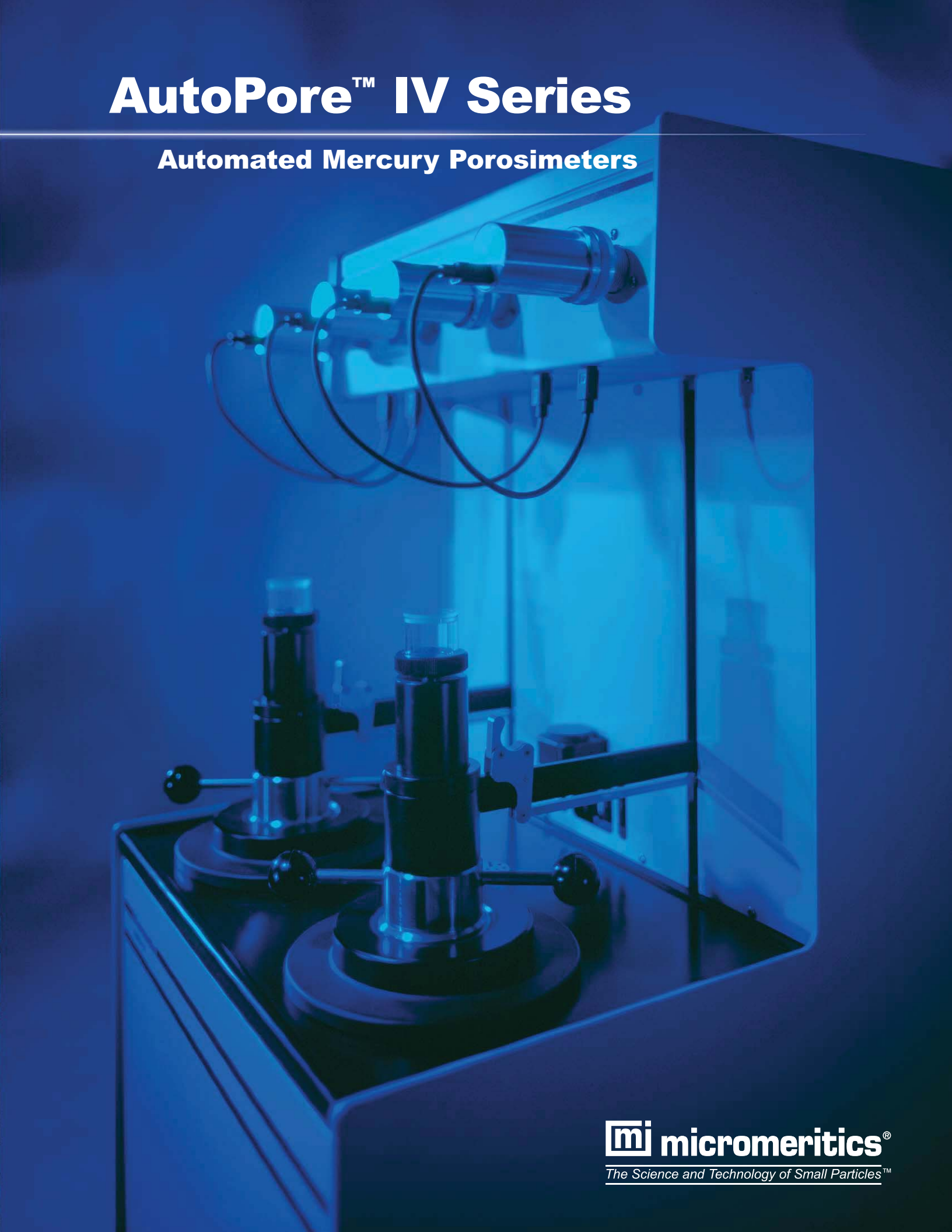
AutoPore™ IV Series

Automated Mercury Porosimeters



micromeritics®

The Science and Technology of Small Particles™

Typical AutoPore IV Applications

Pharmaceuticals – Porosity and surface area play major roles in the purification, processing, blending, tableting, and packaging of pharmaceutical products as well as a drug's useful shelf life, its dissolution rate, and bioavailability.

