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Project Summary

Identification, Assessment, and Control of Fugitive Particulate Emissions

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To assist national, state, and local control agency personnel and industry personnel in evaluating fugitive emission control plans and in developing cost-effective control strategies, the U.S. Environmental Protection Agency has funded the preparation of a technical manual on the identification, assessment, and control of fugitive particulate emissions. This report summarizes the organizational structure and content of the manual. The organizational structure follows the steps to be undertaken in developing a cost-effective control strategy for fugitive particulate emissions. The procedural steps are the same whether the sources of interest are within a specific industrial facility or distributed over an air quality control jurisdiction.

The manual summarizes the quality and extent of published performance data for control systems applicable to open dust sources and process sources. The scheme developed to rate performance data reflects the extent to which a control efficiency value is based on mass emission measurement and reported in enough detail for adequate validation. In addition to presenting a cost analysis methodology, the manual identifies primary cost elements and sources of cost data and presents a fully worked industrial example of cost-effective control strategy development.

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

Fugitive particles are emitted by a wide variety of sources both in the industrial and nonindustrial sectors. Fugitive emissions are those air pollutants that enter the atmosphere without first passing through a stack or duct designed to direct or control their flow.

Fugitive particulate emission sources may be separated into two broad categories: process sources and open dust sources. Process sources of fugitive emissions are those associated with industrial operations that alter the chemical or physical characteristics of a feed material; e.g., emissions from charging and tapping of metallurgical furnaces and those from crushing of mineral aggregate. Such emissions normally occur within buildings and, unless captured, are discharged to the atmosphere through forced or natural draft ventilation systems. Open dust sources entail the entrainment of solid particles into the atmosphere by the forces of wind or machinery acting on exposed materials. Open dust sources include industrial sources associated with the open transport, storage, and transfer of raw, intermediate, and waste materials, and nonindustrial sources such as unpaved and paved public roads and construction activities.

To assist national, state, and local control agency personnel in evaluating fugitive emission control plans and to assist industry personnel in developing cost-effective control strategies, the

U.S. EPA has funded the preparation of a technical manual on the identification, assessment, and control of fugitive particulate emissions. The manual describes the procedures for developing a cost-effective strategy for the control of fugitive particulate emissions within any specific plant or area setting. Also, it provides sources of data or in some cases actual data needed to implement the procedures.

Within the manual, cost-effectiveness is defined as the annualized cost of control divided by the reduction in total annual particulate emissions ($/Mg), as a result of the fugitive emission control system being used. Control costs include the capital, operating, and maintenance costs associated with the system over its useful life.

Scope of Document

The manual describes the recommended steps in developing a cost-effective control strategy for specific sources of fugitive particulate emissions. Whether the sources of interest are contained within a specific industrial facility or distributed over an air quality control jurisdiction, the general procedure for control strategy development is the same:

1. Source identification.
2. Preparation of an emissions inventory.
3. Identification of control alternatives.
4. Estimation of control system performance.
5. Estimation of control costs.
6. Selection of cost-effective controls.

Figure 1 summarizes the procedure. It is assumed that the need for a reduction in emissions has been determined as required to achieve a desired net improvement in air quality or to provide an offset for an increase in emissions from an expanding source operation.

Unless otherwise indicated, use of the term particulate emissions in the manual refers to the particle size fraction collected by the standard high-volume sampler, which is the reference device for the existing National Ambient Air Quality Standards for particulate matter. Although the standard high-volume sampler does not have a sharp particle size cut-point for capture of airborne particulate matter, an effective cut-point of 30 μmA (aerodynamic diameter) is frequently assigned. This particle size fraction is normally referred to as total suspended particulate matter (TSP).

