next to the dispenser compartment at the short end of the instrument to switch on the light.

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 light button again even if the light has not yet been switched off.

2.1.1 Mounting the eyepiece

It is possible to increase the accuracy of the readings with the integral eyepiece offering additional 7x magnification (Figure 2.1). Push the eyepiece foot under the bezel to mount it onto the instrument.



Fig. 2.1 Removable eyepiece

2.1.2 Remove the specimen stage

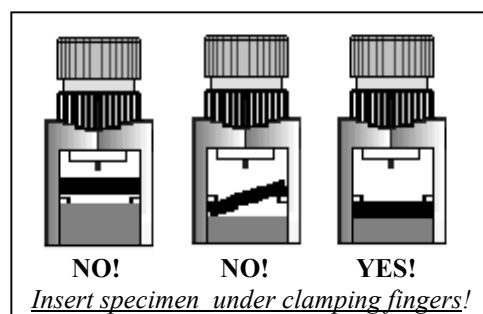
The specimen stage accepts specimen strips of up to 2.5 mm thickness. Thicker specimens up to 12 mm can be tested if the specimen stage is removed in the following way:

- Remove the two screws accessible through the holes at the bottom of the instrument.
- Turn the instrument over and remove the specimen stage.
- Add a spacer of suitable thickness to support the specimen at the proper height.
PLEASE NOTE! The “point of reflection” should appear at the horizontal baseline.

2.2 Loading a Specimen

Prepare your sample as described in Section 5.

Push on top of the two specimen clamps and slide the strip into position on top of the specimen stage. When the specimen clamps are released the specimen strip should be firmly held under the four clamping fingers. Soft materials can be attached to the carrier strip with a special pre-cut adhesive tape, which can be used for several specimens before replacement (Appendix A).



2.3 Filling the Manual Dispenser

For testing with different liquids it is recommended to use a separate dispensing unit for each test liquid to avoid contamination of test liquids. To fill the manual dispensing unit, use the procedure below.

PLEASE NOTE! The manual dispenser can not be used for test liquids of high viscosity or quickly drying solvent inks (e.g. rotogravure ink.) To apply liquids of high viscosity, please see Section 2.7.

- a) Remove the manual dispenser from its storage space by unscrewing the knob at the short end of the instrument, next to the light button.
- b) Rotate the volume wheel until it is in the top position under the applicator knob.
- c) Insert the dispensing tip into the test liquid and fill the dispensing unit with a few pump strokes. *Move the plunger slowly to avoid air sucked into the dispensing unit from the rear end.*

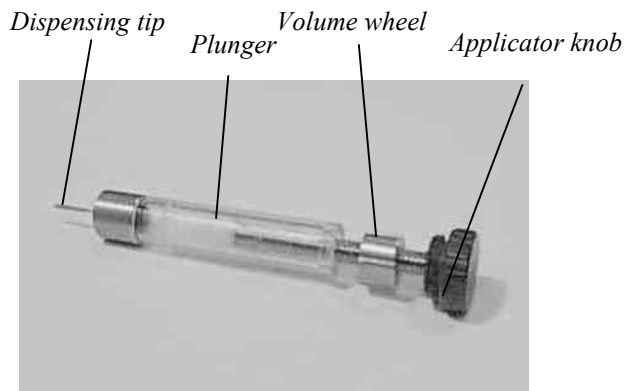


Fig. 2.2 Manual Dispenser

- d) Turn the dispensing unit with the tip pointing upwards and tap gently on the dispenser to bring air bubbles inside the liquid to the top. Push the plunger slightly forward to remove the air at the tip. Rotate the volume wheel forward until it barely touches the end of the dispenser. Then press at the end of the shaft and a small droplet should appear at the dispensing tip. *Make sure there are no visible air bubbles inside the liquid system.*
- e) Check the PTFE sleeving is adapted at the dispensing tip. Without this sleeving the test liquids might climb on the outside of the tip because of wetting forces.
- f) Insert the dispensing unit into the dispensing bridge.

PLEASE 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 manual dispenser each time a different liquid is used, it is recommended to use dedicated dispensers for each liquid.