Ceramics – Pore area and porosity affect the curing and bonding of greenware and influence strength, texture, appearance, and density of finished goods.

Adsorbents – Knowledge of pore area, total pore volume, and pore size distribution is important for quality control of industrial adsorbents and in the development of separation processes. Porosity and surface area characteristics determine the selectivity of an adsorbent.

Catalyst – The active pore area and pore structure of catalysts influence production rates. Limiting the pore size allows only molecules of desired sizes to enter and exit, creating a selective catalyst that will produce primarily the desired product.

Paper – The porosity of print media coating is important in offset printing where it affects blistering, ink receptivity, and ink holdout.

Medical Implants – Controlling the porosity of artificial bone allows it to imitate real bone that the body will accept and allow growth of tissue.

Electronics – By selecting high surface area material with carefully designed pore networks, manufacturers of super-capacitors can minimize the use of costly raw materials while providing more exposed surface area for storage of charge.

AutoPore IV Advantages

- Ability to measure pore diameters from 0.003 to 1100µm
- Available with two low- and one high-pressure ports or four low- and two high-pressure ports for increased sample throughput
- Available in 33,000 psi or 60,000 psi models
- Quiet, high-pressure generating system
- Upgradeable without the need for more lab space
- Enhanced data reduction package; includes tortuosity, permeability, compressibility, pore-throat ratio, fractal dimension, Mayer-Stowe particle size, and more
- Equilibration by sample-controlled, rate of intrusion
- Operates in scanning and time- or rate-equilibrated modes
- Collects extremely high-resolution data; better than 0.1 µL for mercury intrusion and extrusion volume
- Controlled evacuation prevents powder fluidization

Aerospace – Surface area and porosity of heat shields and insulating materials affect weight and function.

Fuel Cells – Fuel cell electrodes require controlled porosity with high surface area to produce adequate power density.

Geoscience – Porosity is important in groundwater hydrology and petroleum exploration because it relates to the quantity of fluid that a structure can contain as well as how much effort will be required to extract it.

Filtration – Pore size, pore volume, pore shape, and pore tortuosity are of interest to filter manufacturers. Often, pore shape has a more direct effect upon filtration than pore size because it strongly correlates with filtration performance and fouling.

Construction Materials – Diffusion, permeability, and capillary flow play important roles in the degradation processes in concrete, cement, and other construction materials.

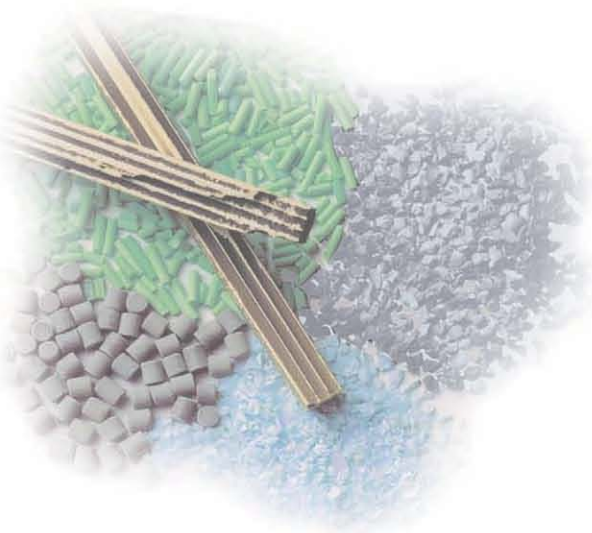
Fast and Accurate Porosimety Analyses

AutoPore IV Series Automated Mercury Porosimeters

The term "porosimetry" is often used to include the measurements of pore size, volume, distribution, density, and other porosity-related characteristics of a material. Porosity is especially important in understanding the formation, structure, and potential use of many substances. The porosity of a material affects its physical properties and, subsequently, its behavior in its surrounding environment. The adsorption and permeability, strength, density, and other factors influenced by a substance's porosity determine the manner and fashion in which it can be appropriately used.

