# Series 8500 Filter Dynamics Measurement System



## Automated Particulate Matter Mass Measurement — Accounting for Nonvolatile and Volatile PM Components

Air Monitors Limited-Rupprecht & Patashnick Co., Inc.

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# Measurement of Nonvolatile and Volatile PM Fractions

R&P has developed the Filter Dynamics Measurement System (FDMS™ unit) to accomplish the challenging task of accounting for both the volatile and non-volatile components of particulate matter (PM), and reporting the combination as a mass concentration result. This is done by measuring the volatile portion of the sample independently from the total incoming sample, and using this fraction in calculating the PM mass concentration.

This sampling and measurement system is based upon a number of technologies successfully applied by R&P, including the true-mass filter-based TEOM microbalance, a diffusion drying system, and a self-referencing technique to assess the volatile component of ambient PM. The FDMS unit provides a new PM measurement approach that offers the ability to quantify more representatively the PM mass concentration as it exists in ambient air.

As the name implies, the FDMS System takes into account the dynamics of PM that has been deposited on a sample collection filter, and how that material behaves over time. The device is designed to provide high-quality, representative PM mass concentration readings for both short-term averages (one hour) as well as 24-hour averages. The system's basic output consists of running 1-hour average mass concentration (in μg/m³) of PM-10, PM-2.5 or PM-1 updated every six minutes. The unit also computes the base mass concentration and reference mass concentration over the same averaging times.

# System Configuration

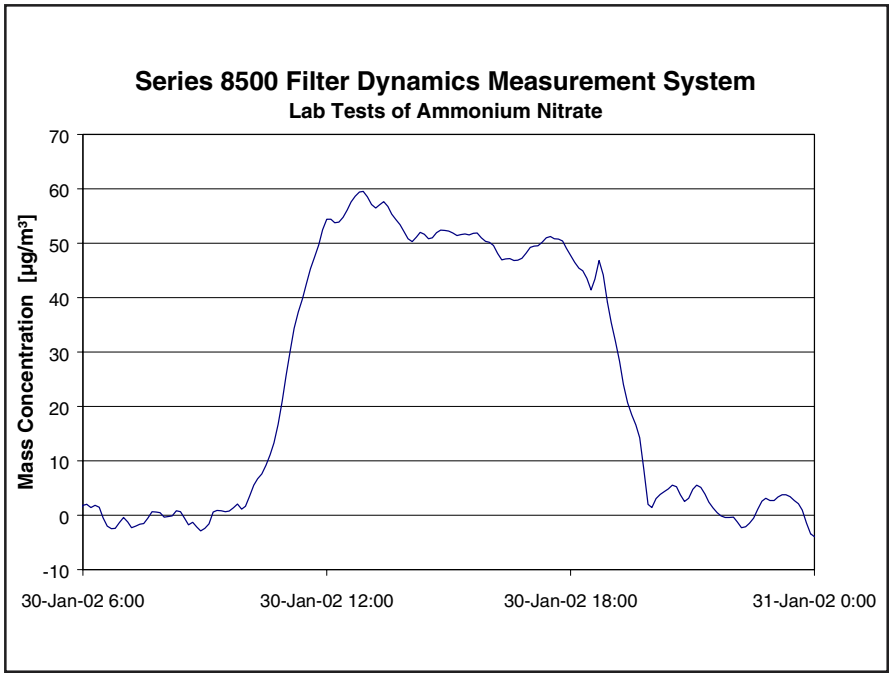
The Series 8500 Filter Dynamics Measurement System is composed of a TEOM Series 1400a Ambient Particulate monitor loaded with special operating software and an FDMS kit. For current users of TEOM Series 1400a (Revision B) monitors, the FDMS kit can be added to an existing installation.

The system schematic shows the major components of the FDMS System as the sample flow passes from the size selective inlet to the mass transducer in the sensor unit and the flow controllers in the control unit. An integral Sample Equilibration System (SES) dryer ensures that the relative humidity of the sample stream is low to minimize the effects of moisture on PM measurements. The Purge Filter Conditioning Section contains a chilled filter maintained at 4 °C that effectively removes particulate matter when the sample stream is switched through the device by the switching valve.

