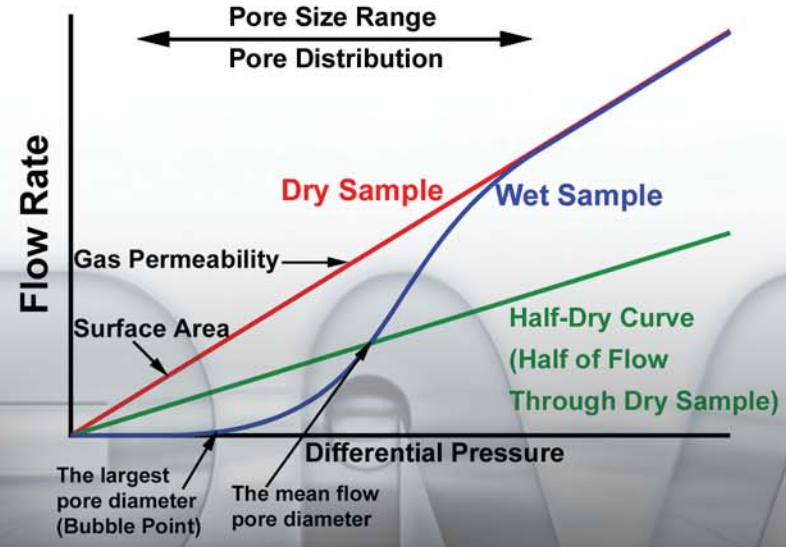
Porometers



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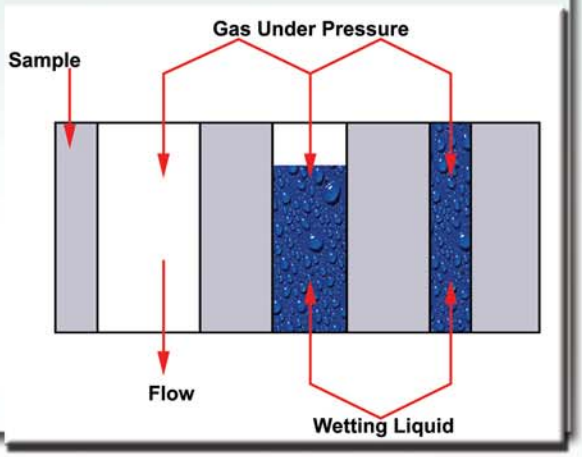
Principle

A wetting liquid spontaneously fills the pores of a sample by displacing the gas present in pores. Application of differential pressure of a nonreacting gas on the sample is required to remove the wetting liquid from pores. The differential pressure p, required to remove the wetting liquid from a pore of diameter D, is given by:

$$p = 4\gamma \cos\theta / D$$

where γ is the surface tension of wetting liquid and θ is the contact angle of the wetting liquid on the sample. Gas flow through the wet sample can start after the largest pore in the sample is emptied. The flow rate increases with increase in differential pressure. Pressure and flow rates of gas through wet and dry samples are measured. In some tests, volume of extruded liquid is measured. Such measurements are used to compute various pore characteristics.



Unique Distinguishing Features

Hardware

- Sample chamber for almost any sample geometry like sheets, plates, discs, rods, tubes, hollow fibers, cartridges, powders, gels, pen tips & sponges
- See-through sample chamber for visual confirmation of test
- Multiple sample chambers for simultaneous testing of many samples
- Mobile sample chambers for avoiding cutting of samples from the bulk product
- Use of chemical resistant construction material for testing with strong chemicals like potassium hydroxide, phosphoric acid and salt solutions
- Robust construction for use in industrial environments
- Hardware option to permit measurement of pore volume and liquid permeability
- Hardware for application of controlled compressive stress on the sample
- Hardware for applying cyclic compression on the sample
- Test temperature variable from sub ambient to 300 °C
- Liquid permeability test at pressures up to 200 psi
- Testing of samples saturated with chemicals
- Options for tests performed under controlled humidity environment

Automation

- Execution of test, data acquisition, data storage and data reduction are automated.
- User friendly interface and menu driven Windows based software make operation very simple.
- Number of data points is user definable.
- Real time status and results of test in progress are graphically displayed.
- Results can be plotted in many useful user specified formats.
- In research mode, user has the option to conduct tests by specifying parameters relevant to the investigation.
- In QC mode, operator involvement is minimal, and test duration is small.

