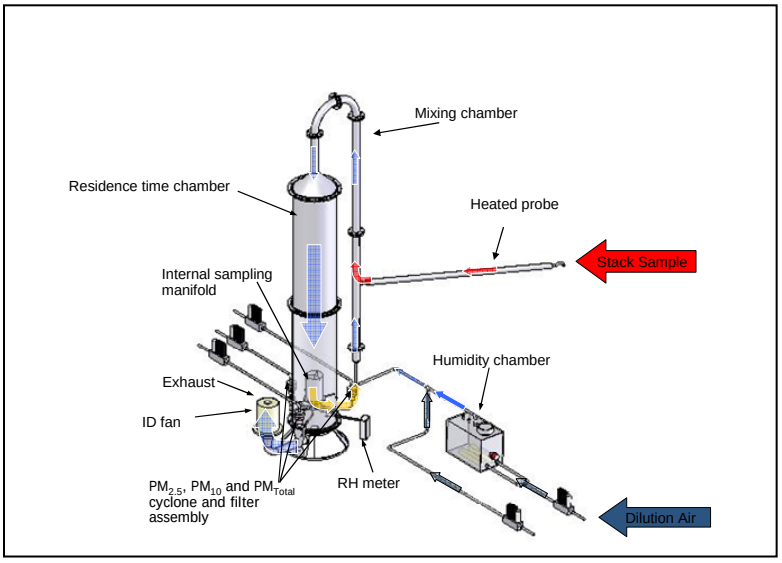
NEW MEASUREMENT METHODOLOGY FOR FINE PARTICULATE MATTER

Background

The 2000 Canada Wide Standards for particulate matter (PM) and ozone introduced for the first time limits for ambient concentrations of very fine particulate matter, known as $PM_{2.5}$ and PM_{10}. These are the particles with aerodynamic diameters less than 2.5 μm and 10 μm, respectively. They are also included in the Priority Substances List (PSL) and the Criteria Air Contaminants list of the National Pollution Release Inventory (NPRL) under the Canadian Environmental Protection Act. These new regulations, similar to those in the US, require reporting ambient particulate matter mass concentrations as they were established based on the reported associations of fine particle mass with adverse health effects including reduced lung function and cardiopulmonary ailment.

Many sources contribute to the ambient particle pollution, including stationary combustors, transportation engines and other natural emitters. Monitoring and control of these source PM emissions are critical to attain acceptable air quality. Prior to establishing PM source emission regulations for combustion sources, such as electric power generating stations and various industrial process plants, we need reliable and practical measurement methods for monitoring and compliance. Accurate emission data for different sources is also required for source apportionment, i.e., identification and quantification of the level and type of emissions that individual point sources are contributing to ambient aerosols.

However, the use of commonly available PM measurement methods have been identified as inadequate in achieving this objective, since they do not simulate the normal dilution and cooling that occur in a plume. The existing industrial database, developed using traditional source measurement techniques, provides total PM emission rates only; it contains no details on the chemical nature or size characteristics of particulates. To chemically and physically characterize the ambient PM, dilution sampling techniques were developed. Dilution sampling consists of diluting the hot stack sample with clean air in order to sufficiently cool and allow for secondary particle formation before PM samples are withdrawn.



CETC-3 prototype

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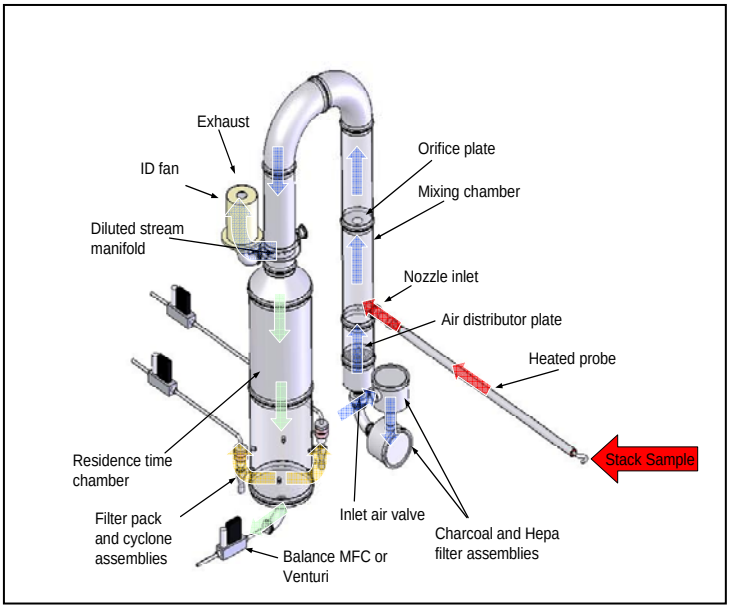
Prototype development