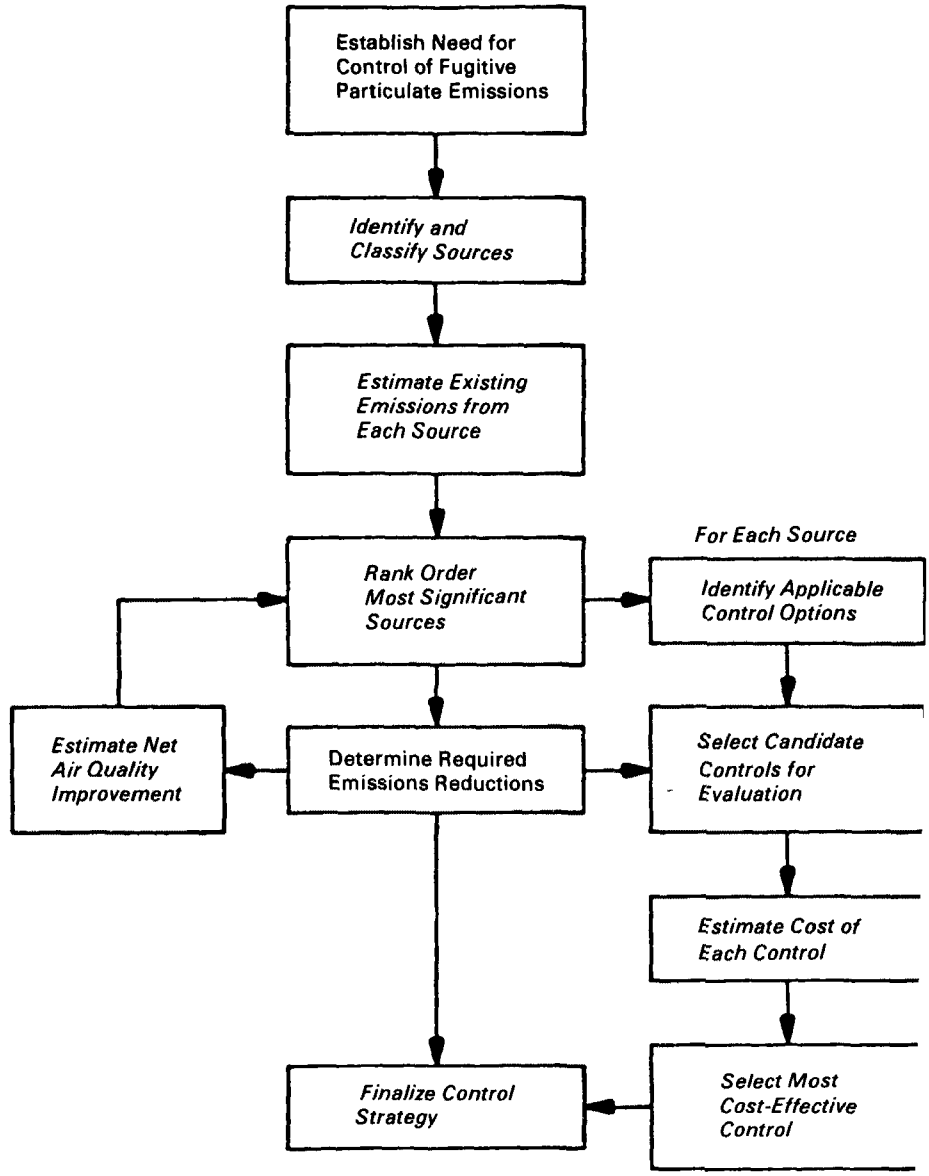

Figure 1. *Flow diagram for the identification, assessment, and control of fugitive particul emissions.*

Other particle size fractions cited in the manual include:

- TP Total airborne particulate matter.
- IP Inhalable particulate matter consisting of particles equal to or smaller than 15 μmA.
- PM_{10} Particulate matter consisting of particles equal to or smaller than 10 μmA.
- FP Fine particulate matter consisting of particles equal to or smaller than 2.5 μmA.

The organization of the manual (i.e., chapter designations) reflects an emphasis on control technology in relati to the other technical areas associat with control strategy developme Also, greater emphasis is placed open dust sources than on proc sources. This, in fact, is consistent w the larger body of available data on performance of open dust source c trols (focusing on controls applicabl unpaved roads). Finally, although fi tive particulate emissions can be duced by reducing the extent of source, the document focuses on use of add-on controls which do not fect the size or throughput of the sou

While a variety of control techniques applicable to sources of fugitive particulate emissions are discussed in the document, control efficiency values are specified only for control options which have been tested for effectiveness. However, the reader is referred to other review documents which present estimated values of control efficiency for control options which have no published performance data. The scheme used in the technical manual to rate control performance data is based on the quality of the supporting test data and the adequacy of documentation in the test reports.

