VIBRATING ORIFICE AEROSOL GENERATOR MODEL 3450

CREATES MONODISPERSE PARTICLES FROM 1 TO 200 MICROMETERS IN DIAMETER

Uniform particle creation is critical for successful aerosol research. Controlled experiments and proper instrument calibration require a generation source that guarantees production of uniform, monodisperse particles. The Vibrating Orifice Aerosol Generator Model 3450 (VOAG) produces solid or liquid aerosols from a wide variety of solutions. It creates aerosol particles that are uniform in size, density, shape, and surface characteristics. The VOAG's integrated design makes it easy to start up and adjust. Liquid flow, dispersion air, dilution air, and oscillation frequency can be conveniently monitored and controlled from the front panel. Because the generation head, syringe pump, and signal generator are contained in one package, the VOAG provides all the data necessary to calculate final particle diameter

Features and Benefits

+ Generates particles from 1 to 200 µm
+ Particles are uniform in size, shape, density and surface characteristics
+ Works with a variety of solutes and solvents

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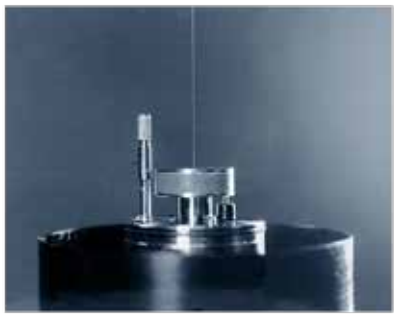
Applications

The VOAG's consistency and accuracy make it an effective aerosol generation standard for a variety of applications. It is especially suited to controlled experiments where airborne particle size must be known and within a narrow range. Typical applications include:

+ Generation of micrometer particles of known size from any material that can be put into solution with a volatile solvent
+ Transport, deposition, collection, charging, and dispersion of aerosols related to aerosol research and health-effects studies
+ Evaporation studies
+ Pharmaceutical formulation testing
+ Calibration of optical particle counters, particle sizers, cascade impactors, cyclones, and impingers
+ Development and testing of equipment such as baghouse filters, cyclones, scrubbers, and electrostatic precipitators
+ Instrument performance studies involving the measurement of design parameter effectiveness as a function of particle characteristics
+ Monodisperse aerosol generation

PRECISE VIEW OF DROPLET GENERATION



The VOAG generates identical droplets from a liquid stream as the stream passes through the vibrating orifice. The droplets form a thin, vertical jet when the VOAG is operating properly. The jet-viewing light allows easy monitoring of this operation.

The operator checks droplet uniformity by using a gentle flow of air to deflect the droplet stream. A single, deflected jet indicates uniform droplet size.

Two or more deflected jets indicate generation of more than one droplet size, and therefore, the need for an adjustment by the operator. The "satellites" shown above can be eliminated simply by adjusting the vibration frequency or amplitude.

Operation

Left uncontrolled, a liquid jet is unstable and breaks into nonuniform droplets. Applying a periodic disturbance of an appropriate frequency can regulate this process. The VOAG uses a vibrating orifice to control the breakup of a liquid jet. This technique enables the VOAG to produce highly uniform droplets with a typical standard deviation of less than one percent of the mean droplet size.

A syringe pump feeds a liquid solution through a small orifice at a predetermined rate. The volumetric flow remains constant. A piezoelectric ceramic driven by an oscillating voltage potential causes the orifice to vibrate at a constant frequency, producing a uniform droplet stream.

