PRODUCT ANNOUNCEMENT

Model 1500—Aerosol Generator and Monitor (AGM™)

A multi-function aerosol system with aerosol generation, classification and monitoring capabilities for:

- *generating monodisperse aerosols by mobility classification with automatic concentration detection and monitoring*
- *size distribution analysis by differential mobility and scanning mobility size spectrometry*

INTRODUCTION

The Model 1500 Aerosol Generator and Monitor™ (AGM™) is a multi-function aerosol instrument comprised of an atomizer aerosol generator, a differential mobility analyzer (DMA) and a condensation particle counter (CPC) for aerosol generation and measurement.

As an aerosol generator the AGM can be used to generate a monodisperse aerosol by atomization and electrostatic classification. The output aerosol concentration is continuously monitored by the built-in CPC to provide a stable aerosol output with a known particle size and a known aerosol concentration from 10nm to1000nm.

The AGM can be used in the corporate standards laboratory to generate monodisperse test aerosols for standardizing and calibrating aerosol instruments for quality assurance purposes including calibrating aerosol particle counters, Diesel exhaust monitoring, etc. to insure consistent measurement results.

The built in differential mobility analyzer (DMA) and condensation particle counter (CPC) in the AGM™ can be used as a differential mobility spectrometer (DMS) or as a scanning mobility spectrometer (SMS) to measure aerosol size distribution from 10nm to 1000nm. The aerosol can be sampled from an external source or generated internally by the built-in atomizer to provide a polydisperse aerosol with a known and monitored size distribution.

The technology embodied in the AGM has been developed at MSP over a period of several years to provide a calibration system for internal use to provide NIST-traceable calibration of MSP's aerosol measuring instruments. MSP's popular Wide-range Particle Spectrometer (WPS), and the Differential Mobility and Scanning Mobility Spectrometers (DMS and SMS) are calibrated by systems with technology similar to that embodied in the AGM.

These laboratory instruments are now made available in a user friendly package for the corporate standards laboratory to perform its own NIST traceable instrument calibration for quality assurance purposes.

In addition to the above, the multi-function aerosol generation and measurement capability of the AGM has made it possible to use two such systems to perform aerosol studies by the tandem differential mobility analysis (TDMA) method.

In a typical TDMA study one DMA is used to classify an aerosol into a monodisperse fraction having a uniform and known particle size. This aerosol is then subjected to a physical or chemical change. The resulting change in particle size is then measured by a second DMA and CPC.

The TDMA method has been used to study the growth of hygroscopic particles in humid atmospheres. For such studies, the aerosol is generated at one relative humidity and following electrostatic classification by one DMA, the aerosol is then exposed to a different relative humidity. The resulting particle size is then measured by a second DMA with a CPC to

determine the change in particle size due to moisture absorption or desorption by hygroscopic particles.

Another TDMA study is the kinetics of oxidation of soot particles from a Diesel engine to study the rate of oxidation in an oxygen rich, reactive atmosphere. For details see the references cited below:

- Rader, D.J. and P.H. McMurry, "Application of the Tandem Differential Mobility Analyzer to Studies of Droplet Growth or Evaporation," *J. Aerosol Science,* 17:771-787 (1986)
- Higgens, K.J. et al, "Size Selected Nanoparticle Chemistry: Kinetcs of Soot Oxidation," *J. Phys. Chem. A,*106:96-103 (2002)

For TDMA studies with the AGM, two systems are needed. One AGM is operated as an aerosol generator to generate a monodisperse aerosol by electrostatic classification using a laboratory aerosol generated internally by the built-in aerosol generator, or an aerosol sampled from an external source. This monodisperse aerosol is then subjected to a physical or chemical change leading to a change in particle size. The size distribution of the aerosol is then measured by the second AGM operating in the DMS or SMS mode as an aerosol size distribution analyzer.

DESCRIPTION

The Model 1500 AGM is provided with three basic aerosol instrument components:

- an atomizer aerosol generator to produce a polydisperse aerosol
- a differential mobility analyzer for size classification of aerosol by electrical mobility and
- a condensation particle counter for counting particles by vapor condensation and droplet growth, followed by droplet detection by laser light scattering.

Figure 1 is a simplified schematic diagram of the AGM. The instrument is designed to be user friendly and easy to operate. Many of the key components are easily accessible to the user.

