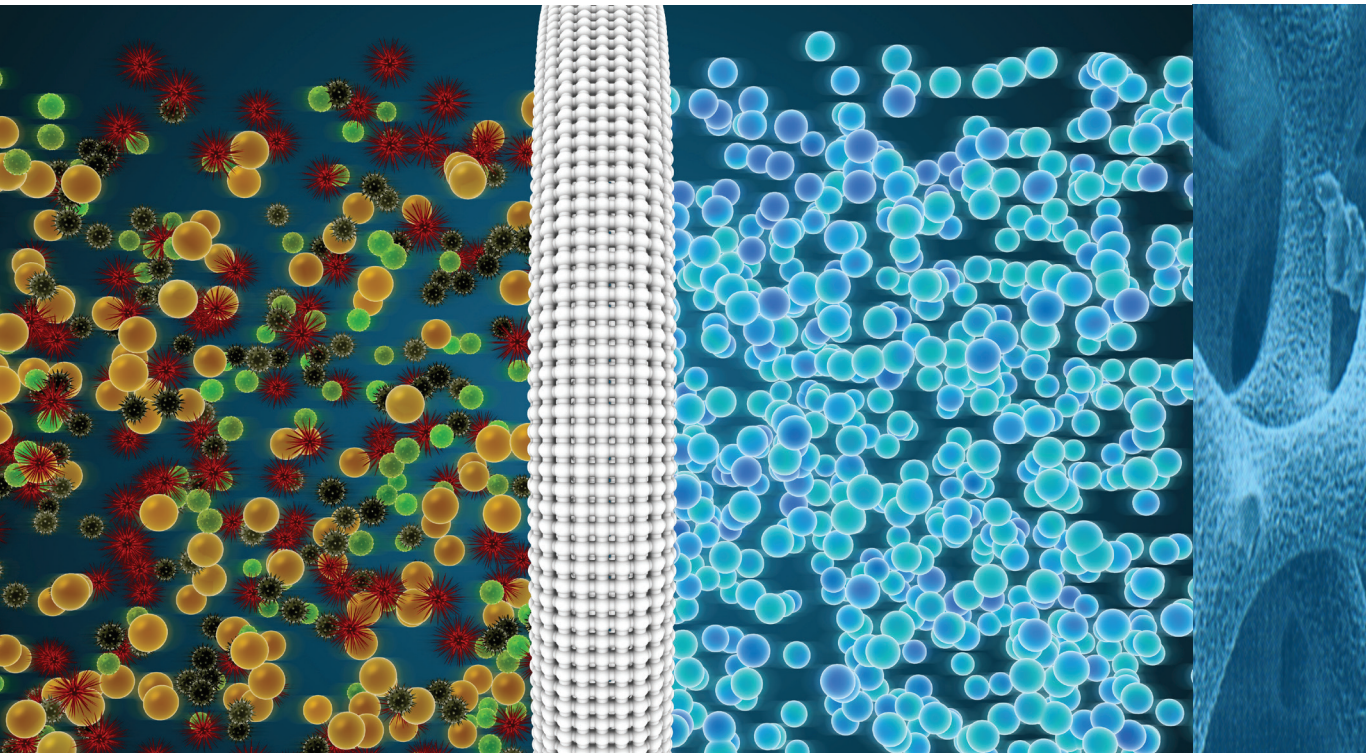


# POROMETER 3G<sup>TM</sup>

through-pore size analyzer

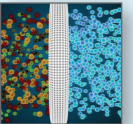


POROMETER

Membranes



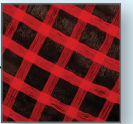
Filters



Non-Woven



Textiles



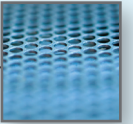
Papers



Ceramics



Sintered Metals



## THE 3G SERIES

Quantachrome's 3G porometers represent state-of-the-art in capillary flow porometry: exceptional performance in a compact bench-top unit, controlled by powerful PC-based software. The four models offered, representing different pressure (i.e. pore size) and flow rate ranges, allow the best match between material properties and instrument performance

(sensitivity, accuracy, reproducibility) for a wide variety of applications. Each **Porometer 3G** is a complete measuring system consisting of pressure control, pressure and flow sensing, sample holder, control and data acquisition software, even a built-in coalescing particle filter, and a comprehensive accessory parts kit.

