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Project Summary

Application Guide for Measurement of $PM_{2.5}$ at Stationary Sources

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This manual presents two options which allow determination of stationary source $PM_{2.5}$ emissions. $PM_{2.5}$ can be measured in conjunction with PM_{10} and it can be measured as $PM_{2.5}$ only. When determination of both $PM_{2.5}$ and PM_{10} is the object of a test series, either the Constant Sampling Rate (CSR) procedures or the Exhaust Gas Recycle (EGR) sampling system can be used. When $PM_{2.5}$ is the only size fraction of interest the CSR procedures are selected. This application guide should be used as a companion to the application guides for CSR and EGR. With all of the options, stack gas is sampled at multiple points using an in-stack inertial sampler with a constant flow rate. The operating principle of the CSR procedures limit errors due to anisokinetic sampling to within specified limits related to the maximum particle size of interest. For $PM_{2.5}$ measurements only, the maximum allowable error due to anisokinetic sampling is 10% for 2.5 µm particles. The range of duct velocities permitted for a nozzle with this maximum allowable error is broad enough that rarely is it necessary to break a traverse into subtraverses with different sampling nozzles.

The sampling device described in this manual is Cyclone IV of the SRI/EPA five-stage series cyclone. This device provides a 2.5 µm size cut at a flow rate of approximately 0.36 dscfm; the precise flow rate depends on local stack conditions. These procedures specify the precise flow rate for $PM_{2.5}$ measurements when Cyclone IV is used alone and for both PM_{10} and $PM_{2.5}$ measurements when Cyclone IV is used in conjunction with Cyclone I as a two stage inertial sampler.

This Project Summary was developed by EPA's Atmospheric Research and Exposure Assessment Laboratory, Research Triangle Park, NC, to announce key findings of the research project that is fully documented in a separate report of the same title (see Project Report ordering information at back).

Introduction

Airborne particulate matter of less than 2.5 µm aerodynamic diameter is of interest because these particles are respirable. Measurement of source particulate emissions in this size band ($PM_{2.5}$) is subject to much the same considerations as particulate matter of less than 10 µm aerodynamic diameter PM_{10} and, therefore, will require similar sampling procedures.

Two methods have been developed for determination of PM_{10} emissions. One method uses the principle of Exhaust Gas Recycle (EGR) to meet the constraints of particle sizing (constant flow rate through the sampling device) and representative sampling (isokinetic sampling at the number of traverse points prescribed by Method 1). The second method, Constant Sampling Rate, (CSR), limits error due to anisokinetic sampling and spatial variation to the level of more intrinsic errors, such as source fluctuations. A complete traverse of the sampling plane is synthesized from one or more runs operated within these limits. Although greater accuracy in mass concentration is achieved by the more stringent limits on isokinetic sampling exercised by the EGR method, development of new sampling hardware is required. The CSR method, on the other hand, uses existing Method 5 or Method 17 hardware.

Two options for $PM_{2.5}$ sampling are considered here: (1) measurement of $PM_{2.5}$ in junction with PM_{10} and (2) measurement of $PM_{2.5}$ only. When determination of both $PM_{2.5}$ and PM_{10} is the object of a test series, either CSR or EGR can be used. The procedures required for each method will be described in this text. When $PM_{2.5}$ is the only size fraction of interest, the effects of anisokinetic sampling are much less significant; consequently, the greater accuracy achieved by the EGR method becomes insignificant. For this reason, only CSR procedures will be described for this option.