Reliability & Validity

- Pore sizes determined in PMI porometers are in excellent agreement with those measured in Scanning Electron Microscope.

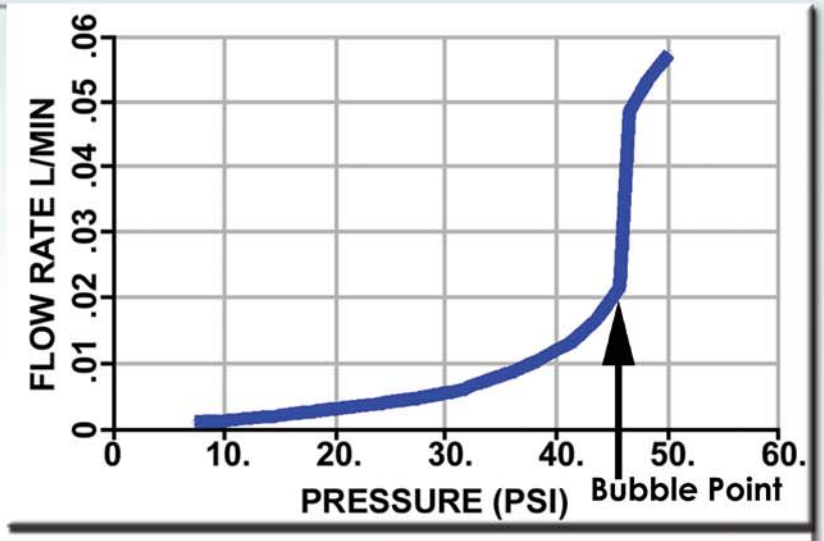
Etched Circular Pore Diameter, µm	
SEM	POROMETER
87.1 ± 5.2	86.7 ± 4.1
4.5 ± 0.5	4.6 ± 0.1

- Published data based on thirty repetitions show better than 2% repeatability.

Integrity Tester

Operation

Gas pressure on the sample wetted with the wetting liquid is increased and the amount of gas flowing through the sample is measured. Gas often diffuses through the sample by diffusing through liquid contained in pores even before the largest pore in the sample is emptied. Desired pressure drop data using unwetted or wetted samples can also be created.



Application

Integrity of many materials including filter media, membranes, paper and battery separators is tested in this instrument. Bubble point can also be determined in the same instrument. The addition of optional features to the instrument allows testing of samples under tension, compression and elevated temperatures.

Average Fiber Diameter Analyzer

Operation

The average fiber diameter analyzer measures flow rate and differential pressure across a dry sample and computes the average fiber diameter using the relation by Davies.

Application

Determination of average fiber diameter takes only a few minutes in this completely automated instrument that is simple to use, robust and inexpensive. The instrument is suitable for quality control and production control.

Envelope Surface Area & Average Particle Size Analyzer

Operation

The instrument measures flow rate through a dry sample as a function of differential pressure and computes external surface area (surface area of through pores in a porous material) using Carman-Kozeny equation. The average particle diameter, D is computed using the following relation.

$$D = 4V/S = 4/S\rho$$

Where V is the volume of solid per unit mass, S is the envelope surface area per unit mass and ρ is the absolute density of powders. Results compare well with those by gas adsorption.

Envelope Surface Area Analyzer: 0.56 m^2/g
Gas Adsorption: 0.52 m^2/g

Application

The envelope surface area analyzer takes only minutes to perform a test, is fully automated, requires very little maintenance, is robust, and is inexpensive. One of its important applications is in quality control and process control.

QC Porometer

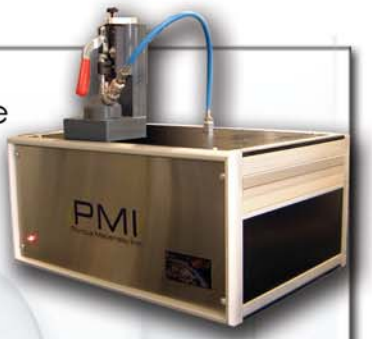
Operation

QC porometer is a capillary flow porometer incorporating special design features so that it is simple to operate, requires very little operator involvement, is user friendly, takes only a few minutes per test, is compact, and requires very little maintenance.