### 3G micro

The **Porometer 3G micro** is our entry level capillary flow porometer with small-to-medium pore size capability, and customizable flow rate options. The 3G micro is especially suitable for a wide variety of woven and non-woven materials having narrower pore size distributions.

### 3G z

The **Porometer 3G z** is a compact, automatic, broad size range capillary flow porometer, customizable with a wide range of available flow rate sensors. The 3G z is therefore the ideal porometer for samples of controlled geometric size and through-porosity since these parameters, not just pore size, significantly control absolute gas flow through the sample.

### 3G zh

The flagship porometer has the widest pore size measurement range in the series, with both low and high flow rate sensing capability as standard. The pressure capability of up to 500 psi allows for pore sizes from 500  $\mu\text{m}$  down to as small as 13 nm to be measured quickly and reproducibly. Its measurement flexibility means that the 3G zh is appropriate for research applications.

# POROMETER 3G<sup>TM</sup>

through-pore size analyzer



## THE 3G SERIES

### Operator Convenience

The Porometer 3G requires minimal hands-on activity to be performed by the operator. The sample holder is totally accessible, mounted in a small, repositionable stand, right on the bench top. The control unit can be placed alongside, or under the bench for even greater space-saving.

### Technical Excellence

Proper sensing of pressure at the sample is essential for accurate pore sizing, and this is where the Porometer 3G excels. The “breakthrough” pressure is measured using precision sensors independent of the pressure controllers – each part of the pressure system optimized for their discrete functions. High resolution mass flow sensors (<0.05% f.s.), ensure accurate pore analyses, a necessity at very low flow rates when the pressure exceeds the bubble point as the largest pores empty and the sample begins to allow through-flow of gas.

### Flexibility

Porometry measurements comprise pressure and flow rate data. Flow rate is used as the “quantity indicator” and pressure as the “pore size indicator”. Since flow rate through a pore varies with the fourth power of its radius (Hagen-Poiseuille equation) huge flow rate differences are seen if the full range of the Porometer 3G series is considered. To provide the maximum capability a wide choice of flow meters is available together with a comprehensive range of sample holders.

### Software

The 3GWin<sup>TM</sup> program has a fully featured run module with real time data plotting and comprehensive data reporting all with the familiar look and feel of a Windows<sup>®</sup> interface. Newly updated, our 3GWin Version 2 program provides many advanced features:

#### Multiple run modes including:

- Wet run then dry run
- Dry run then wet run
- Wet only
- Dry only
- Bubble point only

Our QC mode offers a simplified interface for routine sample measurements while a Supervisor has complete access to many advanced features. A user with supervisor privileges may save run setting files that include all the parameters required to measure a specific type of sample. A user may recall all run settings by simply loading the file named by the supervisor at any time. Complete flexibility in choice of the number of data points gives the ability to achieve rapid measurements with 100 data points or ultra-high resolution data with 1000 points or more.

### Firmware

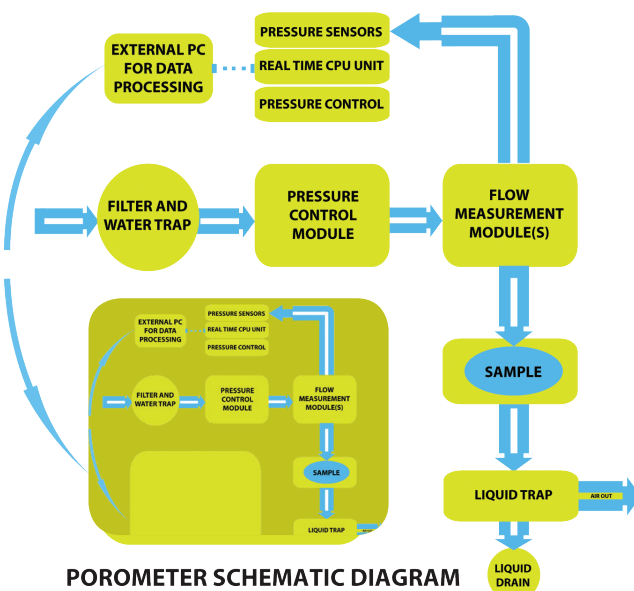
Full instrument control is achieved through the embedded processor. Direct on board data acquisition components give exceptional low noise performance. Its operational program together with instrument specific calibration settings are all stored in Flash memory. The latest firmware may be uploaded with a simple process using an external connector on the back of each instrument.