2.4 Drop Application

- a) Load a non-absorbent specimen or a carrier strip on top of the specimen stage (Section 2.2). Make sure the specimen is firmly held under the four clamping fingers.
- b) Apply a gentle pressure on top of the applicator knob with your first finger and rotate the volume wheel slightly counter clockwise between your thumb and long finger to pump out a small pendant droplet at the dispensing tip (Figure 2.3). A reflecting image of the droplet may now appear below the droplet (Figure 2.4).
- c) After a droplet has been pumped out at the dispensing tip, the drop dispenser can be pushed downwards until the droplet makes contact with the specimen surface. Upon contact, two different situations may occur, which can be described as

a “released” droplet, (Figure 2.5)
which is immediately transferred to the specimen upon contact with the surface;

a “trapped” droplet, (Figure 2.6)
which is in contact with the specimen surface but has not released from the dispensing tip. In this case, slowly release the pressure on the dispenser and the droplet should release from the dispensing tip. If not, try using a smaller droplet size in a new test position.



Fig. 2.3 Drop Application



Fig. 2.4 Reflecting Image

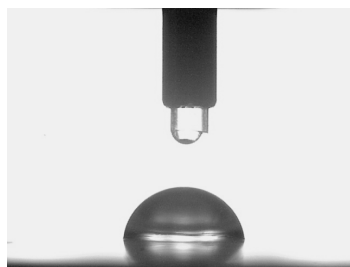


Fig. 2.5 Released droplet

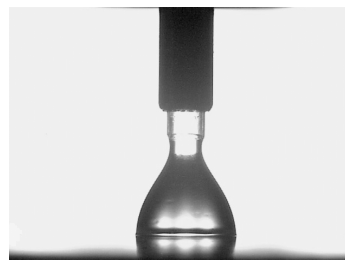


Fig. 2.6 Trapped droplet

2.5 The Displayed Image

A magnified image of the released droplet should now appear on the projection screen. It is necessary the contact point between the droplet and the substrate is in view. The image is viewed slightly from above which produces a “reflected image” of the contacting point for a reading.

2.5.1 Parallax errors

The rotating protractor has a set of parallel grid lines. The centre line is easily located, as it has no grid lines next to it. The grid lines are used when taking contact angle readings from the displayed droplet image. These readings can be quite accurate (error $< 2^\circ$) but it is very important to avoid parallax errors. This is why there are two centre lines on the protractor, one at the top and one at the back of the rotating disk. If these lines are viewed from an angle they appear as a “double centre line” as the two lines are not overlapping each other completely (Figure 2.7). When the protractor is viewed from the correct (perpendicular) angle these two lines will appear as a single line (Figure 2.8) and the parallax error is eliminated.

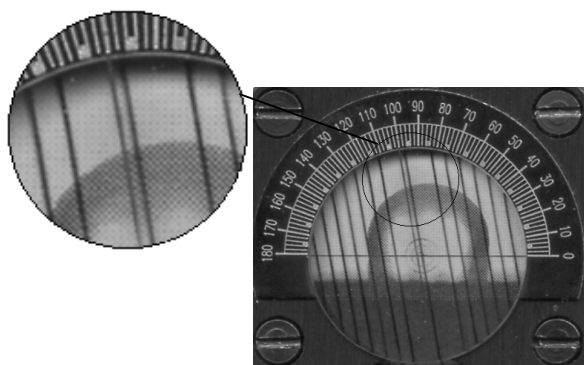


Fig. 2.7 With parallax errors

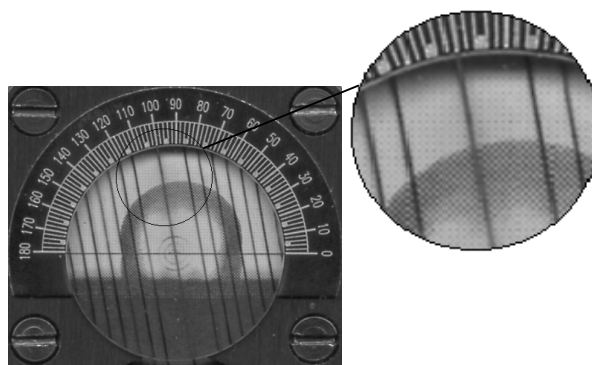


Fig. 2.8 Without parallax errors

2.5.2 The Sliding Specimen Stage

For droplets wetting out on the surface it might not be possible to see both sides of the droplet simultaneously. In this case it will be necessary to slide the specimen stage sideways or simply reduce the droplet size when this can be done.

