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Project Summary

Third Symposium on the Transfer and Utilization of Particulate Control Technology: Volume IV. Atypical Applications

F. P. Venditti, J. A. Armstrong, and M. Durham

Summarized herein is Volume IV of the four volumes of proceedings of the Third Symposium on the Transfer and Utilization of Particulate Contol Technology held in Orlando, FL, March 9-12, 1981. Volume IV papers discuss a wide variety of applications of particulate control devices and techniques: dry scrubbers, cyclones, electrostatic precipitators (ESPs), and venturis for collecting particulates under high pressure and high temperature; fugitive emissions; and opacity modeling, plume sampling, and flyash light absorption.

Volumes I, II, and III are described in three separate project summaries.

This Project Summary was developed by EPA's Industrial Environmental 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

The papers in these four volumes of proceedings were presented at the Third Symposium on the Transfer and Utilization of Particulate Control Technology in Orlando, FL, March 9-12, 1981, sponsored by the Particulate Technology Branch of EPA's Industrial Environmental Research Laboratory at Research Triangle Park, NC.

The symposium brought together researchers, manufacturers, users, government agencies, educators, and students to discuss new technology and provided an effective means for the transfer of this technology out of the laboratories and into the hands of the users.

The three major categories of control technologies -- electrostatic precipitators (ESPs), scrubbers, and fabric filters -- were the major concern of the symposium. These technologies were discussed from the perspectives of economics, new technical advancements in science and engineering, and applications. Several papers dealt with combinations of devices and technologies, leading to a concept of using a systems approach to particulate control, rather than device control. Additional topic areas included novel control devices, high-temperature/high pressure applications, fugitive emissions, and measurement techniques.

The symposium was conducted as a series of parallel sessions, each containing four to six related papers. The sessions were scheduled to avoid conflict due to simultaneous sessions dealing with the same topic. Each series of related sessions represented a thread of technology. These parallel threads, extending over the total period of the symposium, provided a highly integrated approach to the total subject of particulate control technology, with strands of specialized technologies. These strands of specialized technologies, or perspectives, provided the basis for the division of the papers into four volumes, each volume containing a set of related session topics so as to provide easy access to a unified technology area.

Volume IV Papers

Volume IV, summarized here, consists of papers grouped in the categories of advanced energy applications, fugitive emissions, opacity studies, measurements, and emissions from mobile sources. The combining of the papers under the heading "Advanced Energy Applications" provides, to persons dealing with new energy concepts, a localized collection of particulate control topics imbedded in the jargon of the energy research community, thereby enabling them to associate particulate control with the other more familiar technology of energy extraction. With the background obtained from a review of these papers, the energy-oriented technologist will then find it possible to delve into the more specialized sections of the other volumes. The application of particulate control devices to high-pressure, high-temperature combustion systems comprised the majority of these papers. Among the devices described for hot gas cleanup were ESPs, granular-bed filters, and cyclones. The energy technologies encompassed in these presentations were magnetohydrodynamics, fluidized-bed combustion, oil shale incinerators, solvent refinement of coal, and advanced gas/solids separators for coal conversion. The technology of control of fugitive emissions covered the use of techniques and processes as well as technological discrete devices. Studies on the use of windscreens as well as charged-fog and spray charging were presented. Sampling and measurement techniques unique to fugitive emission applications were also presented. The subject of opacity as a special segment of technology was well-covered in this volume by a small collection of papers. An overview of opacity dealt with the relationship of flyash-light-absorption to opacity. Other work treated the sampling and measurement of plumes and the modeling of smoke plume opacity. The topic "Measurements" covered a large portion of Volume IV with papers devoted to analysis of sulfuric acid, development of sampling trains, and design and use of real-time mass monitors. Much of the measurements material was related to inhalable particulates. Finally, Volume IV contains several papers on particulate removal from exhausts generated by mobile energy sources. These papers were all dedicated to the diesel exhaust problem and dealt with mechanical removal as well as electrostatic and electrostatically augmented removal techniques.

Section A — Advanced Energy Applications

High Temperature Particle Collection with A.P.T. EPxP Dry Scrubber

S. Yung, Air Pollution Technology

The A.P.T. EPxP Dry Scrubber is a novel device for controlling fine particle emissions at high temperatures and pressures. It uses relatively large particles as collection centers for the fine particles in the gas stream. Fine particles and collector granules are contacted in a venturi-type contactor, and fine particles are collected by the granules through the mechanisms of inertial impaction, diffusion, and electrostatic deposition. For maximum efficiency, the particles are precharged and the collectors are polarized.

Bench scale (0.5 Am^3/min) and pilot scale (4.8 Am^3/min) experiments have been run at temperatures from 20°C to 820°C to determine the performance characteristics of the system. This paper presents the system design and experimental results for the bench and pilot scale tests.