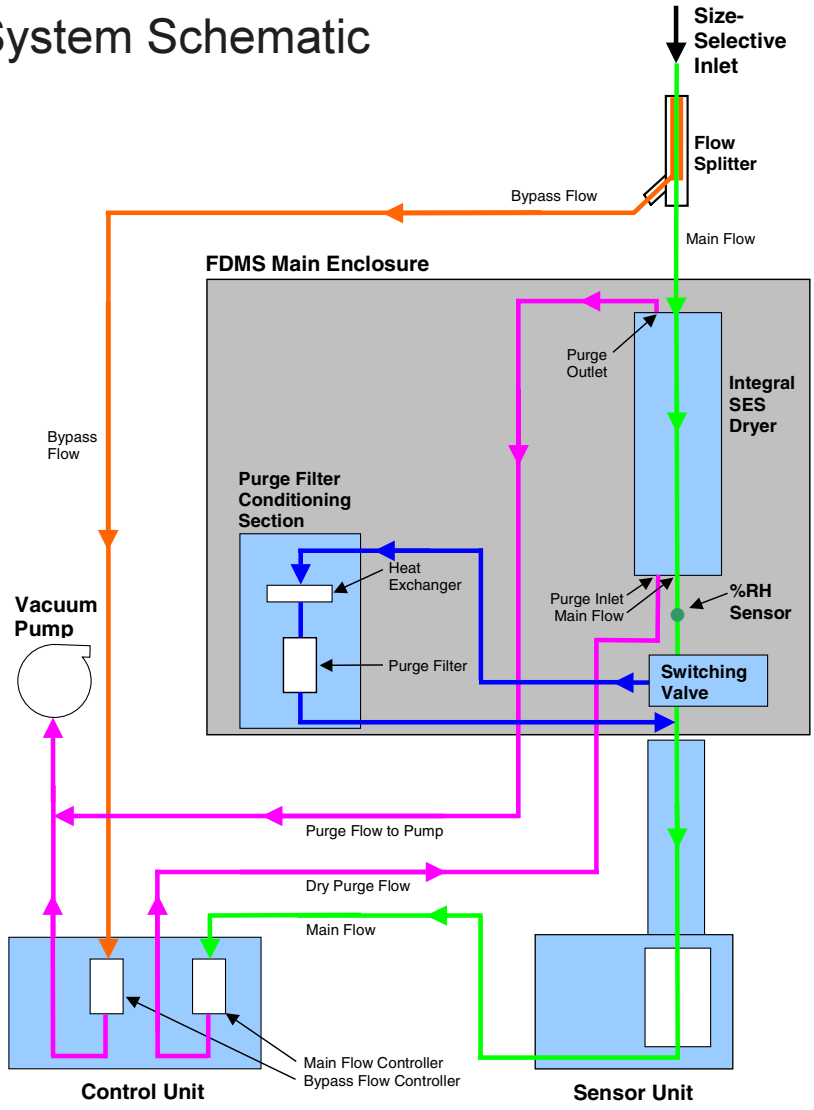
# Response to Volatile PM Materials

The FDMS System is designed to provide representative short-term readings of the ambient PM concentration, even in the presence of volatile materials. This capability is demonstrated for a laboratory challenge aerosol containing pure ammonium nitrate, a volatile material at room temperature.

Conventional PM monitoring approaches do not account for the rapid mass loss that occurs on a collection filter while sampling ambient PM. The FDMS unit, however, automatically adds such volatilization effects into its computed mass concentration result. The appropriate response of the unit to sudden upward and downward step changes in the ammonium nitrate concentration demonstrates the effectiveness of this approach.



## System Schematic




FDMS Main Enclosure.

Exchange of Purge Filter.

# Principle of Operation

The FDMS instrument computes its running PM mass concentration average based upon independent measurements of the base and reference mass concentrations. To accomplish this, the FDMS unit constantly samples ambient air and uses a switching valve to change the path of the main flow every six minutes. The sampling process consists of alternate sample and purge (filtered) air streams passing through the exchangeable filter in the TEOM mass sensor.

The purge filter in the FDMS main enclosure effectively removes aerosols at 4 °C. The exchangeable purge filter can provide a time-integrated particulate matter sample that can be used for subsequent chemical analysis. A standard R&P FRM-style molded filter cassette holds a 47 mm diameter PTFE-coated borosilicate glass fiber filter as the purge filter.

The sample and purge air flows alternately pass through the exchangeable filter in the TEOM microbalance, which generates a direct measurement of the collected mass. The system automatically adjusts the mass concentration from the particle-laden air stream by referencing it to the mass change that may occur during purging. For example, if the FDMS unit measures a decrease of filter mass during the six-minute purging period, this mass decrease is added back to the mass measurement obtained with particle-laden air.

Manual gravimetric samplers and filter-based continuous monitors have an uncertain response to mass changes due to water, secondary aerosols such particulate nitrate, and lighter molecular weight organics. Even filter tape based systems cannot avoid the loss of collected materials due to heating, drying and/or ventilation effects that occur on a time scale shorter than the sampling period between tape advances. The Series 8500 Filter Dynamics Measurement System quantifies the effects that lead to mass changes on a collection filter using NIST-traceable mass and flow measurement techniques.