2.6 Taking a reading

First of all the protractor disk must be rotated into the correct position.

In general the objective is to match the parallel grid lines to the contour of the droplet image. This can be done in different ways depending on the shape of the droplet, which falls into one of three categories.

2.6.1 The Standard Method

This method is fast and allows contact angle measurements on both sides without sliding the specimen stage.

- Locate the point of reflection on the droplet at the edge of the contour (Figure 2.9).
- Turn the protractor until the grid lines are parallel to the tangent at the point of reflection. Slide the specimen stage slightly sideways until the point of reflection matches a grid line (Figure 2.10).
- The centre line is now pointing at the contact angle for the droplet. Take your reading on the scale avoiding parallax errors (Section 2.5.1).

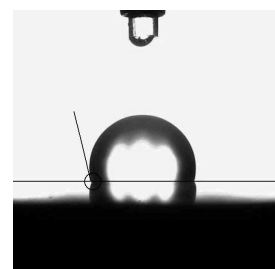


Fig. 2.9 Point of reflection

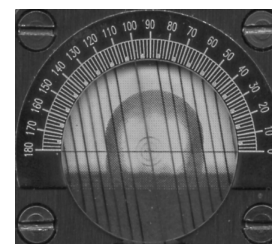


Figure 2.10

PLEASE 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).

The alternative methods for contact angle measurements described below may give contact angle readings with increased precision depending on droplet shape. The following images display the three typical droplet shapes:

A "flying saucer"?

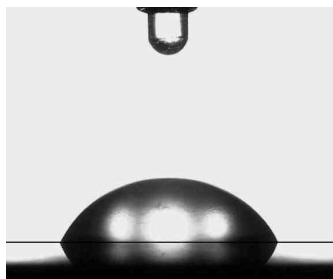


Fig. 2.11 Droplet shape $< 90^\circ$

An "eight shape"?

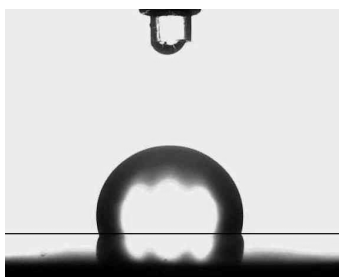


Fig 2.12 Droplet shape $> 90^\circ$

A "perfect sphere"?

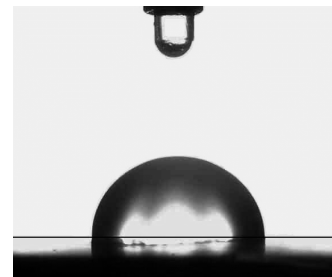


Fig 2.13 Droplet shape is 90°

2.6.2 Contact Angles below 90 degrees

Figure 2.11 shows a droplet with a contact angle < 90 degrees. The recommended way to measure the contact angle on a droplet shape like this is to:

- Rotate the protractor until centre line is at 90 degrees.
- Locate the point of reflection on the droplet at the edge of the contour (black circle in Figure 2.14).
- Slide the specimen stage to the left until the point of reflection is aligned with the centre line. *PLEASE NOTE! It is important the point of reflection to be positioned exactly at the centre line.*
- Rotate the protractor until the centre line is aligned with the tangent at the point of reflection (Figure 2.15).
- The centre line is now pointing at the contact angle for the droplet. Take your reading on the scale avoiding parallax errors (Section 2.5.1).

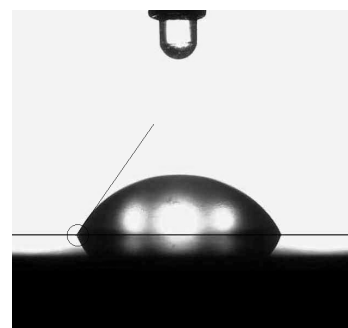


Fig 2.14 Point of reflection

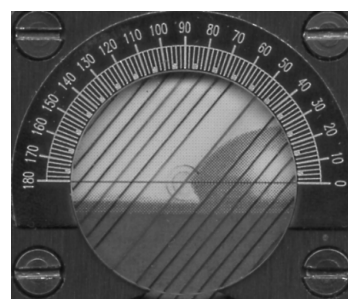


Figure 2.15

2.6.3 Contact Angles above 90 degrees

Figure 2.12 shows a droplet with a contact angle > 90 degrees. The recommended way to measure a droplet with a contact angle > 90 degrees is described below.