This manual should be used as a companion to the operator's manuals for CSR and EGR for PM_{10} measurement. Text here is confined to those changes in procedure or hardware required to measure $PM_{2.5}$. To simplify incorporating information presented here with EGR or CSR operating procedures for PM_{10}, this manual is organized in a manner identical to the PM_{10} operating manuals,with one significant difference. Because two options are available to the operator when sampling for $PM_{2.5}$, certain sections of the text will be repeated to present the procedures for each option separately and completely. For example, Section 5A presents setup calculations for measurement of $PM_{2.5}$ only, and Section 5B presents these same calculations for measurement of $PM_{2.5}$ along with PM_{10}. Other than this duplication, all sections of the CSR and EGR manuals are incorporated into the outline for this manual, including Operating Principles, Hardware Requirements, Calibration, Pretest Activities, Sampling Parameters, Taking the Sample, Sample Retrieval, Postsampling Checks, Data Analysis, Maintenance, Audit Procedures, and Recommended Standards for Traceability.

Operating Principles

The most significant difference between the PM_{10} sampling techniques previously developed and the $PM_{2.5}$ methodology described in this manual is the two options (measurement of $PM_{2.5}$ only or measurement of $PM_{2.5}$ in conjunction with PM_{10}) available to the operator when sampling for $PM_{2.5}$. The operating principles must encompass both of these options. Generally, the principles of operation for the PM_{10} samplers ensure at worst comparable accuracy for $PM_{2.5}$ sampling. Typically, errors in $PM_{2.5}$ from anisokinetic sampling will be significantly less than for PM_{10}. The lower inertia of $PM_{2.5}$ would lead one to expect less stratification of particle concentration across a duct than with PM_{10}. Unfortunately, there are not sufficient data available to evaluate this effect. Therefore, the number of traverse points specified by the chosen sampling method (EGR or CSR) for measurement of PM_{10} will be required for $PM_{2.5}$ whether measured in conjunction with PM_{10} or not.

Sampling Hardware

The sampling system used to measure $PM_{2.5}$ for either the CSR or EGR method is the same as for PM_{10} with the exception of the particle sizing device. The only device that has been developed for the EGR method at present is a two-stage cyclone (one stage to cut at 10 μm and one stage to cut at 2.5 μm). For the CSR method, more choices exist. When $PM_{2.5}$ is the only size fraction of interest, a single-stage cyclone or a cascade impactor may be used as the sampling device. When determination of both $PM_{2.5}$ and PM_{10} is the objective of a test series and CSR is the chosen operating method, either a two-stage cyclone or a cascade impactor may be used as the sampling device. However, while cascade impactors have been recognized as viable sampling devices for the measurement of $PM_{2.5}$ and PM_{10} they are not recommended for widespread use because of the potential for error and interferences inherent in such devices. These problems would tend to increase the concentration at smaller particle diameters which can be critical to measurements of this type. To avoid these errors, an experienced operator is required.

One sampling device known to meet $PM_{2.5}$ cyclone performance specifications is the commercially available version of Cyclone IV, the fourth stage of the SRI/EPA Five-Stage Series Cyclone. Laboratory calibrations have shown that Cyclone IV produces a 2.5 μm D_{50} at a flow rate of approximately 0.36 dscfm.

The basic principles of system operation for either the CSR or EGR sampling method are unchanged by the addition of $PM_{2.5}$ to PM_{10}. However, experience has shown that, in most situations, the stages of a sampling device will not follow exactly the same scaling laws with respect to changes in cut diameter when changes in operating conditions occur. Consequently, when the two-stage cyclone sampler is used, obtaining data for both size fractions that meet the acceptance criteria for both measurements and provide the maximum tolerance for measurement error will require some compromise between these two flow rates. A number of approaches may be used to choose a flow rate within the limits of tolerance for both the PM_{10} and $PM_{2.5}$ cyclones that would maximize the allowable tolerance. The approach chosen for this manual translates the limiting flow rates into the corresponding Cyclone I D_{50}'s, chooses a D_{50} within the calculated range, and converts the chosen D_{50} into the corresponding flow rate. This approach is presented for both CSR and EGR setup calculations.

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The complete report, entitled "Application Guide for Measurement of $PM_{2.5}$ at Stationary Sources," (Order No. PB 90-247 198/AS; Cost: $23.00, subject to change) will be available only from:
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