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Project Summary

Critical Review of Open Source Particulate Emission Measurements: Field Comparison

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This project consisted of a review of sampling and analytical procedures used by various testing firms to quantify particulate emissions from open sources; e.g., roads and storage piles. Seven firms, who account for nearly 100 percent of all open source data in the literature, prepared documents describing their current sampling and analytical procedures. Five of these firms then participated in a simultaneous side-by-side field test on a simulated unpaved road at a major steel plant. Each participant independently measured the particulate emission concentrations produced by roadway traffic. These measurements produced not only the particle-size-dependence of the emissions but also the concentrations as functions of the distance above the road surface. The results for each testing organization were expressed as emission factors for total particulate and the mass fractions of the particulate with sizes <30, <15, <10, and <2.5 μm diameter. Based on an analysis of the results, it was found that all five profiling systems were capable of producing equivalent results in terms of total emissions. This was not the case for emissions by particle size. The only technique of those tested that produced reliable emission factors by particle size was the inertial sizing method.

This Project Summary was developed by EPA's Air and Energy Engineering Research 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

During the past decade, research has shown that particulate emissions from open sources such as roads and material storage piles contribute significantly to ambient particulate matter concentrations in many areas. The current EPA emission trading policy allows excessive emissions from one source to be offset by improved control of another source within the same plant. In implementing this bubble policy, many steel plants have agreed to reduce fugitive dust emissions in lieu of tighter controls on process emissions. However, the efforts of several groups to develop equipment and methods for quantifying emissions from nontraditional sources such as roadways have resulted in estimates of emission factors and emission rates with substantial variability. Whereas it is generally agreed that emission factor estimates of process emssions from ducted sources are good to ±50 percent of a specified measured value, predictions of open source fugitive dust emission factors may vary from measured values by as much as an order of magnitude. These large uncertainties are due to differences in both the measuring techniques used and the site examined. Even for sites with very similar physical characteristics, measured emissions have been found to differ by as much as an order of magnitude. In an effort to resolve these differences, the U.S. Environmental Protection Agency contracted with Southern Research Institute (SoRI) to conduct a critical review of the various measurement and predictive methods and to conduct a side-by-side field test in which testing organizations, whose methods represent the principal techniques which have commonly been applied, would simultaneously sample emissions from an unpaved road.

Part I of this review was the compilation of documents that describe in detail each testing method and data reduction technique used in developing the existing data base. As a result of Part I of this study, documents were received from seven organizations.

Each of these current procedures documents (CPDs) specifically addressed the following points:

1. A description of the testing methods and data reduction schemes employed in a specific field test conducted by that organization for the measurement of both the total particulate and the size distribution of that particulate resulting from open source fugitive emissions and other ancillary measurements such as surface loading of silt on the roadway.
2. A discussion of the historical development of the current technique with emphasis on changes that have been made and the reasons for those changes. If either the sampling or data analysis technique has undergone change, the respective organization described how data obtained before the modifications were instituted could be correlated with those obtained afterward or detail why such correlations cannot be made.
3. One or more detailed reports from recent field tests which utilized the sampling and data reduction techniques described in (1), above. Included in these reports were sufficient raw data to enable the reader to reproduce the final results quoted.
4. A discussion of how the testing and data reduction procedures described above would be modified for use at various site locations and under varying site conditions.

As a result of the review of the CPDs, four organizations were selected to participate in the simultaneous field comparison during Part II of this study. (A fifth firm participated at its own expense.) The four firms were selected because either:

1. They have made a significant contribution to the existing fugitive emission data base using different methodologies; or
2. They represent alternative methodologies not included in those selected by (1), above.

Because much of the use of the emissions trading policy with respect to roadways had been in the iron and steel industry, the desired test site was an unpaved road within an integrated iron and steel facility. Negotiations were undertaken with several companies for plant availability for the tests; the United States Steel Corporation responded favorably, offering the use of their Gary Works. The nature of the tests required a moderately long, straight stretch of roadway that was oriented more or less perpendicular to the prevailing wind and clear of local perturbing influences for a length of a few hundred meters. It was also desirable that the road have a moderately high traffic density for emissions generation. Unfortunately, all otherwise suitable roads on the Gary Works property were either paved or had been treated with chemical dust suppressant. The most suitable road section in terms of physical layout and traffic density was a paved slag haul road parallel and adjacent to Lake Michigan. Consequently, this road was made to simulate an uncontrolled unpaved road by applying a 5-10 cm thick layer of dirt to one 300 m section. This portion of the road was well away from other potentially confounding sources and wind flow obstructions. Five side-by-side test positions, each about 15 m wide, were laid out on both sides of the road near the center of the simulated unpaved road section. A total of 11 tests were conducted over a 5-day period in June 1984.