The mercury porosimetry analysis technique is based on the intrusion of mercury into a porous structure under stringently controlled pressures. Besides offering speed, accuracy, and a wide measurement range, mercury porosimetry permits you to calculate numerous sample properties such as pore size distributions, total pore volume, total pore surface area, median pore diameter, and sample densities (bulk and skeletal).

The AutoPore IV Series Mercury Porosimeters can determine a broader pore size distribution (0.003 to 1100 micrometers) more quickly and accurately than other methods. These instruments are enhanced with features that enable them to more accurately gather the data needed to characterize the porous structure of solid materials. They also offer new data reduction and reporting choices that provide more information about pore geometry and the fluid transport characteristics of the material.



Wide Variety of Benefits

- Controlled pressure can increase in increments as fine as 0.05 psia from 0.2 to 50 psia. This allows detailed data to be collected in the macropore region.
- A quick-scan mode allows a continuous pressure increase approximating equilibrium and providing faster screening. The high repeatability and reproducibility of this method by the AutoPore means that small, but significant, differences between samples will be detected. You can use this technique to screen a sample for conformity to specification because repeatability remains high.
- High-resolution (sub-microliter) measurement of intrusion/extrusion volumes produces extraordinary precision allowing the development of tighter sample specifications, improved production processes, and high-quality research data.
- A choice of correction routine for baseline (automatic, differential, or manual) produces greater accuracy by correcting for compressibility and thermal effects caused by high pressure.
- Choice of pressure ramping methods lets you choose the scanning technique for high-speed or on-demand results, or equilibration techniques for more accurate results with greater detail.
- The instrument allows the user to program data collection using a minimum number of data points. However, during intervals of unexpectedly large amounts of intrusion, the AutoPore will automatically collect additional data points.
- Choose between three data plot routines constructed of collected data points, a continuous curve plotted from interpolated data, or a combination of points and curves.
- A variety of pore volume, pore area, and pore size plots is available as well as the ability to calculate total intrusion volume, total pore (surface) area, median pore diameter, average pore diameter, bulk density, and apparent (skeletal) density.

Two Models

The AutoPore IV Series is available in four models to best match the needs of individual quality assurance and research labs.

AutoPore IV 9520: 2 high-pressure (60,000 psia maximum pressure) and 4 low-pressure analysis ports

AutoPore IV 9505: 2 high-pressure (33,000 psia maximum pressure) and 4 low-pressure analysis ports

Broad Choice of Analysis and Report Parameters

Operating Software

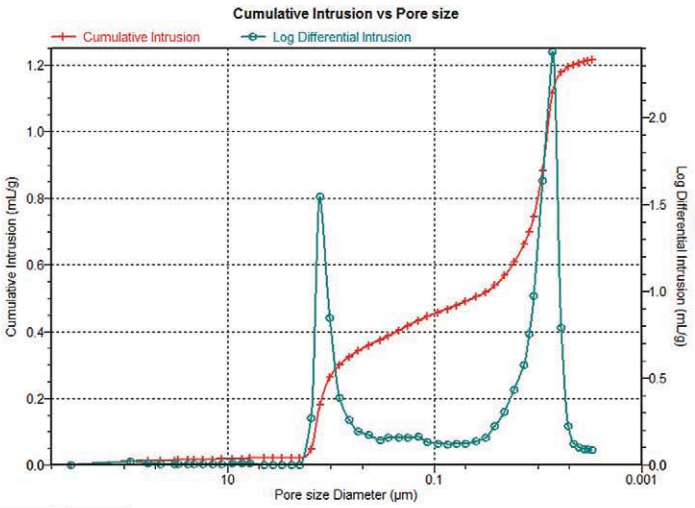
The AutoPore offers various options for obtaining important sample information as quickly as possible and for presenting the data in a format which you can design. Analysis options include choice of analysis variables, equilibration techniques, and pressure points at which data are collected. After operating conditions for the instrument have been chosen, they can be stored as a template and then reapplied to other samples, saving time and reducing the potential for human error.

A selection of report options lets you customize many aspects of the data pages. You can select a specific range of data to be used in calculations; arrange columns of tabular data; select cumulative, incremental, or differential plots; scale the X-axis to display in either logarithmic or linear format for pore size; report actual or interpolated data; and select data presentation units such as psia or MPa, diameter or radius, and micrometers or Angstroms.