The chapter contents of the manual are:

- *Chapter 2 (Source Identification)* defines the terms used to identify sources of fugitive particulate emissions, describes generic source categories, and classifies specific sources by generic category within each major industry in a matrix format.
- *Chapter 3 (Preparation of an Emissions Inventory)* reviews the standard procedures used to develop an emissions inventory and to determine the desired reduction in particulate emissions from fugitive sources.
- *Chapter 4 (Identification of Control Alternatives)* identifies control alternatives by generic category and presents a matrix of feasible control alternatives for specific sources within each major industry.
- *Chapter 5 (Estimation of Control System Performance—Open Sources)* documents and rates published performance data on open source controls, identifies the parameters which affect control performance, and compiles performance data for control alternatives applicable to each generic source category.
- *Chapter 6 (Estimation of Control System Performance—Process Sources)* documents and rates published performance data on process source controls, identifies the parameters which affect control performance, and compiles performance data for control alternatives applicable to each generic source category.
- *Chapter 7 (Estimation of Control Costs and Cost-Effectiveness)* describes estimation procedures for capital, operating, and maintenance costs, and outlines the methodology for calculating cost-effectiveness of continuously and periodically applied controls.
- *Chapter 8 (Fugitive Emissions Control Strategy Development)* is a hypothetical case study, presenting a fully worked industrial example illustrating the procedural steps for control strategy development, including the capital, operating, and maintenance costs of representative controls.
- *Appendix A (Estimation of Air Quality Impact/Improvement)* describes the mathematical modeling techniques for assessing the air quality impact of specific sources and for predicting the improvement in air quality resulting from the implementation of specific controls.
- Appendix B is a glossary of terms used in the manual.

Identification of Control Alternatives

Chapter 4 of the manual identifies control alternatives for open dust sources and for process sources of fugitive particulate emissions. More than one option for reduction of the uncontrolled emission rate can be considered. To begin with, the uncontrolled emission rate is the product of the source extent and uncontrolled emission factor. A reduction in either variable produces a proportional reduction in the uncontrolled emission rate.

Although the reduction of source extent results in a highly predictable reduction in the uncontrolled emission rate, such an approach in effect usually requires a change in the process operation. Frequently, reduction in the extent of one source may necessitate an increase in the extent of another, as in the shifting of vehicle traffic from an unpaved road to a paved road. The option of reducing source extent is beyond the scope of this manual and will not be discussed further.

The reduction in the uncontrolled emission factor may be achieved by process modifications (in the case of process sources) or by adjusted work practices (in the case of open sources). The key to the possible reduction of the uncontrolled emission factor is the knowledge of how the factor depends on the source conditions that might be subject to alteration. For open dust sources, this information is embodied in the predictive emission factor equations for fugitive dust sources as presented in Section 11.2 of "Compilation of Air Pollutant Emission Factors" (EPA report AP-42, Volume I, GPO 055-000-00251-7, September 1985).

Besides the reduction of source extent and the incorporation of process modifications, two basic techniques can be utilized to control fugitive particulate emissions: prevention of the creation and/or release of particulate matter into the atmosphere, and capture and removal of the airborne particles. Control of open dust sources by work practices fits under the category of preventive measures.

Open Dust Sources

The alternative approaches available for the control of open dust sources include:

1. Stabilization of Unpaved Travel Surfaces
   - Wet suppression
   - Chemical stabilization
   - Physical stabilization
   - Paving
2. Improvement of Paved Travel Surfaces
   - Surface cleaning
   - Resurfacing
   - Reduction of track-on
3. Stabilization of Piles/Exposed Areas
   - Wet suppression
   - Chemical stabilization
   - Physical stabilization
4. Enclosure of Piles/Exposed Areas or Materials Handling
   - Passive enclosures (including wind fences)
   - Active enclosures
5. Wet Suppression for Materials Handling
6. Plume Aftertreatment for Materials Handling
   - Fine water sprays
   - Charged fog

The first three of these categories, passive enclosures, and wet suppression are preventive measures; whereas, active enclosures and plume aftertreatment are capture/removal methods. Published performance data on open dust source controls are presented in Chapter 5 of the manual.