### Options

Factory installed options such as three flow-meters and the pressure hold valve for integrity tests provide enhanced capabilities.

### Expansion

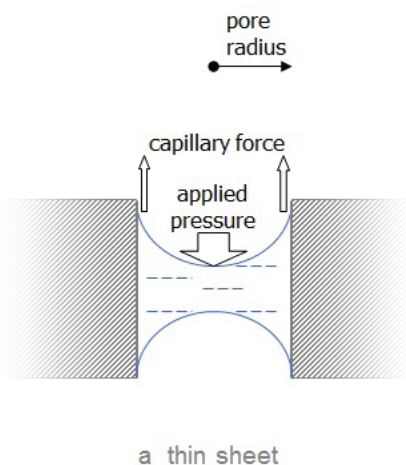
A Liquid permeability accessory is available together with a comprehensive choice of sample holders.



## CAPILLARY FLOW POROMETRY

Liquid Filtration can be considered to be the separation of solid particles from liquids. This is achieved with a filter typically constructed in flat sheet hollow fiber or powder bed configuration. This is most often performed by ensuring that only particles of a certain size range may pass through a membrane layer.

Industries such as the, Water Filtration Industry, rely upon quality testing to ensure that consistent products are always provided. For the purposes of ensuring that the mechanical nature of the product is proper for its use, the technique known of as Capillary Flow Porometry is used extensively.



Capillary flow porometry, or just Porometry (also known as the liquid expulsion technique) uses the simple principle of measuring the gas pressure required to force a wetting liquid out of through pores. Both pressure and the flow rate of gas through the emptied pores are recorded to yield through-pore size distributions.

Through pores are simply those that connect from one side of a material to the other. Typically sheet or cylindrical samples are measured.

The pressure at which through-pores empty is inversely proportional to the pore size. Larger pores require a lower pressure than do smaller pores. The first applied pressure is chosen so as to not empty any pores but do so as the pressure is increased.

Smaller and smaller pores are progressively emptied. Empty pores allow the pressurizing gas to flow through them and this gas flow is recorded to provide a measurement of the quantity of pores while the pressure gives the size of the pores.

### Bubble Point

The Porometry method was developed as an extension of the single point classic "Bubble Point" measurement. It simply measures the maximum pore size by determining the pressure at which the first stream of bubbles is detected through sample that is covered with a wetting liquid. It has been in use for many years and has been detailed in several standards such as the Bubble-Point Test Method detailed in ARP901A (Society of Automotive Engineers). The Bubble Point method yields only the largest pore size whereas the Porometry method extends it to provide a complete pore size distribution.

The standard, **ASTM F316-03(2011)** describes a test method for pore size characteristics of Membrane Filters by Bubble Point and Mean Flow Pore Test. The Quantachrome **Porometer 3G series** implements this method and yet provides much more information.

### Pore Size

Pore Size is calculated using the Washburn equation using pressure,  $P$ , surface tension of the wetting liquid,  $\gamma$  and the contact angle,  $\theta$ .

