# PROJECT UPDATE

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New York State Energy Research and Development Authority

Environmental Monitoring, Evaluation, and Protection Program

NYSERDA
New York State Energy Research and Development Authority

# Fine and Ultrafine Particulate Emissions Profiles

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## Project Location

Statewide


Credit: England

The Dilution Tunnel Sampler enables the use of a broad range of sampling media and analytical techniques to determine full PM component profiles.

## Contact Information

For more information on this project see:

http://www.nyserda.org/programs/environment/emep

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## Keywords

- Chemical speciation
- Dilution tunnel sampling
- Emission factors
- Emission inventories
- Fine particles
- Source apportionment

## PROJECT FOCUS

Generally, to foster the development of a new method to measure and characterize fine and ultrafine particulate matter emissions from natural gas and oil combustion systems.
Primary objectives were to:

- Design a compact dilution sampler/method, for the measurement of fine, and ultrafine particles (FPs and UFPs, respectively) emitted from combustion sources; and
- Conduct field tests using this method to collect data from stationary sources and to compare it to traditional source sampling methods.

## CONTEXT

Airborne PM comprises a broad class of materials, transported in the air as solid particles or liquid droplets (aerosols). These particles are emitted from a variety of natural processes and human activities, including fossil-fuel combustion, forest fires, wind erosion, agricultural practices, industrial manufacturing, and construction. In July 1997, motivated by concerns about the adverse health effects of PM, the U.S. Environmental Protection Agency proposed a new National Ambient Air Quality Standard (NAAQS) for particulate matter of less than 2.5 microns in diameter ($PM_{2.5}$), including maximum daily concentrations of 65 $\mu g/m^3$ and maximum annual average concentrations of 15 $\mu g/m^3$. UFPs are an important component of $PM_{2.5}$. Extremely small particles of less than 0.1 $\mu m$ in diameter, UFPs are primarily generated from combustion processes, including stationary fossil-fuel electric power generation, industrial processes, boilers, and car and truck engines.

Traditional hot-filter/impinger sampling methods for measuring PM have a number of limitations. One important problem is the variety of different conventions for sampling, analysis, and reporting, which may make data from different measuring efforts incompatible. With regard to the chemical processes involved in these methods, the condensable components of PM pose certain difficulties because of the liquid-phase conversion of gases to solids and insufficient measurement precision. Low PM concentrations can also pose a challenge for traditional sampling methods.

## METHODOLOGY

**Development of Dilution Tunnel Sampling Method**

Using a dilution tunnel sampler (DTS; see figure) the sampled gas is cooled to near ambient temperatures by dilution with filtered ambient air, resulting in conditions similar to those in the actual plume, where exhaust gases leaving the stack mix with the atmosphere. The DTS method produces fewer artifacts than traditional impinger-based methods, thus reducing bias in the results. The DTS allows a broad range of sampling media and analytical techniques to be used for full chemical and physical characterization of PM components as used in ambient air quality testing. This aspect of the project involved:

- Conducting tests to determine the effects that sampler design and operating parameters may have on the PM mass and particle size distribution;
- Designing a “next-generation” dilution sampler that is more portable and compact without sacrificing data integrity; and
- Developing a standard method for the use of dilution sampling for $PM_{2.5}$ mass measurement and characterization.

**Field Tests**

Field tests were conducted primarily on gas-fired combustion sources. Additional tests were conducted on a commercial dual-fuel heater and diesel engine generator. For most tests, $PM_{2.5}$ mass and precursor emission factors and $PM_{2.5}$ chemical speciation profiles for 40+ elements, major ions, and volatile and semivolatile organic compounds (VOCs and SVOCs, respectively) were determined.

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Credit: England
Compact Dilution Sampler (top). Method 5 vs. Dilution Sampler (below).

### *Project Status*

- Initiated 2000
- Completed 2004

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Since 1975, the New York State Energy Research and Development Authority (NYSERDA) has developed and implemented innovative products and processes to enhance the State's energy efficiency, economic growth, and environmental protection. One of NYSERDA's key efforts, the Environmental Monitoring, Evaluation Protection (EMEP) Program, supports energy-related environmental research. The EMEP Program is funded by a System Benefits Charge (SBC) collected by the State's investor-owned utilities. NYSERDA administers the SBC program under an agreement with the Public Service Commission.

These tests also compared the performance of the DTS method with existing methods used as a reference in the regulatory arena. They also allowed further refinement of the DTS method. A database of test results from this and other selected projects will be developed as the basis for an industry-specific tool for estimating emissions from industry sources.

## PROJECT FINDINGS

**Traditional Hot-Filter/Impinger Sampling Methods**

- $PM_{2.5}$ emissions from gas-fired sources are extremely low, generally below the capability of traditional methods to measure with confidence.
- Liquid-phase conversion of dissolved sulfur dioxide to sulfate in impingers, which is subsequently counted as PM mass in the analysis procedure, remains a significant source of bias and variability in PM emissions measurements from gas-fired and, in some cases, other fuel sources.
- The condensable portion of primary $PM_{2.5}$ may be overestimated due to the significant presence of sulfate artifacts.

**Dilution Tunnel Sampling**

Dilution methods offer the potential for clarification of $PM_{2.5}$ emission factors and broad chemical and physical characterization.

- The method was successfully applied to seven field campaigns on gas- and oil-fired sources, and comprehensive inorganic and organic chemical speciation profiles were developed.
- The current size of the sampler limits applications to units with adequate platforms. For widespread use, design and operating parameters for different applications and a consensus standard method need to be developed.

**General Remarks**

- Different test methods provide very different results. Data accumulated using traditional methods should not be mixed with speciation profiles from dilution sampling methods.
- For source apportionment and source-receptor modeling, dilution tunnel results are most accurate.

## PROJECT IMPLICATIONS

Currently, PM air-quality regulations focus on the FP fraction of total PM. A proper understanding of emission inventories and source contributions is therefore necessary to ensure that initiatives addressing impacts from FP are based on sound data. In particular, adequate characterization of source emission profiles is a key factor in developing equitable regulations that properly address public health concerns.

While traditionally, PM mass has been measured by testing emissions from industry smoke stacks, little attention has been paid to determining its chemical composition or to quantifying its UFP or aerosol-precursor components. Existing emissions inventories are inadequate for developing air-quality management plans as they may overestimate or underestimate the contribution of some energy-related sources to airborne PM based on the method used. Moreover, the FP and UFP emissions data currently available are very limited. Additional efforts are needed to develop realistic source emission profiles and mass emission rates. This information would serve as a basis for scientifically sound emission inventories and for successful strategies to reduce emissions from source types of special concern.

This project addressed these needs by generating both the methodology and emissions data necessary for the development of accurate emission inventories. On the basis of this study and other data, the EPA has announced it will revise the PM emissions from natural gas combustion in the final version of the 2002 National Emissions Inventory. The revision will decrease the emission factors for $PM_{10}$ and $PM_{2.5}$ by about 95%. The reason for this adjustment is that EPA believes that the current AP-42 factors for condensable emissions are too high.