Conclusions and Recommendations

Each profiling system used in these tests exhibited both pros and cons in terms of its versatility and ease of deployment. Consequently, no conclusions are drawn as to the optimum mechanical design of the profiling towers or associated hardware. However, several conclusions may be drawn regarding the methods of sampling.

The data from this test series clearly indicate that there is significant exposure at heights up to at least the 9 m level. Consequently, the placement of a sampler at the 9 or 10 m (preferably 10 m) level is highly recommended. Also, because the maximum exposure values usually occur at a height of 1.5 to 2.0 m, any future profiling system should include a sampler at this level. The ideal profiling system would have mass samplers at 1.5, 2.5, 4.0, 6.0, 7.5, and 10.0 m, with concurrent particle sizing devices at 1.5, 4.5, and 7.0 m. This configuration would better characterize both the exposure and size distribution of the particulates in the plume. It was also demonstrated that sampling isokinetics can be maintained for each sampling head on the profiler tower. Therefore, it is recommended that each sampler be equipped with a servo system and individual velocity sensors to provide continuous adjustment of the flow rate based on wind speed at that elevation.

The five profiling systems tested were found to be capable of producing equivalent results in terms of total emissions. This was not the case for particle size distributions and emissions by particle size. Long recognized problems in reconstituting size distributions of airborne particles from resuspensions of collected bulk material lead to the conclusion that, for fugitive emission sampling of the type undertaken here, the sizing should take place prior to collection (or concurrent with collection as in cyclones and impactors). The recommended procedure for measuring the particle size distribution is the cyclone/impactor technique (used by Midwest Research Institute) with some modifications. With regard to field operations, first, a further reduction in the sampling flow rate from 20 to 15 cfm would help minimize errors from particle bounce. Alternatively, adhesive coated substrates could be used at the current 20 cfm flow rate. Second, potential errors resulting from the possible transfer of material from the outlet tube of the cyclone to the first stage of the impactor can be avoided by counting only the material collected in the body of the cyclone as its catch. The outlet tube catch would then be combined with that of the first impactor stage. At the current 20 cfm flow rate, this would result in a cyclone D_{50} of 22 μm being used rather than the current 14 μm. Lastly, while particle size was measured at the lower elevations (1.5 and 4.5 m), an additional cyclone/impactor unit at a height of about 7 m would provide additional information regarding the changes in size distribution as a function of height within the dust plume.

A better data analysis technique than the current cyclone/impactor procedure would be that commonly used in reducing in-stack impactor data from industrial sources, where a spline fit is made to the cyclone/impactor data in the cumulative percentage form of the distribution. The fit is made in a manner that requires continuity in the slope of the curve, and the solution is forced to be asymptotic to 100 percent at a diameter equal to the maximum diameter present in the sample. The fitted curve is then used to interpolate or extrapolate as needed to obtain the mass fractions in the selected size intervals. This technique avoids the requirement of assuming a functional form for the distribu

on and makes use of the complete data
et rather than just two of the data points.

With regard to the exposure integration rocedure, the resultant emission factor ppears to be relatively insensitive to the ɘchnique used so long as the exposure is dequately characterized with regard to eight. The most critical area is that where ıe peak exposures occur (usually at 1.5 ͻ 2.5 m). With samplers at 1.5, 2.5, and .0 m, this should not be a major source ꞉ error. However, under greatly different te conditions (road type, silt content, ·c), samplers at the lower elevations may ɘed to be positioned at different heights.

The utility of an emission factor predicve equation is that of predicting the emisons from a particular site in lieu of actual ıeasurements. In order that the equation ɘ applicable over a wide range of site cations and conditions, it should include ; many of the relevant parameters de꞉ribing the site as possible. This reqires ıat the predictive equation be developed om as large a data base as possible. The ղuation currently described in "AP-42, ompilation of Air Pollutant Emission Facırs," was developed from a fairly broad ıta base using multiple linear regression ·chniques. The data base has some unɘrtainties particularly with particle size stributions. These uncertainties cast ɔme doubt on the accuracy of the values ɜed for the particle size multiplier, k, in ıis equation. However, without an extenve evaluation of the existing unpaved ɪad emissions data base, there is no justi꞉ation for invalidating the relation. This ղuation is probably the most reliable prector of unpaved road emissions currently ⁄ailable. Because of past problems with ɜrticle sizing techniques, the values used ɪr k are less reliable than the overall ղuation.

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The complete report, entitled "Critical Review of Open Source Particulate Emissions Measurements: Field Comparison," (Order No. PB 86-239 787/AS; Cost: $16.95, subject to change) will be available only from:
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