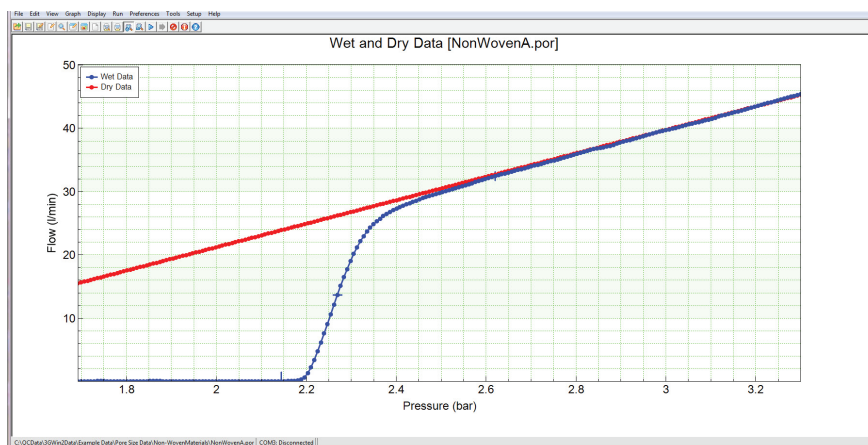
$$D = \frac{4\gamma \cos \theta}{P}$$

In this form, the pore diameter calculated assumes a cylindrical pore model. For many membranes and other test materials, a cylindrical model is not appropriate. The **Porometer 3G series** software, 3GWin incorporates a pore shape factor that is used as a multiplier to the Washburn Equation. Our Tech Note 60 describes the derivation of shape factor and its use to calculate pore size.

## CAPILLARY FLOW POROMETRY

### Run Data

To calculate pore size distributions, a complete set of 'wet run' data is required. Multiple data points over a pressure range are measured for two runs, the wet run and in addition a 'dry run' is measured and used for reference for the calculations. Graph A shows both wet and dry run plots.

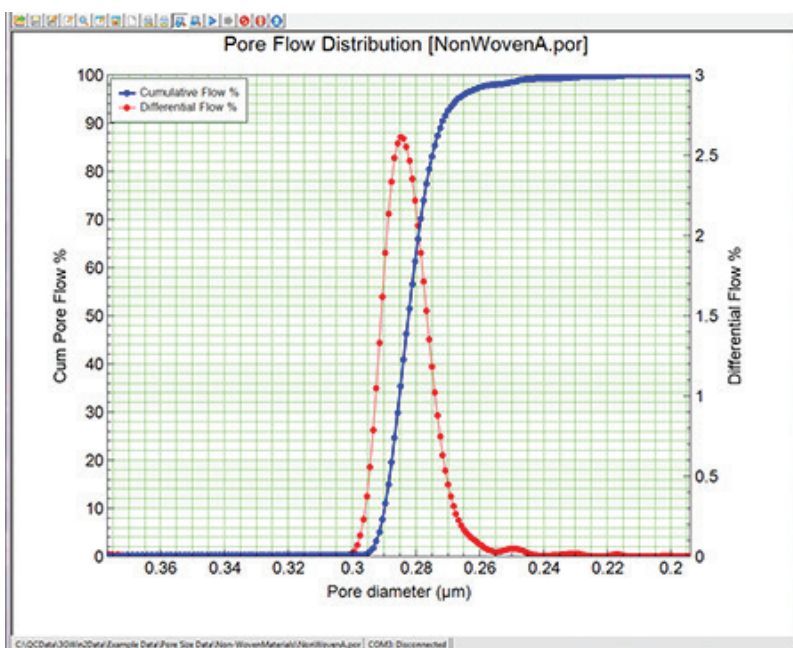


### Pore Flow % Distributions

The wet and dry data flow data is used to calculate the cumulative flow % values that in the simplest form is given below that are plotted against the pore diameter, calculated from the Washburn equation. It's differential provides the second.

$$\text{Cumulative flow } (CF(n)) = \frac{\text{Wet Flow } (n)}{\text{Dry Flow } (n)}$$