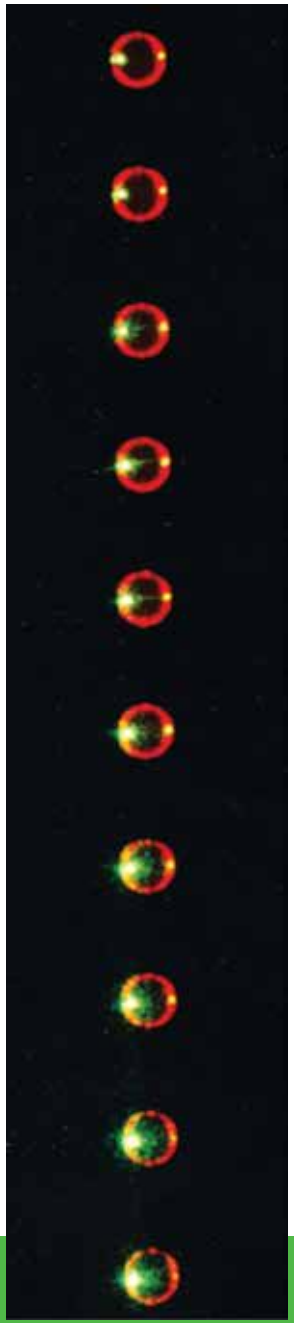
The droplet stream is introduced into the center of a turbulent air jet, dispersing droplets and preventing coagulation. The dispersed droplets mix with a larger volume of clean, dry air, which evaporates any volatile portion of the droplets.

The VOAG generates primary droplets in the 21 to 48 micrometer range using a standard, interchangeable set of 10 and 20 micrometer nominal diameter orifices. Larger orifices are optionally available to generate larger primary droplets. The solution used to generate the droplets determines evaporation and ultimate particle size.

Because each disturbance cycle produces only one droplet, the precise size of the droplet can be calculated using operating parameters. The two key parameters are liquid flow rate (Q) and oscillation frequency (f). If a portion of the primary droplet is volatile, the final particle size depends on the volumetric concentration (C) of the nonvolatile portion. Using the Q, f, and C parameters, the following equation calculates the final particle diameter:

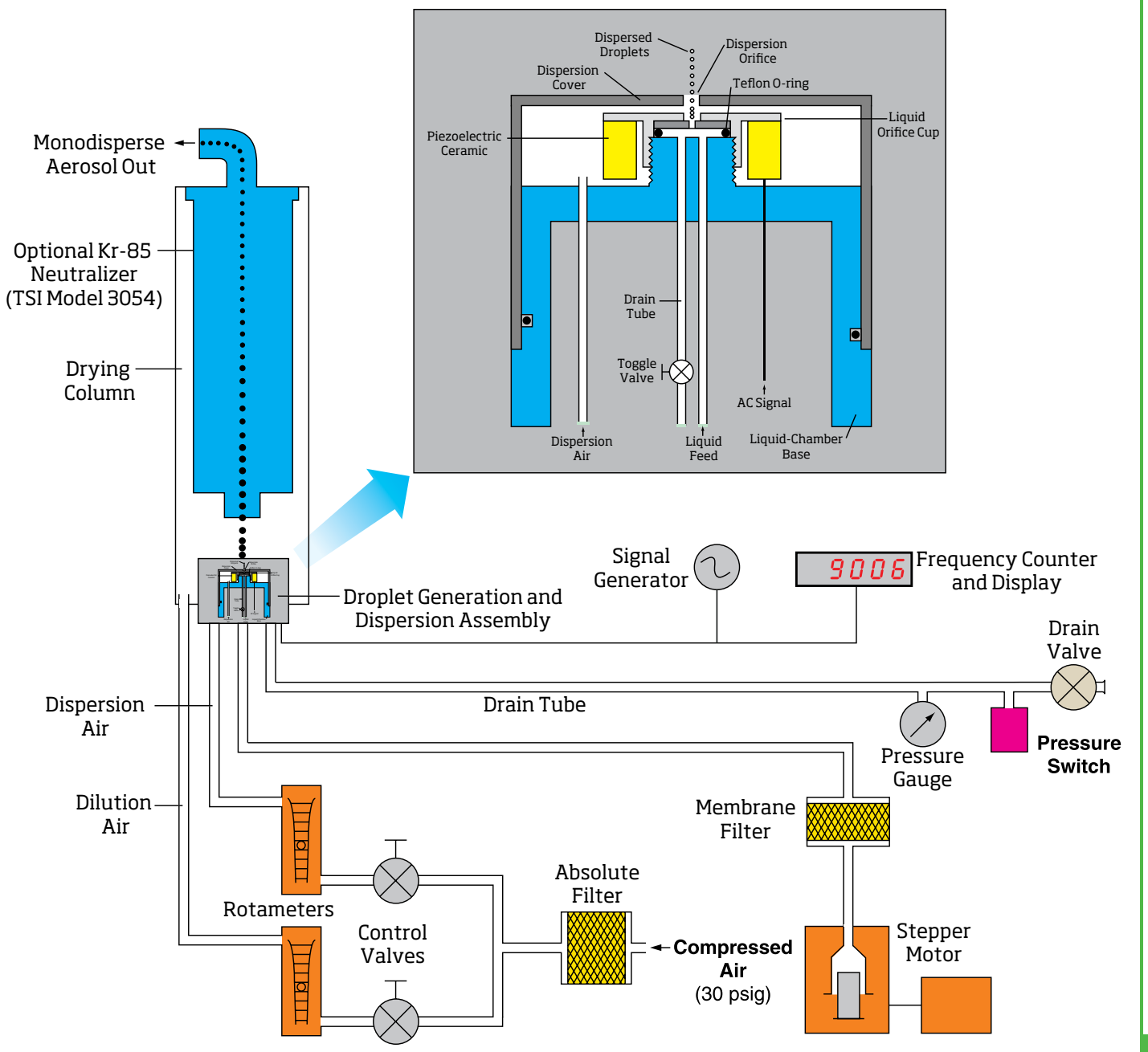
$$D_p = \left(\frac{6QC}{f}\right)^{1/3}$$