Most of the preventive measures involve periodic rather than continuous control application. Familiar examples are the watering of unpaved travel surfaces and the cleaning of paved travel surfaces. The resultant control efficiency follows a cyclic pattern, decaying in time from the highest value immediately after application. Because of the

finite durability of these control techniques, ranging from hours to months, it is essential to relate an efficiency value to a frequency of application. For measure of lengthy durability such as paving, the application program required to sustain control effectiveness should be indicated. One likely pitfall is the use of field data collected soon after control measure application to represent the average control efficiency over the lifetime of the measure.

For a periodically applied control measure, the most representative value of control efficiency is the time average, given by:

$$C(T) = \frac{1}{T}\int_{0}^{T} c(t)\,dt \qquad (1)$$

where C(T) = average control efficiency during a period of T days between applications (percent)
c(t) = instantaneous control efficiency at t days after application (percent), where $t \leqq T$.

It must be emphasized that the rate of control efficiency decay is heavily dependent upon the source and control variables discussed below.

Process Sources

The alternative approaches available for the control of process fugitive emissions include:

1. Wet Suppression
   - Water sprays (with and without chemical additives)
   - Foams
2. Enclosures
   - Passive enclosures (without evacuation)
   - Active enclosures (with evacuation to a dust collector)
3. Hooding Systems
   - Receiving hoods
     - Canopy hoods
     - Close capture hoods
     - Hoods for mechanically directed plumes
   - Capture hoods
     - Side draft hoods
     - Push/pull hooding systems
     - High-velocity low-volume hoods
     - Close capture hoods
4. Plume Aftertreatment
   - Fine water sprays
   - Electrostatic foggers

Wet suppression and passive enclosures are preventive measures; whereas, hooding systems and plume aftertreatment are capture/removal methods. All of these controls are designed to be continuously applied. Performance data on process controls are presented in Chapter 6 of the manual.

Estimation of Control Costs and Cost Effectiveness

Development and evaluation of particulate fugitive emissions control strategies require analyses of the relative costs of alternative control measures. Cost analyses are used by control agency personnel to develop overall strategies for an air pollution control district or to evaluate plant specific control strategies. Industry personnel perform cost analyses to evaluate control alternatives for a specific source or to develop a plant-wide emissions control strategy. Although the specifics of these analyses may vary, depending on the objective of the analysis and the availability of cost data, the general format is similar.

The primary goal of any cost analysis is to provide a consistent comparison of the real costs of alternative control measures. The aim of this portion of the manual is to provide the reader with a methodology that will allow such a comparison. It describes the overall structure of a cost analysis and provides the resources for conducting the analyses. Because cost data are continuously changing, specific cost data are not provided. However, sources of cost information and mechanisms for cost updating are provided.

The approach outlined in Chapter 7 of the manual focuses on cost-effectiveness as the primary comparison tool. Cost-effectiveness is the ratio of the annualized cost of the emissions control to the amount of emissions reduction achieved. Mathematically, cost-effectiveness is defined by:

$$C^* = \frac{C_a}{\Delta R} \qquad (2)$$

where C^* = cost effectiveness ($/mass of emissions reduction)
C_a = annualized cost of the control measure ($/year)
ΔR = reduction (mass/year) in annual emissions

The annualized cost includes capital, operating, and maintenance costs averaged over the useful life of the associated control equipment.

Cost-effectiveness for comparison of control measures or control strategies can be calculated in four steps: (1) alternative control/cost scenarios are selected, (2) capital costs of each scenario are calculated, (3) annualized costs for each alternative are developed, and (4) the cost-effectiveness is calculated taking into consideration the level of emissions reduction.

The discussion of control costs and cost effectiveness in Chapter 7 is divided into three sections: (1) a description of the general cost analysis methodology, including the various types of costs that should be considered and methods for calculating those costs; (2) identification of the primary cost elements associated with each fugitive emissions control system identified in Chapter 4; and (3) identification of the sources of cost data, including methods for updating cost data to constant dollars. Chapter 8 of the manual presents a fully worked industrial example illustrating the procedural steps for cost-effective control strategy development.

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The complete report, entitled "Identification, Assessment, and Control of Fugitive Particulate Emissions," (Order No. PB 86-230 083/AS; Cost: $16.95, subject to change) will be available only from:
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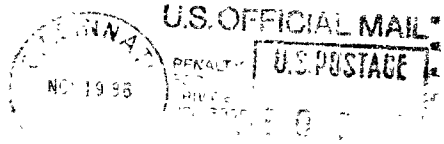

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