Particle Collection in Cyclones at High Temperature and High Pressure

R. Parker, R. Jain, S. Calvert, Air Pollution Technology

This paper presents the results of an experimental study of cyclone efficiency and pressure drop at temperatures up to 700°C and pressures up to 25 atm. The cyclone efficiency was found to decrease at high temperature and increase at high pressure for a constant inlet velocity.

Available theoretical models could not predict the observed effects of high temperature and pressure on collection efficiency. Pressure drop models predict the effects of temperature and pressure fairly well.

Collection efficiency data correlated well against Reynolds Number and the square root of Stokes' Number. This correlation accurately accounted for the effects of both temperature and pressure. These data are for a 2-in. diameter cyclone at relatively low velocities (less than 5 m/s). Data for a 6-in. cyclone similar configuration and operating 635°C, 700 kPa, and 36 m/s also agre well with this correlation.

Operating Results of Electrostatic Precipitators at High Temperature and High Pressure

P. L. Feldman, Research Cottrell

ESP under extreme conditions temperature and pressure has bee under investigation for over 50 year This paper presents the results of fiv pilot systems with combined operatin experience to 1700°F and 850 psi These five pilot ESPs provide a stron data base for sizing, design and operatio of a high temperature, high pressure ESI Development questions remai however, in design of the system, selection of materials, and in the actu application to pressurized fluidized-be combustors.

Control of Particulates in Process Area 12, Solvent Refined Coal Process

W. Wilks, P. D. Wilkinson, Catalytic, In

The Solvent Refined Coal (SR Process is a major undertaking in th DOE Synthetic Fuel Progran International Coal Refining Co. (ICRC), partnership of Air Products ar Chemicals and Wheelabrator-Frye, now in the design stage of a 6000 t/ demonstration plant. In many facets the process, 100% definitive solutior are not readily available, which is part the reason for the relatively larg demonstration plant. The environment problems, on the other hand, were solve with established control philosophies ar procedures.

Catalytic, Inc. is responsible for th design, engineering, and speci equipment procurement in one proces area. This paper describes th environmental effort of Catalytic, Inc. i solving the particulate problems in th area. The contents include the identific tion of the emission points, the definitic of the problem areas, the application basic control principles, and th equipment selection and design based c accepted and proven approaches.

Non-plugging Retaining Structure for Granular Bed Filter for HTHP Application

A. M. Presser, E.F.B.

Electrically augmented granular bed filters, modeled after commercial Electrified Filter Bed (EFB) technology, are being considered as HTHP particulate control devices. High efficiency filtration in a moving granular bed is achieved through the combined action of inertial impaction and electrical image forces. Plugging of granule-retaining structures by buildups of sticky dust, a fundamental problem encountered in HTHP gas cleanup, is prevented by large inlet louvers backed by a shallow "fast face" region. In this region, granules are moved at a significantly faster rate than in the remainder of the bed, sweeping away dust accumulations.

A 100-hour test of an EFB collecting Burgess No. 10 pigment dispersed in 0.38 Nm^3/sec (800 scfm) of room-temperature air at concentrations up to 5 g/Nm^3 showed no filter plugging. Dust buildups on superfluous metal structures, which might lead to problems in longer tests, were eliminated in another set of similar tests.

Particulate Emissions Control from a Coal-Fired Open-Cycle Magnetohydrodynamics/Steam Power Plant

H. H. Wang, University of Tennessee

A coal-fired open-cycle magnetohydrodynamic (MHD) power plant will generate particulates that differ significantly from those produced in conventional coal combustion. Potassium is added to the extremely hot combustion gases (approx. 2727°C) to increase gas conductivity and to capture the sulfur as potassium sulfate. This material, along with coal ash constituents that have been melted and/or vaporized and recondensed, form the particulates that must be collected. The size distribution of these particles, along with chemical composition and dust loading, must be experimentally verified. A test facility designed to fire 0.9 kg/s of coal is under construction at the University of Tennessee's Space Institute near Tullahoma, TN. In order to specify and design the most appropriate particulate collection device for the Coal-Fired Flow Facility, available information has been reviewed concerning MHD particulates and high efficiency collection devices. ESPs, fabric filters, and high energy venturi scrubbers, with and without agglomerating pretreatment, were considered.

Real Time Coarse Particle Mass Measurement in a High Temperature and Pressure Coal Gasifier Process Treatment

J. Wegrzyn, Brookhaven National Laboratory

A sampling system, using a probe appropriate for direct extractive sampling of erosive range particulate matter from a coal gasifier outlet, has been designed, constructed, and calibrated at Brookhaven National Laboratory. The sampling train is scheduled to be tested at Morgantown Energy Technology Center's 42-in. bed coal gasifier. This system consists of four modules: 1) a null balance extractive probe with porous lined tubing, 2) a stem-type virtual impactor separator, 3) a filter tape collector, and 4) a Beta-attenuation total mass detector. The key design feature of this system is the stem-type virtual impactor, which separates (at the ambient gas-stream conditions) the coarse particles from the sampling stream, so that upon filtration, no condensible vapors or any fine particles ever pass through the filter tape. The system can provide coarse particle mass flux data with a time resolution of 30 seconds or better.