for  $n = 0$  to  $x$  user selectable data points



## CAPILLARY FLOW POROMETRY

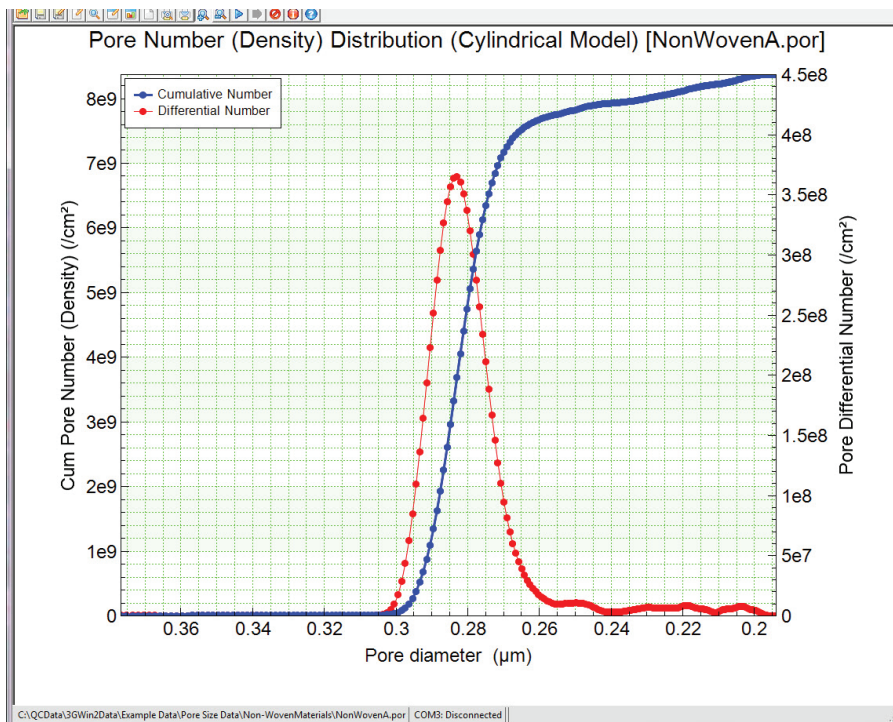
### Pore Density

Also known as the total pore number, this represents the total population of all pores in a specific sample area, usually specified / cm<sup>2</sup>. It is calculated from the Hagen-Poiseuille equation that describes the flow rate through a tube of radius, r.

$$Q = \frac{N\pi r^4 \Delta P}{8nl}$$

The Hagen-Poiseuille Equation

We determine pore diameter by applying the Washburn equation to the sample run data and so with some arrangement of the Hagen-Poiseuille equation above normally, we can determine the number of pores at each of the pore sizes derived from our measurement. We can therefore construct a full pore number distribution based upon a cylindrical pore model.