Application

The unique features of the instrument, especially its ability to generate highly reproducible data quickly, make it suitable for quality control and process control operations. The instrument is used in these applications in a wide variety of industries.

Clamp-On Porometer



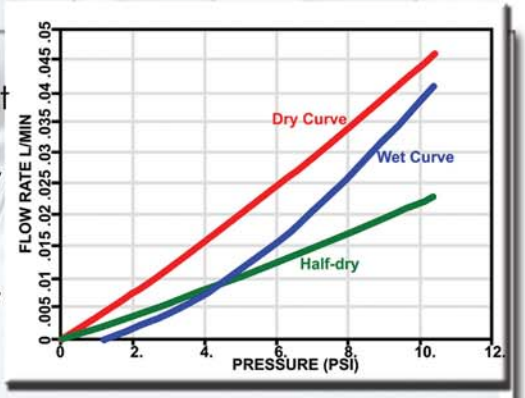
Operation

The Clamp-On porometer is a capillary flow porometer containing a unique mobile sample chamber. The sample chamber can be attached to the area of the bulk sample to be tested or the sample could be made to slide through the sample chamber. Thus, the need for cutting samples and damaging the bulk product is eliminated.

Application

The instrument is ideal for testing samples without damaging those in any way. The unit is robust and simple to use. Testing is fast and reproducible. Process control is one of the important application areas for this instrument.

Microflow Porometer



Operation

Gas flow rates through samples with very low permeability cannot be measured by the flow meters in the regular flow Porometer. In the Microflow Porometer, in stead of measuring flow rates by flow meter, the flow rates for each applied pressure are computed from the rate of pressure change in the down stream side of the sample in a closed sample chamber. The graph illustrates the low flow rates detected in the sample.

Application

In very low permeability samples, the Microflow Porometer can determine all properties measurable by the Capillary Flow Porometer. Applications include characterization of polymeric and ceramic membranes, and other low flow filtration media.

Bubble Point Tester

Operation

The instrument uses a wetted sample and measures pressure that starts flow through the sample. This pressure is the bubble point, which yields bubble point pore diameter. Multi-head testers can simultaneously test many samples. Pass/fail or go/no-go material selection procedures can be adopted.

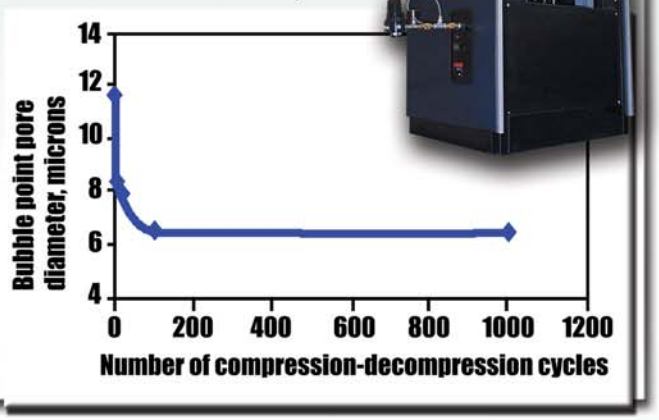
Application

Large volumes of samples are conveniently tested. The option of testing samples individually or simultaneously is available. Many options for segregating materials on the basis of the test results can be incorporated. This is widely used in industries for characterization of a variety of materials.

Cyclic Compression Porometer

Operation

The Cyclic Compression Porometer subjects the sample to cyclic compressive stress in the specified stress limit for the desired number of cycles and measures the pore characteristics like a capillary flow porometer. The instrument is fully automated and can perform many tests on the same sample after executing the number of stress cycles specified for each test.