The Design, Engineering, and Start-up of a Venturi Scrubber System on an Oil Shale Off-Gas Incinerator

P. A. Czuchra, FMC Corp.

This paper describes the design, engineering, and start-up of a venturi scrubber removing particulate matter and SO_2 from an oil shale retort off-gas incinerator. Since oil shale recovery is a new technology, little data exist as to what conditions are to be expected going to the scrubber. Therefore, certain assumptions concerning the design conditions had to be made. The assumptions made to develop the design criteria for the scrubber system are discussed, along with the preliminary results concerning the accuracy of these assumptions.

Fluidized-Bed Combustion Hot Flue Gas Cleanup Perspective on Cyclones and Other Devices

R. Henry, Argonne National Laboratory

Pressurized fluidized-bed combustion combined cycle generation of electricity promises appreciably higher efficiencies and less impact upon the environment than conventional boilers with flue gas desulfurization. Implementation of the combined cycle requires that flue gas to be expanded in the gas turbine be cleaned of particulates to tolerable levels. This cleanup problem is currently the focus of research and development into several types of advanced second-generation hardware; to date, the best performance has been obtained with the more conventional type cyclones. These performance data have been compared to theory, and predictions for performance for several cyclones in series show that required turbine tolerance levels should be attainable with reasonably sized equipment. Hot gas cleanup downstream from the turbine might still be required with some coal/sorbent combinations to comply with EPA's NSPS, but further development and demonstration of conventional cyclones appears justified, and, in fact is planned by several industrial developers.

Pressurized and Non-Pressurized Acoustic Agglomerators for Hot-Gas Cleanup Applications

K. H. Chou, State University of NY at Buffalo

The application of an acoustic agglomerator (AA) as a dust particle preconditioner has been recently investigated in our laboratory. Several experiments have been conducted with the following AA parameter values: AA tube diameter, 1 to 18 in.; flow rate, up to 200 scfm; pressure, 1 to 7 atm; temperature, room to 500°C; sound pressure level, up to 170 db; sound frequency, 0.4 to 20 kHz; and acoustic generator types, siren, whistles, and EM speakers.

The major advances are: 1) AA works effectively when acoustic-induced turbulence is initiated at about 160 db (this threshold value is experimentally determined and is shown to be independent of the tube size); 2) the acoustic turbulent agglomeration rate is relatively independent of the sonic frequency (to avoid the mechanical

vibration and the intensive sonic attenuation loss along the AA tube, the optimum frequency is in the range of 0.8 to 1.2 kHz); and 3) the immediate application of AA technology is limited by the lack of experience in large-scale sound generator design and operation (our preliminary results show that large air-jet choppers driven by dusty air and pneumatically controlled oscillation metallic-diaphragm generators are two possibilities with the least R&D cost).

Alkalis and Their Contributions to Corona Current at High Temperature and High Pressure

R. W. L. Snaddon, General Electric Co.

Corona is being investigated as a means of providing the charging necessary for the electrostatic augmentation of particle removal from high temperature, high pressure (HTP) gas streams. In applications such as coal fired combined cycle power generation, the HTP gases resulting from the combustion of fossil fuels usually contain alkali in the vapor phase. Because of the low ionization energies associated with alkalis, it has been feared that the presence of these species in concentrations as low as a few parts per million might give rise to prohibitively large currents. This paper describes an experimental investigation of the effects of injecting alkali salt into a HTP gas stream. The results are discussed in the light of the chemical equilibria governing the concentration of species in these systems.

Hot Gas Cleanup in Pressurized Fluidized-Bed Combustion

L. N. Rubow, Gilbert Associates

Pressurized Fluidized-Bed Combustion (PFBC) for electric power generation provides a direct combustion process for coal and low-grade fuels with the potential for improved thermal conversion efficiency, reduced costs, and acceptable environmental impacts. For the successful operation of combined cycle PFBC power plants, the gas cleanup system must be able to reduce the particulate loading and, possibly, alkali metal concentrations, in the combustion off-gas to levels compatible with gas turbines and environmental standards. With the rapid development of PFB combustors, hot gas cleanup threatens to become a bottleneck in the development of a combined cycle power generation system.

This paper summarizes the status of hot gas cleanup development for PFBC, including approaches taken for hot gas cleanup, an outline of present development programs, and a review of other special problems associated with HTP gas cleanup. Special attention is given to recent PFBC cyclone tests in series, with encouraging results. Projections of performance for commercial-sized equipment and the effect of cleanup system requirements on the PFBC cycle have also been analyzed.