The operator can conveniently monitor liquid flow rate, dispersion air rate, and oscillation frequency from the VOAG's front panel. The VOAG produces a charged aerosol. While this charge does not affect particle-size uniformity, it often causes considerable transport losses, especially with smaller-sized particles. TSI recommends using a radioactive neutralizer for applications involving particles smaller than 5.0 micrometer in diameter. The VOAG's acrylic drying column easily accommodates a TSI Model 3054 Aerosol Neutralizer.



The Model 3450 produces highly uniform, monodisperse particles, in solid or liquid form. (Photo courtesy of Prof. Richard K. Chang, Center for Laser Diagnostics and Department of Applied Physics, Yale University)

OPERATION


Dispersed Droplets
Dispersion Orifice
Dispersion Cover
Teflon O-ring
Liquid Orifice Cup
Piezoelectric Ceramic
Drain Tube
Toggle Valve
AC Signal
Dispersion Air
Liquid Feed
Liquid-Chamber Base
Monodisperse Aerosol Out
Optional Kr-85 Neutralizer (TSI Model 3054)
Drying Column
Droplet Generation and Dispersion Assembly
Signal Generator
9006
Frequency Counter and Display
Drain Valve
Drain Tube
Dispersion Air
Pressure Gauge
Pressure Switch
Dilution Air
Membrane Filter
Absolute Filter
Rotameters
Control Valves
Compressed Air (30 psig)
Stepper Motor

Features

Acrylic Drying Column. Made of clear acrylic so you can view particles as they are generated, the drying column facilitates the evaporation of solvent. It may be removed for special experimental needs, or it can hold an optional TSI Aerosol Neutralizer* Model 3054 to remove charge from the generated aerosol.

Jet-Viewing Light. A built-in halogen lamp produces a highly focused light beam, allowing easy visual verification of droplet monodispersity. (See photographs on opposite page.)

Removable Generation Head. The generation head can be removed and inverted to accommodate the generation of large particles. This flexibility also makes it easy to deliver aerosol to the desired location.