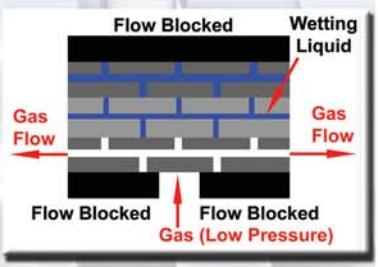
Application

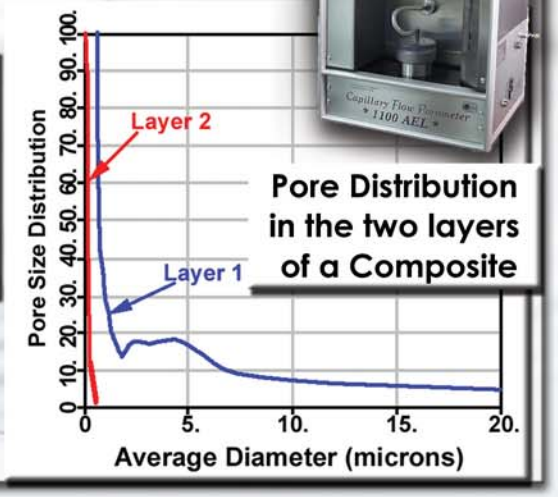
Many products like felts used for dewatering paper, filtration media, battery separators, and fuel cell components are subjected to cyclic stresses. Such products need to be characterized under simulated true service conditions to give realistic data.

In-Plane Porometer

Operation

The In-Plane Porometer is such that gas moves radially from the center to the periphery of a sheet shaped sample. Both wet and dry samples are used. Pore characteristics responsible for flow in the plane of the sheet material are computed. Pore structure characteristics in any desired direction in x-y plane are also measurable.





Pore Distribution in the two layers of a Composite

Application

In-Plane and directional pore structures are important for applications of products like paper, separators,textiles, electrodes, pharmaceuticals, biotech products and felts. This instrument is also used for in-situ pore structure characterization of individual layers of multi-layer products.

Compression Porometer

Operation

The Compression Porometer is a capillary flow porometer that is capable of maintaining the sample under controlled compressive stress while the test is being performed. Compressive stress up to 1000 psi may be applied.

Application

The pore characteristics of products experiencing considerable stress during service could be appreciably different from those evaluated in the laboratory. This instrument provides a unique opportunity for evaluating the component under true service conditions. The instrument is invaluable for products such as filtration media and battery components.

Versatility

- Instruments may be custom built to suit the requirements of customers.
- One instrument can have the ability to perform many tests.
- Tests can be performed without cutting samples
- Many test options may be added to a basic unit.
- Tests can be performed with any wetting liquid.
- Tests can be performed under simulated service conditions.

Measurable Characteristics

- The largest constricted through pore diameter (Bubble point pore diameter)
- The mean flow through pore diameter
- Flow distribution over pore diameter
- Through pore volume
- Pore volume distribution
- Envelope (external) surface area
- Average fiber diameter/Particle Size
- Effect of compressive stress
- Effect of cyclic compression
- Effect of temperature
- Effect of chemical environment
- Effect of orientation (x, y & z directions)
- Hydro-head
- Integrity
- Liquid permeability
- Gas permeability(Darcy, Gurley, Frazier & Rayl)
- Microflow permeability