Venturi Scrubbing for Control of Particulate Emissions from Oil Shale Retorting

G. M. Rinaldi, Monsanto Research Corp.

During September 1980, a mobile pilot-scale venturi scrubber, owned by EPA and operated by Monsanto Research Corp., was tested for control of particulate emissions from Laramie Energy Technology Center's 150-ton simulated in-situ oil shale retort. The retort off-gas flow of 500 acfm, discharged from a heat exchanger at a temperature of 140°F and saturated with water, was scrubbed at liquid-to-gas ratios of 10 to 20 gpm/1000 acfm. Sampling and analysis of the scrubber inlet and outlet gases were conducted to determine particulate control efficiency. In addition, sulfur compounds (SO_2, H_2S, COS), nitrogen compounds (NO_x, NH_3, HCN), hydrocarbons, CO, and trace elements were measured to assess the effects of water scrubbing on these species and to provide further characterization of oil shale retorting emissions.

Overview of the Department of Energy's Pressurized Fluidized-Bed (PFB) Combustor Cleanup Technology Program

W. Moore, U.S. Department of Energy

An overview of DOE Fossil Energy's HTP cleanup program for meeting PFB combined cycled requirements is presented. Overall scope, objectives, and schedules are reviewed for individual projects. This program is structured to accommodate both new approaches and those concepts at the subpilot scale level. Program focus is on innovative particulate and alkali removal concep including, at the laboratory sca magnetic and electrostatic granular b filtration, acoustic agglomeration, c plate scrubbing, and ceramic membra filtration. The subpilot concepts incluc an electrocyclone, a ceramic felt bag, ESP, and a fixed granular bed filter. T laboratory scale projects provide possil backup approaches for the near-te subpilot concepts that are scheduled testing in the 1982-1983 time frame the government-furnished facility Curtiss Wright Corporation (CW Woodridge, NJ. Following these subpi tests, a pilot scale cleanup system will selected for integration/test with the MW electrical pilot plant presently unc construction at CWC.

The Cyclocentrifuge — An Advanced Gas/Solids Separat for Coal Conversion Processe

P. R. Albrecht, Mechanical Technology In

Various coal conversion processes the emerging U.S. energy program ha focused renewed attention on the need develop efficient gas cleanup syster The Cyclocentrifuge is one approa being funded by the Department Energy to remove particulate matter fro coal-derived fuel gas for use in combin cycle power generation. The Cyclocent fuge is an inertial separation devic using a bladed centrifuge rotor to create high centrifugal force on the particula within a cyclone shell. Laborato development testing of a 1000 acfm u at near ambient conditions is describe Tests results include velocity profil within the unit and particulate separati efficiency measurements. The design o high temperature unit is briefly di cussed, and plans to test this unit usi 1000°F, 250 psi synthesis gas from a cc gasifier are outlined.

Section B — Fugitive Emissio

Demonstration of the Use of Charged Fog in Controlling Fugitive Dust from Large-Sca Industrial Sources

E. T. Brookman, TRC-Environmental Consultants, Inc.

A unique method for the control of pa ticulate emissions works on the princi

that most industrial pollutants acquire an electrostatic charge as they are dispersed into the air. Exposing this charged airborne material to an oppositely charged water fog enhances contact between the particulates and the fog droplets, resulting in rapid agglomeration and particle fallout. A device that generates charged fog has now been substantially developed and is being offered commercially by the Ritten Corp.

TRC-Environmental Consultants, Inc. has been contracted by EPA/IERL-RTP to test the Ritten Corp.'s Fogger IV on several large-scale fugitive dust sources. This paper presents preliminary test results in terms of percent reduction in both TSP and the inhalable fraction of TSP, and visibility improvement. The changes in fogger effectiveness due to variations in operational parameters are also discussed.

The Control of Fugitive Emissions Using Windscreens

D. H. Carnes, TRC-Environmental Consultants, Inc.

Studies have been completed which demonstrate that wind screens can effectively reduce fugitive emissions from industrial sources. The equations developed by Raine and Stevenson, which describe wind velocity reduction in the vicinity of a wind screen, were compared to results from field tests conducted by TRC on a commercially available screen. These results verify that wind screens significantly reduce incident winds and, therefore, present a viable solution to fugitive emissions problems. Some commercially available wind screens are reviewed in this paper and their respective costs are presented. A hypothetical test case demonstrates the theoretical effectiveness of a wind screen to reduce emissions. The source for the test case is an active coal pile where sediment transport results from a combination of winds and activity on the pile.

The Influence of Aggregate Pile Shape and Orientation on Particulate Fugitive Emissions

D. J. Martin, TRC-Environmental Consultants, Inc.

While it has long been recognized that pile shape and orientation have some influence on the amount of particulate matter emitted, quantitative data have been lacking. This is due primarily to the inherent difficulties of any field program which would attempt to establish such a relationship. To correct this lack, studies were conducted in a wind tunnel to determine quantitatively how pile shape influences emissions. It was found that the slope of the pile played an important part with respect to the acceleration of the wind up the front of the pile. Also, it was shown that emissions from the top of the pile depended on the orientation of the pile with respect to the wind. The implications of this study are that fugitive emissions from a pile can be reduced significantly simply by changing its shape slightly and reorienting it with respect to the wind. Estimates of the potential reduction are given.