PLEASE NOTE! This method is only applicable when the top of the droplet is easily determined.

- Rotate the protractor until centre line is at 90 degrees.
- Locate the point of reflection on the droplet at the edge of the contour (black circle in Figure 2.16).
- Slide the specimen stage to the left until the point of reflection is aligned with the centre line. *PLEASE NOTE! It is important the point of reflection to be positioned exactly at the centre line.*
- Locate the top of the droplet and rotate the protractor until the centre line goes through the top of the droplet (Figure 2.17). *The top of the droplet is easier to locate with smaller droplets, which also will increase the precision.*
- Determine the reading pointed to by the centre line.
- Multiply the reading by two to get the contact angle value.

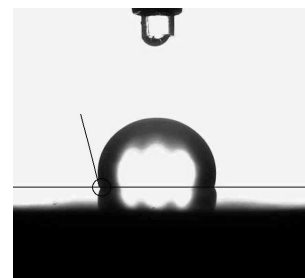


Fig. 2.16 Point of reflection

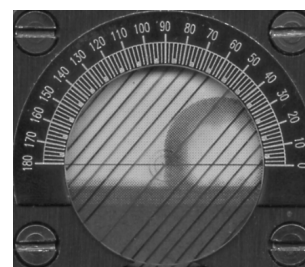


Figure 2.17

2.6.4 A "perfect sphere"

At 90-degrees contact angle the droplet shape will appear as a perfect sphere together with its mirror image (Figure 2.18).

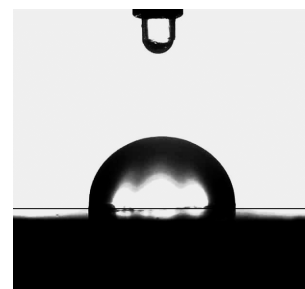


Fig. 2.18 A "perfect sphere"

2.7 Drop Application with external tubing

The manual dispenser supplied with your instrument is designed for water and other liquids of similar viscosity. Test liquids of high viscosity (e.g. glycerine, floor varnish) can not be applied with the manual dispenser. To apply liquids of high viscosity the procedure below can be used. This procedure can also be used for temporary testing with “unusual” liquids, as it will not require cleaning of the dispenser.

The procedure below uses an optional syringe with tip (PN # 860 321). The same procedure can also be used with the manual dispenser delivered with the instrument.

PLEASE NOTE! To avoid contamination it is recommended to use separate tubing for each test liquid.

- a) Hold the top section of the tubing dispenser and turn the lower part a few turns to open the chuck inside.
- b) Insert the applicator tubing into the dispenser without touching the free end. Leave approx. 25 mm of the tubing outside the dispensing tip.
- c) Fit the other end of the tubing onto the RED syringe tip and push the tip onto the syringe.
- d) Push the plunger inside the syringe to its forward position.
- e) Insert the free end of the applicator tubing into the test liquid. *DO NOT dip the dispensing tip into the liquid!*
- f) Pull the plunger gently backwards to fill the tubing. *DO NOT let the liquid enter the syringe tip!*
- g) Remove tubing end from the liquid container and pull the plunger slightly backward to suck some air into the tubing end.
- h) Wipe the outside of the tubing end clean.
- i) Pull the tubing into the dispenser until only a short end (approx. one mm) extends outside the tip of the dispenser. Tighten the chuck gently to lock the tubing.
- j) Install the dispenser in the instrument.
- k) Load a specimen as described in Section 2.2.
- l) Push the plunger very carefully forward until a droplet appears at the dispensing tip. Press on top of the dispenser to apply the droplet on the specimen.
- m) Advance the specimen to a new test position. Pump out a new droplet as described in (l) above and apply it on the surface for the first test droplet.