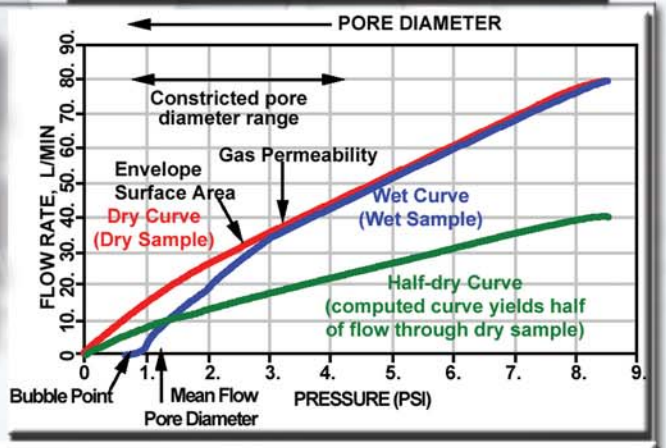
Instruments

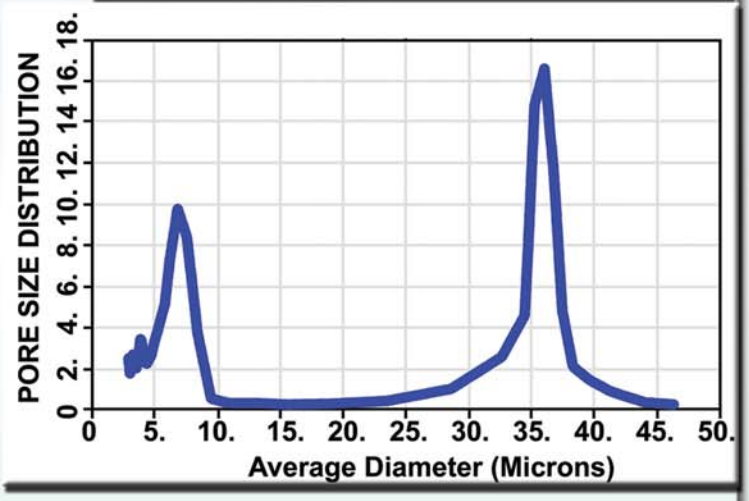
Capillary Flow Porometer

Operation

The pores of the sample are filled with a wetting liquid. Gas pressure is increased on one side of the sample. At a certain pressure the largest pore is emptied and gas flow starts. On further increase of pressure, smaller pores are emptied and gas flow increases. Gas pressure and flow rate through wet and dry samples are measured. Pore diameters are computed from differential pressures and pore distribution is given by the distribution function, $f = -[d(f_w/f_d)100/dD]$ where f_w & f_d are flow rates through wet and dry samples respectively. The flow rate through dry sample gives gas permeability and envelope surface area.

Change of Flow Rate with Pressure





Application

Constricted through pore diameters in the 500 - 0.013 micron range, the largest pore diameter, mean flow pore diameter, and gas permeability(Darcy, Frazier, Gurley & Rayl) of filter media, nonwovens, battery parts, fuel cell parts, ceramics, paper, membranes, textiles, powders, chemicals, pharmaceuticals and biotech products are measurable. The instrument can have options to measure external surface area, average fiber diameter, average particle size, hydro-head and many other properties.

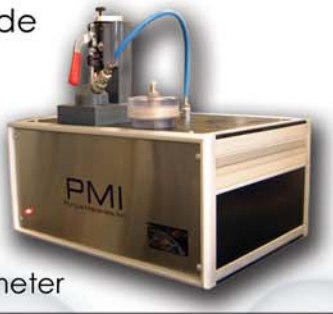
Multi-Chamber and Multi-Mode Porometer

Operation

Multi-Chamber Porometers have multiple sample chambers. The Multi-Mode Porometers have the ability to characterize several different properties in different modes of testing. The Perm Porometer is a capillary flow porometer and a liquid permeameter. The Perm Porometer uses a penetrometer to measure liquid flow rate. The five chamber Multi-Mode Porometer combines the features of the QC Porometer and the Compression Porometer. Four chambers test samples in the QC mode, while the fifth chamber performs sophisticated tests under compressive stress.

Application

Multi-Chamber and Multi-Mode Porometers are used in the industry to test large volumes of samples. The instruments are usually custom made.