Also, it is shown that use of water sprays, chemical stabilizers, and wind screens can be made more cost-effective by selectively applying them to the high emission areas of the piles.

Spray Charging and Trapping Scrubber for Fugitive Particle Emission Control

S. Yung, Air Pollution Technology, Inc.

The Spray Charging and Trapping (SCAT) scrubber system uses air curtains and push jets to contain, divert, and convey the fugitive emissions into a charged spray scrubber.

Experiments were performed on an 8,000 cfm bench-scale scrubber to verify the theory and to demonstrate the feasibility of collecting fugitive particles with charged sprays. The effects of charge levels, nozzle type, drop size, gas velocity, and liquid-to-gas ratio were determined experimentally. The experimental data and theoretical predictions are presented in this paper.

A prototype SCAT system was built and tested in crosswind conditions and on a hot, buoyant smoke plume. Theoretical predictions and experimental data are presented.

Improved Street Sweeper for Controlling Urban Inhalable Particulate Matter

S. Calvert, Air Pollution Technology, Inc.

Dust emissions from paved roads are a major source of urban inhalable particulate matter. A.P.T. is conducting an experimental program to develop design modifications which can be used to improve the ability of municipal street sweepers to remove inhalable dust particles from the street.

A commercial regenerative air sweeper has been purchased and modified. Major modifications include a charged spray scrubber for fine particle collection and a gutter broom hood to help contain redispersed dust particles. Design information and preliminary test data are presented.

A Wind Tunnel for Dust Entrainment Studies

E. J. Shaughnessy, Duke University

Wind-blown dust from open sources constitutes a major portion of the ambient particulate matter; e.g., waste dumps and raw-material storage piles are significant sources of fugitive emissions of potentially toxic substances. A wind tunnel has been fabricated at EPA's IERL-RTP. This tunnel is used to assess potential emissions from different dust types and source configurations, and to evaluate control techniques to reduce these emissions.

The aerodynamics of the tunnel are designed to study the effects of velocity profiles and turbulence on dust entrainment. A sampling protocol was developed to measure emission rates from several model sources. The paper describes the aerodynamics of the tunnel, the experimental procedures, and experimental data on emission rates with and without control options.

Techniques and Equipment for Measuring Inhalable Particulate Fugitive Emissions

H. J. Kolnsberg, TRC-Environmental Consultants, Inc.

EPA has initiated an extensive program to measure IP emissions from industrial sources to obtain data for the development of IP emission factors. About half of the effort has been reserved for fugitive emissions measurements at a variety of industrial sites.

To respond to the special demands of sampling in the limited IP size range, the recognized sampling methods have been modified or restricted and a number of specialized sampling devices have been developed. It is expected that the modified

methods and special devices used and the results achieved in their initial applications will provide the bases for future standard sampling procedures once an IP standard has been adopted.

Balloon Sampling to Characterize Particle Emissions from Fugitive Sources

J. A. Armstrong, Denver Research Institute

A tethered-balloon sampling system has been successfully used to investigate the vertical extent of fugitive dust emissions from various operations at a surface coal mine. Three lightweight, wind-directional particle samplers were flown simultaneously at different heights by a single balloon positioned at selected distances downwind from the mine operations.

A program to extend this sampling method has been started. A series of balloon systems equipped with IP samplers capable of sequential filtration will be used to characterize fugitive emissions from point, line, and area sources. The multiple balloon sampling technique will be coupled with the exposure profiling method to determine source emission factors. In addition, the balloon network will also allow the downwind transport of fugitive emissions to be accurately characterized.

Results of the initial surface coal mine study, as well as the status of the current program, are presented.

An Electrostatically Charged Fog Generator for the Control of Inhalable Particles

C. V. Mathai, AeroVironment, Inc.

Practical and efficient methods for the control of fugitive dust in the inhalable size range are currently of great importance to environmental researchers. A new modified prototype of an electrostatically augmented spray nozzle (fogger) has been developed and was field-tested recently.

This paper presents details of the significant modifications to the fogger to enhance the efficiency of fugitive dust control using charged water fog. The new method of charging the water droplets provides a charge-to-mass ratio of the water droplets in the range to yield maximal capture efficiency. Results from the field tests of the fogger to evaluate its potential to control fugitive dust particles from non-traditional sources under various ambient conditions are presented.

Relative Effectiveness of Chemical Additives and Wind Screens for Fugitive Dust Control

D. C. Drehmel, U.S.E.P.A.

A wind tunnel was designed and built to test the factors affecting reentrainment of dust. Initial tests determined the effects of dust type, particle size, moisture content, and velocity distribution. With the basic parameters defined, a series of chemical additives were tested. These chemicals were mixed with water and applied to the top surface of the test dust. Chemical coatings thus formed shifted the curve relating emissions to wind speed by increasing the threshold for reentrainment. Curves for coal dusts were steeper, indicating that failure of the coating occurred generally, once some small failure occurred locally.