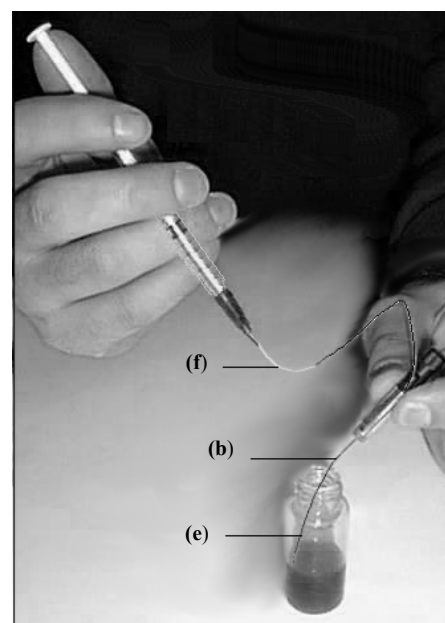


Fig. 2.19 Fill the tubing

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 angles, their applications and how they are measured.

3.1 The Static Contact Angle

This contact angle is measured at “equilibrium” conditions and is only valid for solid, smooth surfaces not penetrated by the test liquid. Section 4.1 contains a description on how to measure the static contact angle at equilibrium with the *PocketGoniometer* model PG-1.

3.2 The Dynamic Contact Angle (“surface hysteresis”)

The interaction between a liquid droplet and a specimen surface is not always characterised by a single contact angle value. In fact, there is a range of contact angles that may appear as a result. A higher contact angle may appear as the liquid advances across the dry surface. When the liquid retracts from a wet surface, a lower contact angle may appear 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 describes how the surface hysteresis is measured with the *PocketGoniometer* model PG-1.

3.3 The Dynamic Contact Angle (“function of time”)

When the liquid spreads across or penetrates into the substrate, the contact angle will change continuously. This “dynamic” contact angle is described as a function of time, where requested data is reported at selected times. To test dynamic contact angles as a function of time, it is necessary to capture a sequence of images with a video camera. The *PocketGoniometer* model PG-2 and PG-3 have an integrated camera for automatic determination of dynamic contact angles as a function of time.

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 *PocketGoniometer* 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 as described in Section 5 and install it on the specimen stage as described in Section 2.2. The specimen surface should be viewed slightly from above.
- b) Fill the manual dispenser with the preferred test liquid as described in Section 2.3.
- c) Insert the manual dispenser into the dispensing bridge.
- d) Pump out a droplet of the requested size (Section 2.4).

- e) Push the spring-loaded dispenser downwards until the droplet gently contacts the specimen surface. Try to obtain a contact angle as high as possible.
- 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, lift the manual dispenser to release the droplet (Section 2.4).
- g) Take a reading avoiding the parallax error (Section 2.6).

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.

4.2.1 Common procedure (“Reverse flow”)

- a) Cut a specimen (Section 5) and install it on the specimen stage (Section 2.2). The specimen surface should be viewed slightly from above.
- b) Fill the manual dispenser with the preferred test liquid (Section 2.3).
- c) Insert the manual dispenser into the dispensing bridge.
- d) Pump out a droplet big enough to make contact with the specimen surface. Increase the droplet volume *while the dispensing tip is still 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 “the highest” as it advances across the specimen surface.
- h) Use the protractor disk to take a reading (Section 2.6.1) from the “advancing” contact angle, which describes the wetting of a dry specimen surface.
- i) 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 kept 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 “the lowest”.
- j) Use the protractor disk to take a reading (Section 2.6.1) from this “receding” contact angle, which describes the de-wetting of a wet specimen surface.

5. Sample Preparation

- a) 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.
- b) Determine and mark the “top” and “back” sides of each sample based on the side relevant for the application.

When the specimen thickness is not greater than 2.5 mm, cut three clean about 100 mm long specimen strips of 15.0 ± 0.2 mm at 45° angle to the machine direction. The strips must be free of folds, wrinkles, blemishes, watermarks and other defects not normally inherent in the sample.

To determine the anisotropy of the surface one strip should be cut in the machine direction, one in the cross direction and one strip at 45° angle to the machine direction with proper markings of the specimen (e.g. MD, CD and 45).

Specimens up to 12 mm thickness can be tested if the specimen stage is removed as described in Section 2.1.2.

- d) Soft materials films or warping materials should be mounted on top of the carrier strip supplied with your instrument (Appendix A).

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 are 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 dispenser for each test liquid.

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

7. Trouble shooting & Maintenance

Light source does not switch on when light button is pressed

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:

- Batteries are out of power?
Unscrew end cover (short side of the instrument) opposite to the light button. Make sure the batteries are inserted as indicated.