Interchangeable Orifices. Two orifice sizes (10 and 20 micrometer diameter) come with the VOAG for varying particle size. Orifices of 35, 50, and 100 micrometers are also available.

Constant-Speed Syringe Pump. A powerful stepper motor drives the built-in syringe pump to maintain constant volumetric flow. This constant flow, rather than constant pressure, ensures uniform particle size. An error detection system and warning light alert the operator to any operational problem.

Corrosion-Resistant Liquid Path. The use of corrosion-resistant materials, such as stainless steel and Teflon®, make the VOAG appropriate for applications that use caustic solutions to generate particles.

Digitally Displayed Signal Generator. The front panel of the VOAG displays a digital readout of the signal generator's frequency output, and includes convenient controls for frequency and amplitude.

Easily Accessible Controls. The front panel also contains controls and indicators for the filtered air supply (both dispersion and dilution air), syringe pump, and halogen lamp. You can even monitor liquid pressure and operate the liquid drain from the front panel.

* Instrument shown with optional Aerosol Neutralizer Model 3054 installed in the drying column. The neutralizer must be ordered separately.

FROM DROPLET TO SOLID PARTICLE

The VOAG generates identical primary droplets, one at a time. By varying the liquid flow rate and oscillation frequency, the operator can generate a specific range of primary droplet sizes.

Primary droplets composed of two liquids with different volatilities produce a less volatile droplet. For example, droplets containing both alcohol and oil lose the more-volatile alcohol in the drying column, leaving only the oil.

Primary droplets composed of a volatile liquid and a nonvolatile solute produce particles from the solute when the liquid evaporates. A saline solution produced the salt particle pictured above.

SYSTEM COMPONENTS

A Complete System For Generating Monodisperse Particles

The Vibrating Orifice Aerosol Generator (VOAG) described in this product sheet is also available in a complete system. The Supermicrometer Monodisperse Aerosol Generation System Model 3941 provides all components needed to generate particles from 1 to 200 micrometers in diameter. The system includes a VOAG, a Aerosol Neutralizer Model 3054, and a Filtered Air Supply Model 3074B. It also includes a complete set of orifices (10, 20, 35, 50, and 100 micrometers, nominal size). Ordering information is provided under "To Order a Complete System," found inside this product sheet.

Specifications
Vibrating Orifice Aerosol Generator Model 3450

Mode of Operation
Constant liquid feed rate through a vibrating orifice

Particle Size Range
1 to 200 µm

Initial Droplet Diameter
20 to 400 µm

Geometric Standard Deviation
<1.01

Particle Type
Oil and solids soluble in water or alcohol*

Particle Generation Rate
1,000 to 300,000 particles/sec (depends on particle size)

Syringe Pump

Syringe Ram Speed	0.1 ¥ 10-4 to 9.9 ¥ 10-3 cm/sec Flow Rate Selectable, 0.001 cm^3/min (10-cm^3 syringe) to 2.2 cm^3/min (60-cm^3 syringe) Syringe Holders Hold 10-, 20-, or 60-cm^3 syringes

Signal Generator

Frequency Range	1 kHz to 1 MHz
Accuracy	±1% of full scale, ±1 digit
Amplitude of Square Wave	0 to 30 V, peak-to-peak

Physical Specifications

Cabinet Size	44 cm x 37 cm x 20 cm (17.3 in. x 14.5 in. x 7.9 in.)
Weight	16 kg (35 lb)
Drying-Column Height	60 cm (23.6 in.)
Drying-Column Material	Acrylic
Orifice Material	Stainless steel
Electrical Requirements	100/115/230/240 VAC, 50-60 Hz, 100 W maximum Compressed-Air Requirements Up to 100 L/min at 207 kPa (30 psig)

*The VOAG is not suitable for use with nonsoluble solids such as polystyrene latex (PSL). To generate PSL aerosol, use TSI's Small-Scale Powder Disperser Model 3433 with a turntable loaded with PSL.