Particle Impact Comparison Between Controlled Stack Emissions for a 2000 MW Electrical Generating Station

H. E. Hesketh, Southern Illinois University

The impact on air quality is evaluated in regard to EPA's National Ambient Air Quality Standards and PSD increments for a coal burning 2000 MW electrical generating station. This hypothetical western station is in mountainous terrain with elevations of up to 6000 ft within 20-30 mi. The comparison is based on the use of NSPS control for the boilers and BACT control for the fugitive emissions. The "Valley" model is used for this impact evaluation.

The combustion emissions are estimated, using a run of mine coal and cleaned coal at two different stack heights. The flue gas emission control system consists of a cold-side ESP followed by a flue gas scrubber. Fugitive emissions include estimates of controlled emissions from coal piles, conveyors, stackers, and dumpers. The importance of fugitive emission control relative to stack emissions in meeting PSD and air quality requirements is shown.

Operating Experience and the Techniques in the Control of Coal Dust Emissions from Large Storage Pile at Nanticoke TGS

N. Krishnamurthy, Ontario Hydro Corp.

The large coal storage and handling operation at Nanticoke Thermal Generating Station has caused significant coal dust control problems. Investigations were made to identify the principal sources of airborne coal dust. The dust emission rates and particle size distribution from different sources were measured, and dispersion was calculated.

The impact of these emissions on the area surrounding the station was estimated. Physical model studies were carried out in an open channel water flume to determine the optimum shape of the coal pile and derive optimum techniques in operation. Several coal dust control agents to reduce the dusty character of the coal were tested and evaluated. The application of these results to the Nanticoke TGS coal-pile management and experience is discussed.

Section C — Opacity

Modeling Smoke Plume Opacity from Particulate Control Equipment

D. S. Ensor, Research Triangle Institute

The ability to predict plume opacity expected for control by control equipment, such as baghouses, ESPs and scrubbers, is important in meeting air pollution regulations. A number of different kinds of models have been written for programmable calculators, personal microcomputers, and large scale computers. This paper describes the uses of these models, parametric studies conducted with the programs and model verification.

Tethered Balloon Plume Sampling of a Portland Cement Plant

J. A. Armstrong, Denver Research Institute

A remote-controlled tethered-balloon sampling system was used to collect

aerosols from a portland cement plant which had a persistent plume opacity problem. The persistent plume was always associated with the prior formation of a water condensate plume which, at times, would be detached from the stacks of the plant's ESP. When the ambient air temperature was high enough so that the water condensate plume did not form, clear stack conditions existed.

Aerosol samples were collected from both persistent and clear plumes. The plume sampling was conducted concurrently with in-stack gas sampling performed by the Gaseous Emissions Research Section of EPA's ESRL. The plume samples were analyzed by scanning and transmission electron microscopy to determine the concentration and composition of the collected aerosols. The field program is discussed, as well as analytical results and hypotheses of the persistent plume formation.

The Relationship of Flyash Light Absorption to Smoke Plume Opacity

S. J. Cowen, Meteorology Research, Inc.

The contribution of flyash light absorption to smoke plume opacity for coal-fired boilers is estimated in this work by two methods: 1) the optical absorptive properties can be directly measured by using the Integrating Plate Method (IPM), or 2) it can be estimated by measuring the carbon soot content of the flyash. The optical properties are then input into the smoke plume opacity model to determine their relative contribution. The measurement of the optical properties of flyash may also be useful for comparison with ambient aerosols to identify the relative contribution of primary particulates to downwind visibility. The IPM technique compares the light absorption through a clean Nuclepore filter to one with a single layer of aerosol by integrating the scattered light with an opal glass, so only absorption is measured. The light absorption is a strong function of particle size, so careful sizing is required for accurate measurement. The absorption data are more easily interpreted if the ash sample contains only submicron particles.

Section D — Measurements

A Special Method for the Analysis of Sulfuric Acid Mists

P. Urone, University of Florida

A number of organic dye precursors were investigated for their use as specific reagents for the detection and measurement of sulfuric acid mists in air. The underlying principle of the method was to have the sulfuric acid react with the organic dye to form a sulfonated product which would produce a specific color that could not be caused by other acids or pollutants in air.

At least five organic dyes were found to react with sulfuric acid to form a uniquely colored sulfonation product. In all cases reversal of the reaction was a recurring and serious problem. It was found that slight heating of the precursor-coated glass fiber filter with the collected sulfuric acid aerosol would fix the sulfonated product and make possible the detection and estimation of the sulfuric acid aerosol. Basic theory is discussed, and methodology, sensitivity, and reproducibility are shown.