The two Chamber Porometer

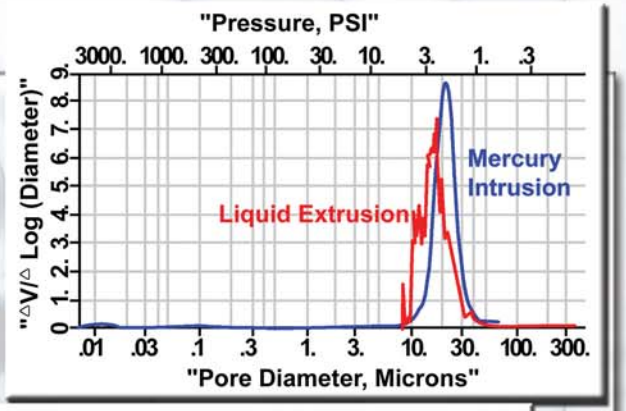
The Perm Porometer

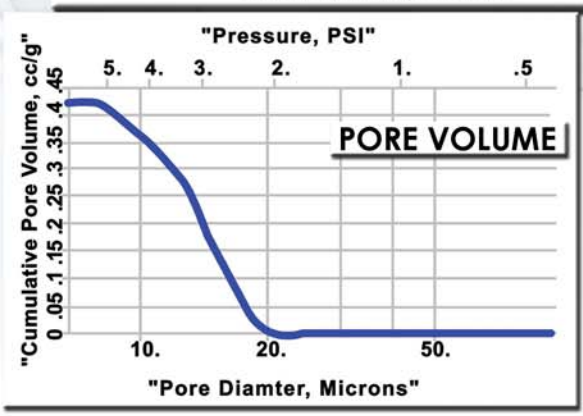
The Multi-Chamber & Multi-Mode Porometer

Liquid Extrusion Porosimeter

Operation

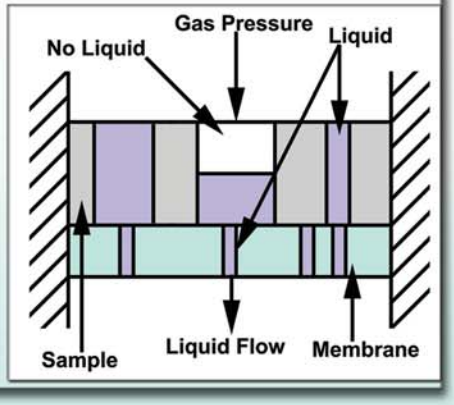
The pores of the sample and a membrane are filled with a wetting liquid and the sample is placed on the membrane. The membrane is such that its largest pore is smaller than the smallest pore of interest in the sample. Gas pressure of a nonreacting gas is increased on the sample to extrude the liquid from pores. The volume of displaced liquid passing through the membrane is measured, while the liquid containing membrane prevents the gas from passing through. The gas pressure gives the pore diameter. The volume of displaced liquid gives the pore volume. Measurement of liquid flow rate without the membrane under the sample yields liquid permeability.





Application

Extrusion Porosimeter is the only instrument that has the capability to measure liquid flow rate, pore volume and pore volume distribution of through pores. The instrument does not use any toxic and harmful material like mercury. The pressure required is much less than that required for mercury intrusion porosimetry. Pore volume and liquid flow rates through powder and solid porous materials having pores in the range of 1000 to 0.05 microns are measurable by this technique.



Specifications

Pressure Capability:	up to 500 psi (up to 2000 psi with microflow)
Pressure Accuracy:	0.15 % of reading
Flow Capability:	up to 200 LPM (Standard)
	up to 10,000 LPM (Optional)
Flow Accuracy:	1% of F.S.
Resolution:	1:60,000 F.S
Pore Diameter (min.):	0.013 μm (0.004 μm with microflow)
Pore Diameter (max.):	1000 μm

Wetting Liquid: Water Mineral Oil Alcohol Silwick™ Porewick™ Galwick™ & Others

Models

Many models are available. Instruments can be custom made to incorporate all the required features. Detailed information is available on request.

Sale **Lease** **Rent**

Other Products From PMI

Mercury Intrusion Porosimeters

Mercury intrusion porosimeters are fully automated instruments capable of measuring pore volume, pore volume distribution, surface area and porosity by mercury intrusion at pressures up to 60,000 psi.

Nonmercury Intrusion Porosimeters

These instruments measure pore volume and pore volume distribution using a nonwetting liquid other than mercury . The use of the toxic mercury is avoided. The pressures needed are small so that concerns related to safety and the effect of pressure on pore structure are avoided. Small pore sizes are measurable. Characteristics of hydrophobic and hydrophilic pore mixtures are measurable. The Aquapore uses water as the intrusion liquid.

Gas Adsorption (BET) Sorptometers

The Sorptometers have the ability to measure single point and multi-point surface area, pore volume, micropores, chemisorption, and adsorption-desorption isotherms. Fully automated instruments with a variety of combination of options are available. Adsorption of a wide variety of gases and vapors is measurable.

Pycnometers

Fully automated gas pycnometers measure absolute density. Mercury intrusion pycnometers are used to measure bulk density of materials.

Contract Testing Service

The analytical services division of PMI has extensive experience in providing reliable, prompt, and comprehensive contract testing service.