The displayed image is not sharp

- Remove fingerprints from the disk with a soft cloth.
- Contact your supplier for adjustment or repair of the lens.

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

- Check for air bubbles inside the Manual Dispenser.

8. Technical Specifications

Specimen thickness	0 – 2.5 mm (max 12 mm with the specimen stage removed)
Dimensions (LxWxH)	160 x 55 x 40
Shipping dimensions (LxWxH)	250 x 220 x 50
Weight (including batteries)	350 grams
Shipping weight	800 grams

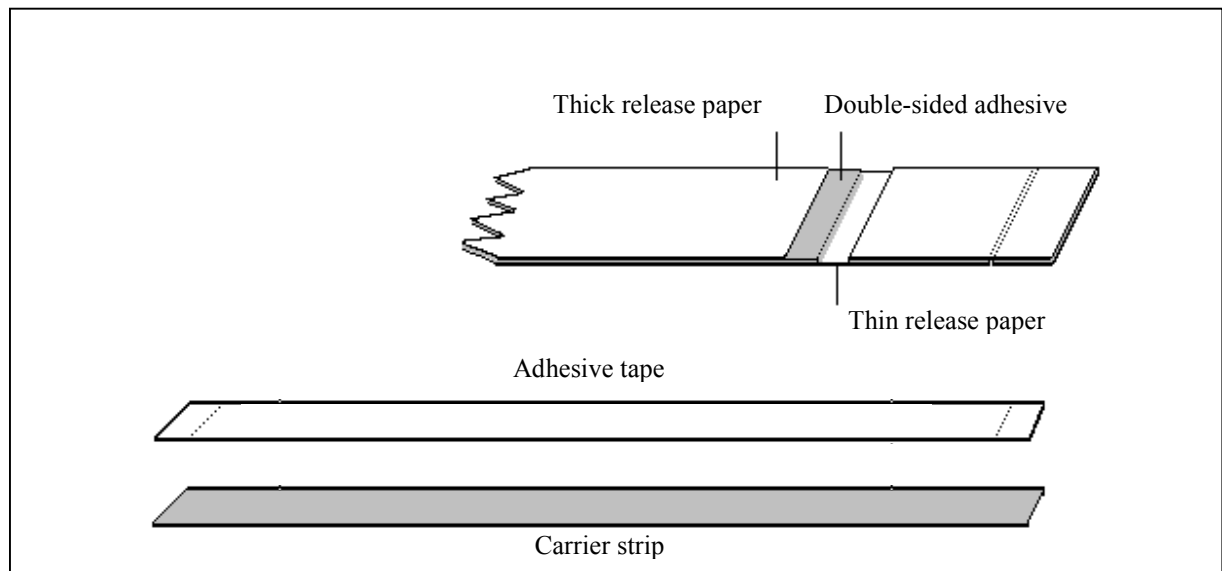
9. Spare Parts and Consumables

Part No.	Description	Contains
860010	Manual Dispenser	5 pcs
860331	Tubing Dispenser	1 pc
860321	Syringe with tip	10 pcs
860314	Applicator Tubing	10 pcs
860103	Special Tape w/o holes	100 pcs
860201	Training Tool	1 pc
860104	Carrier strip w/o holes	10 pcs

Carrier strip for soft or warping test materials

The box with adhesive tapes contains a black carrier strip made of anti-static material.. The adhesive strips have different adhesives on the two sides.
Apply the adhesive strip on the carrier strip as follows:

- a) Remove the yellow backing from the adhesive strip.
This side has a “hard sticky” adhesive.
- b) Attach the sticky side to the carrier strip and press firmly on top of the adhesive strip
Make sure the adhesive tape does not extend outside the edges of the carrier strip.
- c) Remove the release paper on top of the adhesive strip.
The top side is now the “soft adhesive” which can be used for multiple specimen strips.
- d) Cut a 14-15 mm wide specimen strip and apply it on top of the adhesive strip.
Press specimen strip against a clean, flat surface, which does not contaminate the specimen. Regarding sample preparation, see Section 5.
Make sure the specimen does not extend outside the edges of the carrier strip.
- e) Insert the carrier strip into the specimen stage (Section 2.2).
- f) After test is completed, remove the specimen and apply a new specimen using the existing adhesive strip.



PG-1 User's Manual 1.2a/ENG

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