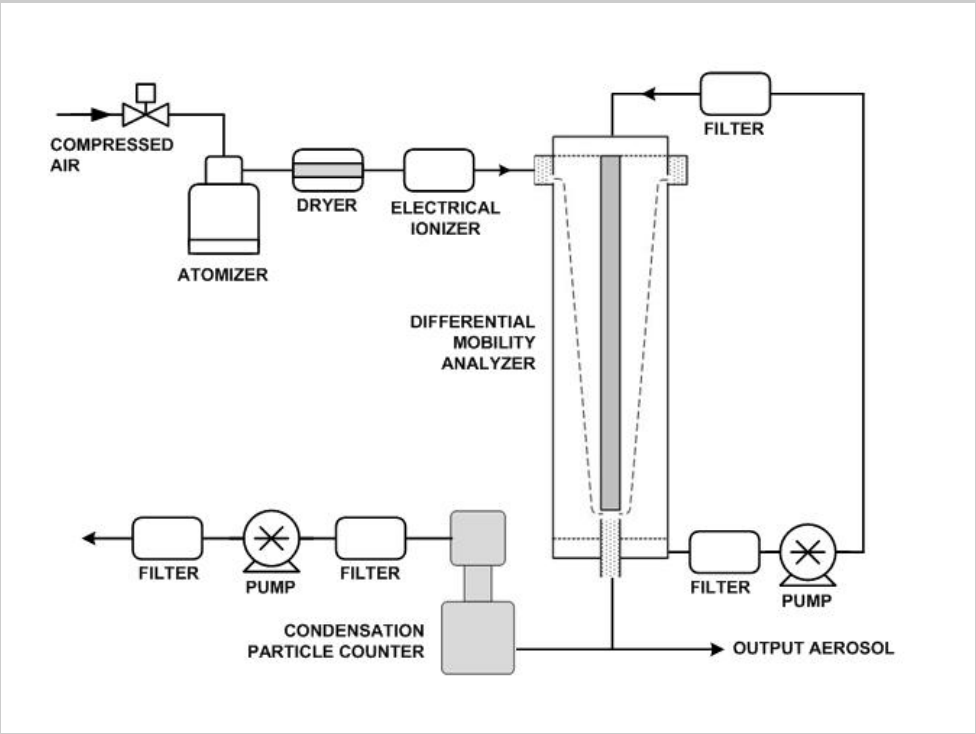

Figure 1. Simplified schematic diagram of the AGM

Atomizer Aerosol Generator

The built-in compressed-air atomizer in the Model 1500 AGM is used to generate a spray of fine droplets suspended in air. The atomizer can also be operated by other compressed gases to generate an aerosol of particles suspended in the atomizing gas. This droplet aerosol is then dried to form a polydisperse aerosol comprised of residue particles formed from the dissolved non-volatile material in the atomized liquid. Common materials used for laboratory aerosol generation include NaCl, other soluble salts, and ammonium fluorescence dissolved in water; polystyrene latex (PSL) spheres suspended in water; and organic material such as oleic acid dissolved in ethanol.

The atomizer used is a single jet Collison-type device operated by compressed air. The droplet spray is about 2 μm in volume mean diameter for an aqueous solution. Drying is accomplished by flowing the droplet aerosol through a NafionR membrane dryer to evaporate water from the droplets to form dry solid or liquid particles of the dissolved non-volatile material.

For NaCl aerosol generation, a solution of, say,1% NaCl concentration by weight can be prepared by dissolving 1.0 gram of NaCl in 100 ml of DI water. This solution when atomized and dried will result in a solid NaCl aerosol having a volume-mean diameter of approximately 0.33μm. When a liquid, such as water, containing suspended solid polystyrene latex (PSL) spheres of a uniform size is atomized and dried, a PSL aerosol comprised of uniform PSL spheres can be generated.

Differential Mobility Analyzer

Aerosols generated by atomization usually have a natural charge that is unknown and in many cases uncontrolled. The aerosol charge can be brought into a state of charge equilibrium by creating a mixture of positive and negative ions in the gas in which the particles are suspended.

Traditionally, positive and negatives ions are generated in a gas by means of a radioactive ionizing source. In the Model 1500, an electrical ionizer is used to generate the ions. Collision of ions with the suspended aerosol particles in air will cause the particles to become electrically charged, with approximately equal concentration of positively and negatively charged particles being present in the final Boltzmann charge equilibrium state. The charged particles can then be classified electrically by mobility by the built-in DMA to provide a monodisperse aerosol at the output.

The DMA is cylindrical in shape and has an overall height of 15.6 inches (400mm). When operated with a sheath flow of 10.0 L/min, the DMA has a mobility range to allow particles as small as 10nm to be classified. At 3 L/min flow, particles as large as 1,000nm can be classified. The aerosol particle size selected for size classification can be adjusted by varying the DC high voltage applied to the DMA using the built-in high voltage power supply in the Model 1500.

The DMA is operated in a re-circulating sheath flow mode, with the sheath flow being controlled accurately by feedback control. A heat exchanger is used to maintain the sheath flow to be at nearly the same temperature as the ambient room air. The temperature and absolute pressure in the DMA are measured and used to correct for temperature and pressure effects when particle size is determined by electrical mobility.