Currently, there are reference methods available for measuring only total particulates from sources. The process of development and verification for measuring $PM_{2.5}$ and PM_{10} is still in progress. CETC-Ottawa has developed a new sampling system and characterization methodology for fine PM from stationary combustion sources under a research consortium. Ontario Power Generation Inc., TransAlta Utilities Corporation and Environment Canada co-sponsored this research that has invested close to $1.5 million to date. The sampling protocol involves dilution of flue gas with purified air by 20 to 40 times inside a dilution chamber maintained at 40% relative humidity. Portions of the diluted gas are withdrawn through selected cyclone inlets and filter packs to collect the PM fractions. The method provides mass concentrations of $PM_{2.5}$, PM_{10} and total PM, and their size and chemical composition information. Of the dilution sampler prototypes being developed, the CETC-3 system is recognized as the most comprehensive system that optimizes ambient simulation and assures data reliability. Using a moisture injection system, realistic plume environments, such as ambient-like humidity and temperatures, are simulated for aerosol condensation and growth inside the dilution chamber. A CO_2 tracer technique ensures accurate stack sample flow and dilution ratio measurement. The CETC-4 model is a simplified version to facilitate better field application.

The features of CETC sampling systems meet the current criteria set by the United States Environmental Protection Agency's (US EPA) conditional test method for $PM_{2.5}$ and the ASTM draft method for $PM_{2.5}$ and PM_{10}. A parallel performance comparison of the CETC units and the US EPA equipment is underway.

Source characteristic profiles

A detailed analysis using computer controlled scanning electron microscopy scheme provides size and number distribution and elemental abundance of particles in different size ranges, while a multi-filter examination scheme provides comprehensive chemical characteristics of the particulate matter. These size and chemical compositions of PM emissions from each source type, known as source signatures or source profiles, are a prerequisite of source apportionment modeling. In addition, potential health impacts of fine particles are believed to be due to their relatively small size and chemical composition. Such speciation information is critical in health impact studies as well. At present, very limited data exist in this area.



CETC-4 prototype

The CETC-Ottawa prototype systems were utilized to provide several source signature profiles for different research and field combustors using a variety of fuels. These include several commercial distillate and residual fuel oils, biodiesels of different origins, bitumen emulsions and pulverized North American coal blends.

Fuel Oils & Others	Pulverized Coals
No. 2, No.4 and No.6 type oils, diesel fuel oils, Biodiesels, oil-sand bitumen emulsions, wood waste & sludge	Eastern US bituminous and US low sulphur, Canadian sub-bituminous, Lignite, PRB
86-88% C, 10-14% H, 0.004-0.4% N Fuel sulphur: 0.01, 0.05, 0.2, 0.7, 2.3, 4.5	10-15% moisture, 10-20% ash, 30-35% volatiles, 60-70% C, 4-10% H, 0.5-0.9% N Coal Sulphur : 0.2, 0.7, 0.99
Combustion Systems	
30 kW, 130 kW hot water boilers ; 1MW research furnace; 7 MW steam boiler	0.7 MW pilot-scale boiler; 160 & 340 MW utility coal-fired boilers

Fuels and Combustion Systems

Residual fuel oil-fired industrial boiler

Coal-fired electricity generating station

CETC-3 sampling system located inside utility stack

Field demonstrations

CETC-Ottawa's Fuel Assessment and Emissions team has successfully applied CETC-3 fine particulate sampler at two coal-fired electricity generating stations, one heavy oil-fired heating plant and an industrial hog fuel-fired boiler. Demonstrations provided new $PM_{2.5}$ emissions and source characteristic profiles from the 160 and 340 MW_e coal-fired boilers and 7 MW_{th} oil-fired boilers.

The fuels used at the utilities were Western Canadian subbituminous C, Canadian lignite and the Powder River Basin coal from the US. The equipment performed well at stack sampling platforms located 75m above the ground as well as indoor installations. The sampler's modular configuration also allows easy transportation and assembly on platforms with limited space.

New emission factors for particulate control strategies

For the first time the Canadian industry has $PM_{2.5}$ emission factors for a limited number of combustion installations employing different fuels and combustion equipment. The measurement methodology also provides PM speciation results and good mass balance data for each sampling site. The speciation profiles are specific to fuel type and composition, boiler and air pollution control equipment configuration, and design and other operating parameters. Based on these correlations, PM control strategies could be established for the industrial installations when sufficient field data are available.

Moving forward

CETC-Ottawa seeks future opportunities to engage in additional field measurements to establish fine PM source characteristic profiles and emission factors for many more combustion installations. By joining forces with researchers at the Meteorological Services of Environment Canada, regional air quality studies are being planned to provide source apportionment through concurrent measurements of ambient and combustion source particulates. Ultimately, the knowledge on the levels of PM contributions from specific source sectors would provide a valuable scientific basis for regulatory implementation relating to stationary source emissions.

Your Invitation to Work with Us

We are interested in collaborating with you. Please contact the Business Office to discuss your particular needs.

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