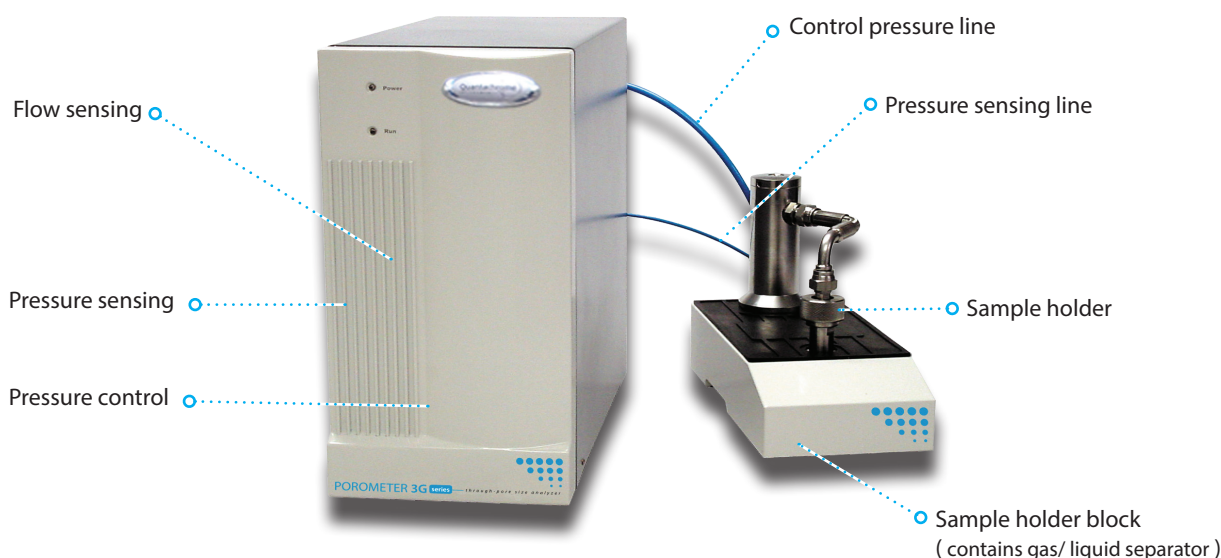


# POROMETER 3G SERIES™

through-pore size analyzer



## INSTRUMENTS FEATURES



## MODEL CONFIGURATIONS

	3G micro	3G z	3G zh
<b>Pore size minimum</b>	0.07 µm	<0.03 µm	<0.02 µm
<b>Pore size maximum</b>	100 µm	500 µm	500 µm
<b>Pressure controllers</b>	1	2	2
<b>Controller # 1</b>	0-100 psi	0-30 psi	0-30 psi
<b>Controller # 2</b>	n/a	0-300 psi	0-500 psi
<b>Pressure sensors</b>	2	3	3
<b>Sensor #1</b>		0-5 psi	
<b>Sensor #2</b>		0-100 psi	
<b>Sensor #3</b>	n/a	0-250 psi	0-500 psi
<b>Flow sensors</b>	1	1 or 2	2
<b>Sensor #1</b>	0-100 L/min	0-100 L/min	0-10 L/min
<b>Sensor #2</b>	n/a	optional 0-200 L/min	0-200 L/min
Flow sensor switching	n/a	manual	auto

Table shows standard configurations. Different pressure and flow rate ranges are available for some models.

### Technical Specifications

- Pressure sensing accuracy: +/- 0.05% f.s.
- Pressure resolution: 16 bit A/D equivalent
- Flow sensor type: Precision thermal mass flow
- Flow sensor settling time: < 2 secs
- Flow sensor temperature coeff.: <0.05%/°C (15-45°C)

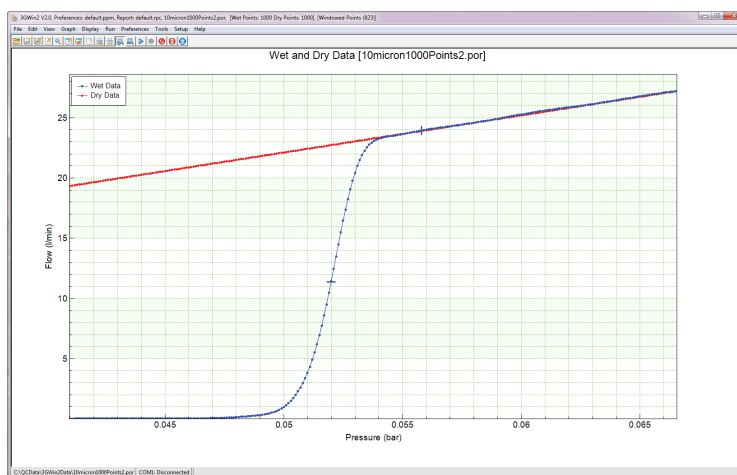
### General Specifications

- Mains power: 90 - 240 Volts AC, 50/60 Hz
- Main control unit dims.: 40cm(H) x 45cm(D) x 19cm(W)
- Sample holder block dims.: 24cm(H) x 32 cm(D) x 15cm(W)
- 3G software package is compatible with Windows® XP and or newer operating system.

## BENEFITS: RESOLUTION, ACCURACY, FLEXIBILITY

### The Quantachrome 3G Advantages

The **Porometer 3G series** uses only targeted pressure points and never use the lower performance scan modes. The use of target pressure points improves run to run repeatability and operator to operator reproducibility. The number of target points may be chosen and ultra-high resolution data may be measured should that be required. The example below shows run data with 1000 points for our reference 10 micrometer membrane.



All **Porometer 3G series** instruments come standard with the ability to include liquid permeability measurement functionality. The customer is not required to purchase this at the time of initial purchase or be forced to purchase an additional instrument should they need this capability in the future. It would simply require the purchase of the externally attached liquid permeability option hardware and activation of the Permeability Software included with 3G Win.

### External Sample Manifold

All **Porometer 3G series** instruments may utilize the available External Sample Manifold option allows for direct connection of numerous custom sample holders including, in most cases, a customer's finished product for pore size analysis.



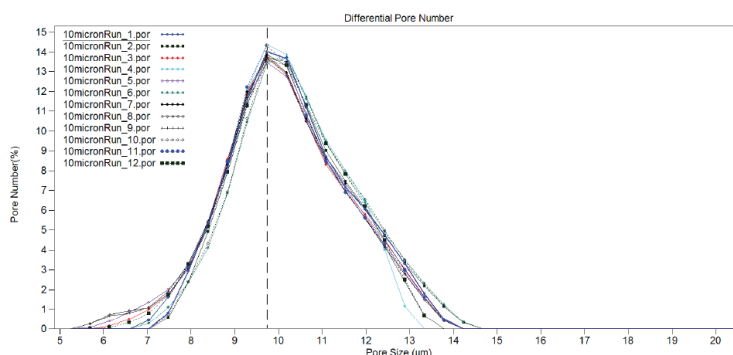
This is a great benefit to many customers, especially when the nature of their samples are not of the standard flat sheet membrane variety with a standard diameter: 10 mm, 18 mm, 25 mm, 37 mm, 47 mm or 50 mm.