Condensation Particle Counter

The Model 1500 uses a condensation particle counter to monitor the aerosol output concentration. The CPC is of a patented MSP design, with two separate fluid reservoirs: one containing the working fluid, typically 1-butanol, and the other for collecting the condensate of butanol and condensed moisture in the condenser. When operating with a 35oC saturator temperature and 10oC condenser temperature, the CPC has a nominal detection limit of 10nm in particle diameter. The nominal flow rate of the CPC is 0.3 L/min.

The output aerosol concentration in the Model 1500 AGM is automatically monitored by the built-in CPC so that the aerosol concentration is also known accurately during measurement. Under normal operation, the concentration range of the CPC is from approximately 1 particle/cc to10000 particles/cc. A feedback flow control system maintains the CPC flow rate at a constant 0.3-L/min. The aerosol leaving the CPC is mixed with clean, dilution-air flow at the rate of about 2-L/min and goes through an activated-carbon filter before it is exhausted.

Calibration

The Model 1500 AGM is calibrated at the factory to provide NIST-traceable particle size calibration by using polystyrene latex (PSL) spheres of 269-nm diameter from the National Institute of Standard and Technology (NIST) as Standard Reference Material (SRM 1691)

System Control

The Model 1500 is a fully automated instrument controlled by a single-board computer to provide automatic feedback control of all major operating parameters such as the flow rate and voltage of DMA, flow rate and temperature of the CPC, and other relevant operating parameters.

FEATURES

- High stability atomizer aerosol generator
- Wide range, high resolution, differential mobility analyzer
- Patented and state-of-the-are dual-reservoir CPC
- Single-board computer control of critical system operating parameters
- Temperature and pressure corrected size analysis by differential mobility
- DMS and SMS data analysis software for aerosol size distribution measurement
- Automatic data logging

APPLICATIONS

The Model 1500 AGM enables the user to generate highly monodisperse aerosols that can be used for a variety of purposes including:

- Generate monodisperse aerosol of an accurately known particle size and concentration as standard test aerosols for calibrating and standardizing aerosol instruments in the standards laboratory
- Characterize the size dependent characteristics of filters and other particle collectors
- Measure transmission loss of particles in tubes, fittings and connectors for accurate aerosol concentration measurement
- Nano-particle research
- Fundamental and laboratory aerosol research
- Aerosol study by the TDMA method

MSP Corporation
5910 Rice Creek Parkway, Suite 300
Shoreview, Minnesota 55126, U. S. A.
Phone: 651.287.8100; Fax: 651.287.8140
Sales@mspcorp.com; www.mspcorp.com

SPECIFICATIONS

Subject to change without notice

Instrument Dimensions	20.6" (W) x 24.0" (D) x 17.6" (H) 525 mm (W) x 610 mm (D) x 450 mm (H)
Instrument Weight	88 lbs (40 kg)
Operating Aerosol Pressure	800 to 1050 mbar absolute pressure
Ambient Temperature Range	10 to 35 ºC
Ambient Humidity Range	0-90% RH, non-condensing
Power requirements	110 or 220 VAC, 50-60 Hz, single phase, 250 W max, 160 W avg
Polydisperse Aerosol Generation System	
Single-Jet Atomizer	Stainless Steel Construction
Pressure	15 to 60 psig (100 to 415 kPa gauge),controlled by pressure regulator
Aerosol Flow Rate	Typical 3 L/min @ 35 psig (240 kPa gauge)
Volume-Mean Droplet Diameter	about 2 µm (GSD< 2.0)
Aerosol Size Range	10 to 2000 nm
Aerosol Concentration	> 10^7 particles/cm3 (typical for NaCl)
Dryer	Diffusion type (Nafion® membrane requires source of clean, dry air)
Differential Mobility Analyzer	
Inlet Aerosol Flow Rate	0.3 to 1.0 L/min, controlled externally by manual valve
Monodisperse Aerosol Flow Rate	0.3 to 1.0 L/min (not directly controlled in aerosol generation mode)
Sheath Air and Excess Air	3.0 to 10 L/min, closed-loop, controlled by internal feedback control system to user-selected setpoint
High Voltage Power Supply	10 to 10,000 V, user-selected (software limits max voltage to 9,000V)
Aerosol Size Range	9 to 1000 nm, user-selected, max size depends on sheath flow rate
Max aerosol input concentration	108 particles/cm3
Aerosol Neutralizer	Electrical ionizer (no radioactive source required)
Particle Type	Solids and non-volatile liquids
Condensation Particle Counter	
Working Principle	Laminar continuous flow with single particle detection
Flow Rate	0.300 L/min controlled by internal feedback control system
Particle Diameter Range	5 nm to 2 µm
Count Accuracy	± 10% (compared to std MSP CPC); Single particle counting mode
Concentration Range	0 to 104 particles/cm3 ; (single particle counting mode)
Working Fluid	1-butanol (n-butyl alcohol)
Response Time (95% response)	< 10 sec