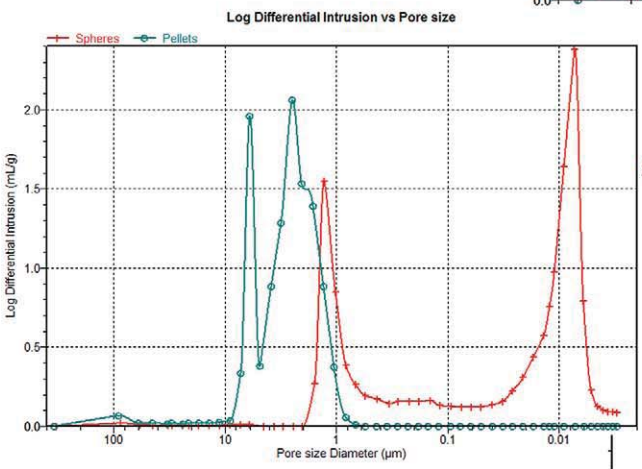
Data Reduction

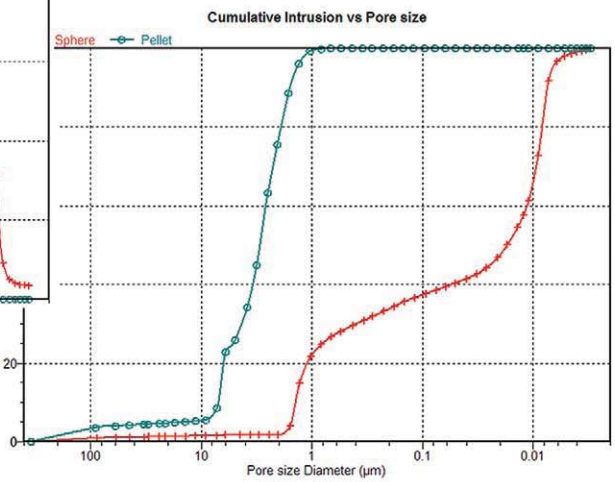
The AutoPore IV generates tabular and graphical reports of percentage pore volume vs. diameter, and a summary report of percentage porosity in user-defined size ranges. The user has the ability to average several analyses and to use the 'resulting average' analysis as a reference with which to compare subsequent analyses. A standard, single, user-defined analysis may also be entered and used for subsequent comparisons. SPC reports are available with collected data or user-defined parameters. In addition to the standard data reduction methods, the AutoPore IV Series also provides the following:

- Mayer-Stowe Particle Size - Reports equivalent spherical size distributions
- Pore Tortuosity - Characterizes the efficiency of the diffusion of fluids through a porous material
- Material Compressibility - Quantifies the collapse or compression of the sample material
- Pore Number Fraction - Reports the number of pores in different size classes
- Pore-throat Ratio - Reports the ratio of pore cavities to pore throats at each percent porosity filled value
- Pore Fractal Dimensions - Quantifies the fractal geometry of a material
- Permeability - Reports the ability of the sample to transmit fluid



The AutoPore software includes a full report system for producing publication-quality graphics and user-specified reports.





The pore size distribution of two alumina samples are overlaid to provide a comparison of pore structure.