## BENEFITS: RESOLUTION, ACCURACY, FLEXIBILITY

Perhaps most important of all, pressure measurements are made just above the surface of the sample. No corrections are needed to compensate for varying flow rate when the pressure is measured at some distance from the sample. When the pressure is measured in the same line that provides the pressure source, inaccuracies due to flowing gas must be accounted for in order to produce accurate data. The lower the pressure and the higher the flow rate the more error is present. In such a case calibration runs must be performed to correct the pressure readings. Quantachrome Porometers do not need this correction because of our "static pressure line". This is very important particularly for large pore size sample materials. The result of this approach is highly accurate and repeatable pore size measurements as seen in the example plot of overlaid analyses:

### 3G Repeatability for 10 $\mu\text{m}$ Membrane



And last, but by no means least, the after sale support offered by Quantachrome Instruments is unsurpassed with the customers that we serve. Whether you have a need for technical or application support with your equipment from Quantachrome Instruments, you can expect the highest level of support. Our Service Technicians and Applications Support Scientists are available for support via telephone and email throughout the lifetime of the instrument. Advanced training in all aspects of the instrument are available. Beyond ensuring that we always deliver world-class equipment, Quantachrome Instruments is dedicated to assisting customers interested in obtaining all of the benefits available from these technologies.

## SAMPLE HOLDERS



### Sample Holders

A 25 mm diameter sample holder is provided. This may be used for a 25 mm circular sample up to 3 mm thick. Other standard sample holders are available including 18 mm for samples up to 8 mm thick, 25 mm for samples up to 9 mm thick, 35 mm and 47 mm diameter. A Universal sample holder is available for use with samples with the following diameters: 10 mm, 18 mm, 25 mm, 37 mm, 47 mm and 50 mm.



### Special Use Sample Holders

Our hollow fiber accessory kit provides the means to measure pore size of hollow fiber membrane materials with pores as small as 13 nm. Hollow fibers may be measured in both flow directions, i.e., from inside the tube to outside of the fiber, or from outside to inside of the fiber. Single or multiple lumens may be measured.



### Tubular Sample Holder

A tubular sample holder is ideal for the measurement of rigid tubes. Custom sized connector pieces provide complete flexibility of tube diameter. Lengths of up to 20 cm are easily accommodated.



### In-Plane Compression Holder

Our standard measurements are for through pores in the through-plane direction. Transverse pores within a material, also known as in-plane pores may be measured with our In-Plane holder shown here. With this holder, the applied pressure is focused on the center of a sample that has a bottom seal blocking all through-paths. The only exit flow path is through the in-plane pores and out of the periphery of the sample disc.

An available compression accessory allows a sample to be compressed with a known force using a pneumatically controlled piston assembly. A heater accessory is available and provides the means to heat our range of smaller diameter holders to elevated temperatures of up to 120 °C.