A Microcomputer-Based Cascade-Impactor Data-Reduction System

M. Durham, Denver Research Institute

This cascade-impactor data-reduction system incorporates the Radio Shack TRS-80 computer. To provide the computational facilities required to reduce raw impactor data to a particle-size distribution, the 50% cut-points for each stage are calculated ; then the cumulative mass distribution is determined. A linear regression analysis is then applied to this distribution in log probability space to determine the log normal distribution parameters. A spline fit routine is used to mathematically describe the cumulative distribution and to generate the first derivative curve, or the Delta Mass/Delta Log D_P curve. A mathematical function is used to extrapolate the data to the maximum particle diameter to determine the amount of mass below the inhalable particulate matter (IP) 15 μm cut. Additional programs provide the capability to statistically combine similar runs and to calculate the efficiency of a control device as a function of particle size.

Development of a Sampling Train for Stack Measurement of Inhalable Particulate

A. D. Williamson, Southern Research Institute

A new system consisting of two cyclones operated in situ, followed by a diluter operated outside the process stream, has been developed to measure the emission of inhalable particles from stationary pollution sources. Collection efficiency of 50% for 15 μm particles was achieved in the initial cyclone at flow rates of 11, 20, and 23 l/min, respectively, at temperatures of 23, 93, and 150°C. At each condition the collection efficiency of the second cyclone was found to be 50% for the particles of $2.5 \pm 0.6\,\mu$m diameter. From the second cyclone, the fine particles pass through a heated probe into the dilution device. The temperature and relative humidity of the dilution air are adjustable, and dilution ratios from 10:1 to 40:1 are possible, with standard operation at a dilution of 25:1. Provision is made to sample the resulting "plume" in the diluter with absolute filters, cascade impactors, electrical aerosol analyzers, optical particle counters, or diffusion batteries.

Inhalable Particulate Matter Sampling Program for Iron and Steel: An Overview Progress Report

R. McCrillis, U.S. EPA

EPA's Office of Research and Development has entered into a major program to develop IP emission factors. The Metallurgical Processes Branch of EPA's IERL-RTP is responsible for the iron and steel industry segment of this program. To date, implementation has proceeded along two major lines of action: 1) the classical route from literature review through prioritization of sources, identification of sources for which existing data is adequate, selection of plants, testing, and reporting results; and 2) meshing the IP requirements with that of other EPA sampling programs, thus reducing overall cost to EPA and minimizing inconvenience to the host plants.

Development of IP Emission Factors

D. L. Harmon, U.S. EPA

In response to the Clean Air Act Amendments of 1977, EPA is considering an IP ambient air standard. Emission factors for inhalable particles are required for implementation of the standard. Steps have been taken to develop IP sampling techniques, extrapolate existing data on particulate characteristics to the IP size range, and select sampling strategies for major sources, based on national and regional impact within budgetary constraints. Three year contracts were awarded to three contractors in September 1979, to conduct plant surveys and source characteristics for IPs. A list of major sources has been developed and testing is underway.

Inhalable Particulate Emission Factor Program Purpose and Development

F. M. Noonan, U.S. EPA

EPA is reviewing the technical criteria and data bases to determine whether the establishment of a particle size based National Ambient Air Quality Standard for IP is warranted. The Clean Air Act would require states to develop and submit revisions to their state Implementation Plans. The revisions would necessitate the collection and use of information from existing and future sources. Thus, a need exists to initiate development of an emission factor data base.

The basis and objectives of the IP program to obtain emission factors are presented. Due to the limitations of resources and the large number of sources to be characterized, source categories had to be selected for the program. The criteria for selection and prioritization of source categories are presented.

Inhalable Particulate Emission Factors for Blast Furnace Casthouses in the Iron and Steel Industry

P. D. Spawn, GCA/Technology Division

This paper presents the results of IP measurements on blast furnace casthouses. Historically, emissions from the blast furnace casting operation (tapping of iron) have been uncontrolled and emitted through building roof monitors. Consequently, mass emission factors and particulate size distributions could be neither easily, nor accurately, measured.

In the fall of 1980, GCA measured total mass and the IP fractions at two controlled casthouses. These tests were performed on the inlets to the baghouse control devices, thus providing an uncontrolled casthouse emission factor. Concurrent with emission measurements, furnace operation and the emission sources inside the casthouse were documented to enable comparison of these tests to other uncontrolled casthouses.

Inhalable Particulate Emissions from Vehicles Traveling on Paved Roads

R. Bohn, M. Small, Midwest Research Institute

This paper gives results of a field sampling program to test the quantity of dust emissions from vehicles traveling on paved urban roads. The sampling protocol focused on the exposure profiling technique. Emission factors were determined for total suspended particulate, inhalable particulate, and fine particulate. The vehicle exhaust component of the total emissions was separated from the traffic entrained particulate on the basis of lead/bromine ratios obtained through an elemental analysis of the collected particulate.