Specifications are subject to change without notice.

The Supermicrometer Monodisperse Aerosol Generation System Model 3941 includes the VOAG and the accessories needed to generate particles from 1 to 200 micrometers in diameter.

TO ORDER

Vibrating Orifice Aerosol Generator Model 3450

Specify	Description
3450	Vibrating Orifice Aerosol Generator

Includes these standard accessories:

Accessory kit: 10-, 20-, and 60-cm3 syringes; 12 filter holders; 100 Teflon® membrane filters (0.5-µm pore size, 13-mm diameter); replacement O-rings; tubing; and air filters
One 10-µm orifice (nominal size)
Two 20-µm orifices (nominal size)
Jet-deflection nozzle
Small syringe holder (for 10-and 20-cm^3 syringes)
Large syringe holder (for 60-cm3 syringe)
250-cm^3 beaker
Light assembly
Exhaust hose
Drying column assembly
Instruction manual

Optional accessories (must be ordered separately):

Specify	Description
393520	10-µm orifice (nominal size)
393530	20-µm orifice (nominal size)
393540	35-µm orifice (nominal size)
393550	50-µm orifice (nominal size)
393560	100-µm orifice (nominal size)
393590	0.5-µm filters, 13-mm diameter (quantity of 100)
3054	Aerosol Neutralizer
3074B	Filtered Air Supply

To Order a complete system

Specify	Description
3941	Supermicrometer Monodisperse Aerosol Generation System

Includes these system components:

3450	Vibrating Orifice Aerosol Generator with one 10- and two 20-µm orifices and standard accessories
3054	Aerosol Neutralizer
3074B	Filtered Air Supply
393540	35-µm orifice
393550	50-µm orifice
393560	100-µm orifice
-	Interconnecting hardware

This system is described on the back of this document.

SPECIFICATIONS

VIBRATING ORIFICE AEROSOL GENERATOR MODEL 3450

Vibrating Orifice Aerosol Generator Model 3450

Operating Features

Source	Kr-85†
Emission	99+% beta
Radioactivity	10 millicurie
Half-Life	10.4 years
Flow Rate (Maximum)	150 L/min
Temperature (Maximum)	50°C (122°F)
Pressure (Maximum)	35 kPa (5 psig)

Physical Features

Inlet Diameter	2.5 cm (1 in.)
Outlet Diameter	3.1 cm (1.2 in.)
Length	50 cm (20 in.)
Housing Diameter	8.9 cm (3.6 in.)
Weight	3.5 kg (7.7 lb)

Filtered Air Supply Model 3074B

Operating Features

Inlet Connection	Parker H2C ¼-in., male, quick-disconnect fitting Outlet Connector ⅜-in. female Swagelok® fitting that connects to ⅜-in. tubing (¼-in. fitting also included)
Roughing Filter	99.5% efficiency at 0.1 µm
Intermediate Filter	99.99995% efficiency at 0.1 µm
Membrane Dryer	Reduces wet, incoming air to a dew-point of 1.6°C (35°F) at 2 scfm (56 L/min) using the principle of selective permeation through a membrane
Final Filter	99.99995% efficiency at 0.1 µm, contains activated carbon
Pressure Regulator	0 to 4.0 kg/cm2 (0 to 60 psig)
Pressure Gauge	0 to 4.0 kg/cm2 (0 to 60 psig)

Physical Features

Dimensions (LWH)	81 cm x 20 cm x 37 cm (32 in. x 8 in. x 14.5 in.)
Weight	2.3 kg (5 lb)

†TSI has been issued general license number 22-12602-03G by the U. S. Nuclear Regulatory Commission to sell and distribute these aerosol neutralizers. Users in the United States need not apply for additional U.S. Government licenses to handle these products. However, some state and local governments may require special licenses, and some organizations may have special handling procedures. Destinations outside the U. S. may also have specific restrictions. Check all local requirements.

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