# POROMETER 3G<sup>TM</sup>

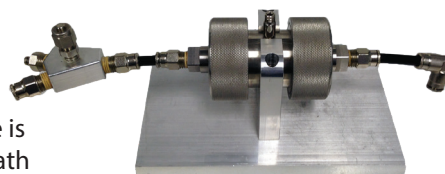
through-pore size analyzer



## SAMPLE HOLDERS

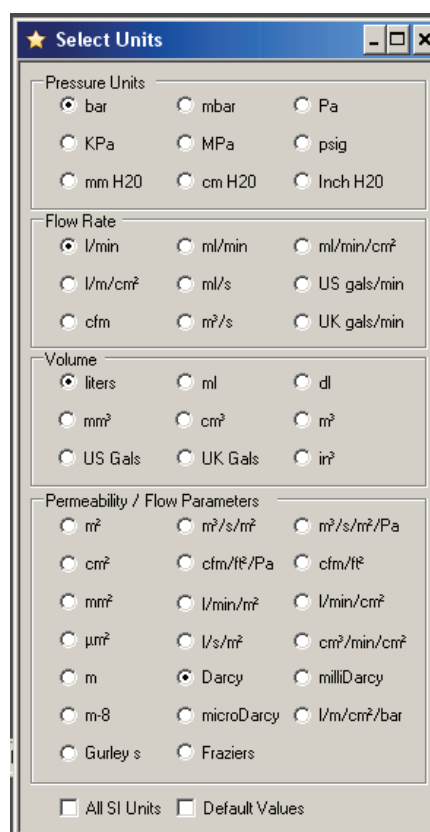
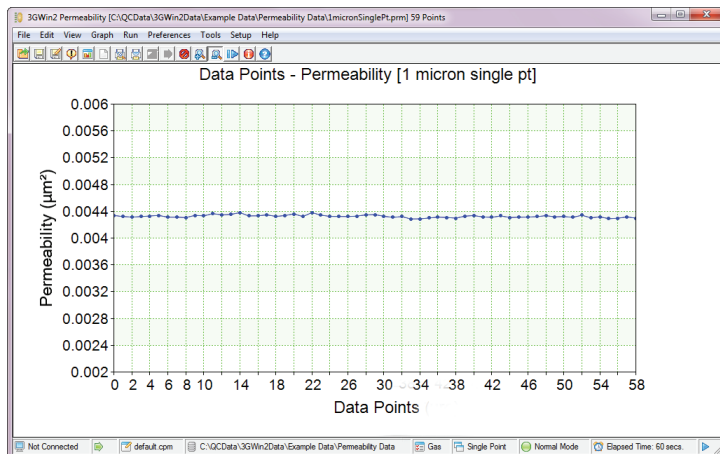
### Solid Piece Sample Holder

Our unique solid piece holder may be used for low pressure measurement of irregular sample pieces or cores. A pressure source is used to seal the outside of the sample while providing a through path through the material.



### Gas Permeability

All Porometer 3G models can perform gas permeability measurement. Usually the gas is either air or nitrogen although helium has been used successfully. Measurements may be made at user selectable single pressures and averaged or over a range of pressures. Many different unit selections are possible. Extended runs may be performed for special applications such as long core samples.



### Liquid Permeability

Liquid permeability measurements may easily be made with an optional accessory. Single pressure liquid flow measurements are made by applying gas pressure to a liquid filled reservoir. After an initial stabilization period a steady flow is achieved and the flow of gas applied measured. This is the same as the liquid flow passing through the sample. Pressure and flow rate are averaged for 30 seconds or more.





Renowned innovator for today's porous materials community.  
The quality of Quantachrome's after sales service support is the reason we are proud to maintain life time relationships with our customers.

## Field Service

Our global service staff assure you that Quantachrome Instruments will continue to be the reliable engines of material characterization laboratories. We offer you the flexibility of choosing from service contracts tailored to provide you with the response time, service package, and spare parts discounts that best fit your needs.

## Spare Parts

Quantachrome spare parts are certified to work with our instruments. We provide rapid response spare parts orders, and keep large inventories of replacement parts and hardware available.

## Application Lab

Our fully equipped, state-of-the-art powder characterization laboratory (email: [application.qt@anton-paar.com](mailto:application.qt@anton-paar.com)), provides the option of contracting for expert testing services. Laboratory services are also available to validate the applicability of our products prior to your purchase using your actual samples.

## Lifetime Application Support

We view the field support of our instruments as an essential component of our business strategy. Our expert scientists are always available to answer questions on applications, or the use of our instruments. We do this as a standard service regardless of whether you have a service contract with us or not.

## Partners in Science

Quantachrome has a scientific research department consisting of world renowned experts in material characterization. Our staff, led by team conducts collaborative research projects with leading material research labs around the world. They regularly publish articles in leading peer reviewed journals, and speak at technical symposiums around the world.

For almost half a century Quantachrome's scientists and engineers have revolutionized measurement techniques and designed instrumentation to enable the accurate, precise, and reliable characterization of powdered and porous materials. We have an unwavering commitment to providing state of the art technology, along with superior and unparalleled customer service and support.

Our commitment to customers is to support you before, during, and after the sale throughout the lifetime of our instruments. This is a big commitment because our products are so robust and reliable that we regularly find many still in use for decades.

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