Penetrometer Characteristics

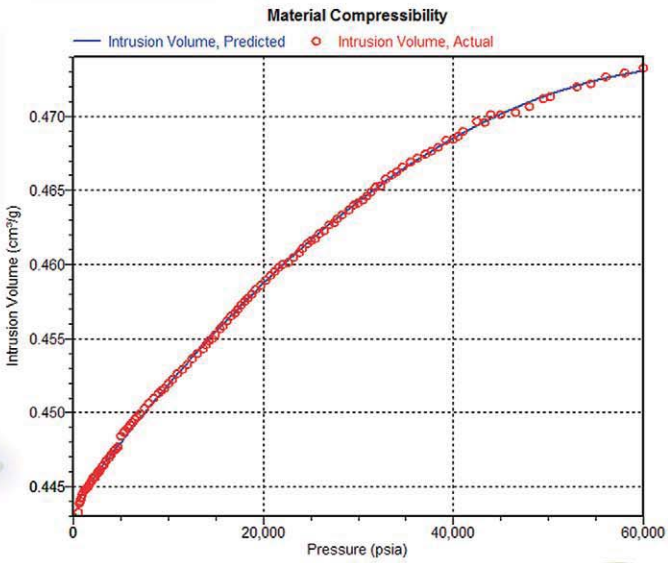
The penetrometer consists of a sample cup bonded to a metal-clad, precision-bore, glass capillary stem. The sample is placed in the sample cup; during analysis, mercury fills the cup and capillary stem. As pressure on the filled penetrometer increases, mercury intrudes into the sample's pores, beginning with those pores of largest diameter. The mercury moves from the capillary stem resulting in a capacitance change between the mercury column inside the stem and the metal cladding on the outer surface of the stem. The AutoPore detects very slight changes in capacitance (equivalent to a difference of less than 0.1 microliter of mercury) so extraordinary resolution is achieved.

Micromeritics also offers a large selection of penetrometer bulbs, volumes, stems, and closures designed to fit most sample forms, shapes, porosity, and quantity. The better the match between the sample, its porosity, and the measurement range of the sample cell, the more precise the results.

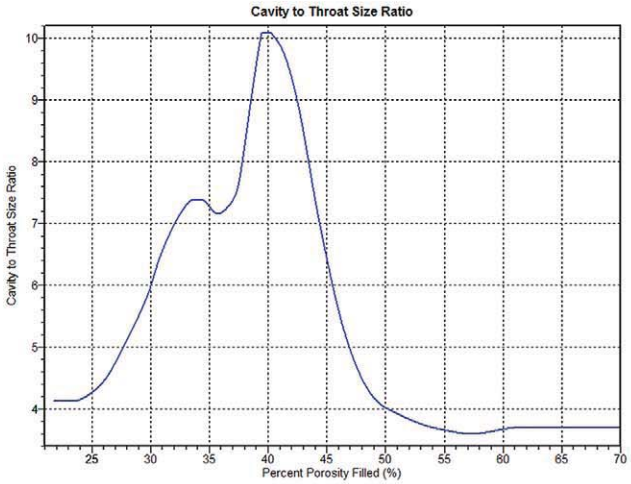
Safety Systems

The AutoPore features several levels of mechanical and electro-mechanical safety devices:

- The computer will not accept keyboard instructions to overpressurize the system.
- The high-pressure system is mechanically unable to generate unsafe pressures.
- A circuit stops the generation of pressure in the event of a failure in the computer.
- The operating specifications of the pressure systems (low = 50 psia, high = 60,000 psia) are well below the actual designed safety limits.



The material compressibility is easily calculated and may be reported both graphically and in tabular form using the AutoPore report system.



The extensive report system includes pore structure calculations including Cavity-to-Throat Size Ratio, Fractal Dimension, Material Compressibility, and Statistical Process Control reporting.

Intrusion Data Summary

Total Intrusion Volume =	1.2166	mL/g
Total Pore Area =	305.880	m²/g
Median Pore Diameter (Volume) =	0.0171	µm
Median Pore Diameter (Area) =	0.0084	µm
Average Pore Diameter (4V/A) =	0.0159	µm
Bulk Density at 0.56 psia =	0.6872	g/mL
Apparent (skeletal) Density =	4.1929	g/mL
Porosity =	83.6101	%
Stem Volume Used =	60	%

A convenient data summary is automatically generated with each sample reported.

Pore Structure Summary

Threshold Pressure:	136.88	psia (Calculated)
Characteristic length =	1.3213	µm
Conductivity formation factor =	0.232	
Permeability constant =	0.00442	
Permeability =	1.7956	mdarcy
BET Surface Area =	230.0000	m²/g
Pore shape exponent =	1.00	
Tortuosity factor =	1.907	
Tortuosity =	3.3265	

Additional pore structure calculations are included in the AutoPore software.

To request a quote or additional product information, visit Micromeritics' web site at www.micromeritics.com, contact your local Micromeritics sales representative, or our Customer Service Department at (770) 662-3636.

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