Samples of the dust found on the road surface silt. The relationships of measured emission factors to road surface silt loadings and vehicle characteristics were investigated.

Quality Assurance for Particle-Sizing Measurements

C. E. Tatsch, Research Triangle Institute

Quality assurance for particle-sizing may be considered in three components: 1) planning, 2) implementation, and 3) appraisal. The first two components relate to activities designed to ensure that the data generated will satisfy project requirements. The last relates to activities designed to assess and document the quality of the reported data. Suitable resources for routine end-to-end field calibration of particle-sizing systems are not readily available. Only certain subsystem parameters may be checked in the hostile environments generally associated with such tests. Therefore, thoughtful execution of a well-designed test plan is crucial to the production high quality data.

Appraisal of data quality consists o combination of qualitative a quantitative checks on operations critic to measurement data quality, a includes reviewing the adequacy of, a adherence to, written operati procedures. Quantitative checks m include checks of various subsyste components, such as flowrate, noz quality, weighing checks, and co-locat measurements. Emphasis must be on t comparability of test data, wi increasing potential for improvi precision and accuracy of particle-sizi data.

Particulate Emissions Characterization for Oil-Fired Boilers

D. Mormile, Consolidated Edison Company of New York, Inc.

The size distribution and compositi of particulate matter emissions fr three oil-fired boilers, representative utility usage, were determined nominal operation under full-lo operating conditions. The selected boile were a 360 MW tangentially fired boil a 346 MW faced fired boiler, and 150,000 lb/hr steam flow steam sendo boiler. In addition, the variability of the particulate characteristics, with chang in excess air level and atomization quali was assessed.

Sizing characteristics were establish with a low pressure, cascade impact system (University of Washington), electric aerosol analyzer (which classifi size according to electric mobility), a electron microscopy techniques wi automatic counting. Particle compositi analyses utilized atomic absorption bulk samples and electron dispersive ray (EDX), Auger Microprobe, a electron spectroscopy (ESCA) individual particles.

A Continuous Real-Time Particulate Mass Monitor for Stack Emission Applications

J. C. F. Wang, Combustion Resear Division

Mass loading and size distribution a the critical parameters which EPA us

for air pollution monitoring and control. Commercially available instruments for detection of particulates are either optical types, which do not measure particle mass directly, or sampling types, which do not provide real-time measurements. Last year, we demonstrated the feasibility of using the tapered-element oscillating microbalance (TEOM) for real-time particle mass measurements at room temperatures. We are now developing for high-temperature applications (up to 300°C) a new TEOM which features periodic backflush for long-duration continuous operations and an interface to a multi-staged cyclone-train for real-time aerodynamic particle size distribution measurements. Fractional particulate mass loading, at 50% cut size of 1, 3, and 10 μm, is obtained using the modified cyclones in the Source Assessment Sampling System (SASS). Test data on the performance of this new monitor are reported.

Section E — Mobile Sources

Studies of Particulate Removal from Diesel Exhausts with Electrostatic and Electrostatically Augmented Techniques

J. L. DuBard, Southern Research Institute

Laboratory experiments on a 5.7 liter GM diesel truck have established the concept of removing particulate emissions from diesel exhaust by a combination of agglomeration and trapping devices. A two-stage ESP is used to agglomerate the primary particulate matter, resulting in an order-of-magnitude increase in mass median diameter. The agglomerated particulate is characterized. Aerosol sampling data are presented for the variation in particle size distribution and the efficiency of trapping the agglomerated particulate in cyclones, fiber filters, and a granular bed filter. Overall mass removal efficiencies greater than 80% have been achieved with an ESP/granular bed filter system for a duty distance greater than 500 miles at constant highway speed. Methods of cleaning the devices and removing collected particulate are discussed. A design for a prototype exhaust cleaning system for a light-duty diesel vehicle is based on these data.

Studies of Particulate Removal from Diesel Exhausts with Mechanical Techniques

M. G. Faulkner, Southern Research Institute

A series of tests, designed to characterize the collection of particulate emissions from diesel exhaust by several different mechanical methods, are discussed. The source of particulate emissions is a 5.7 liter GM diesel truck. The control devices which are discussed include fiber filters, gravel bed filters, and trap/cyclones. The overall mass collection efficiencies, fractional mass collection efficiencies, and operating characteristics of these devices were determined by measurements of inlet and outlet total mass loadings and particle size distributions.

Three different fiber filter materials were investigated and collection efficiencies as high as 90% were achieved, coupled with a quick pressure rise culminating in gas sneakage. The gravel bed device achieved efficiencies which increased from 45% to 70% as system backpressure increased. The trap/cyclone (Japanese Aut-Ainer) achieved collection efficiencies of about 35% with a low pressure drop.

Update on Status of Connecticut's Control Program for Transportation-Related Particulate Emissions

H. L. Chamberlain, Northeast Utilities

Connecticut's unique State Implementation Plan (SIP) is presented.

Results of extensive testing to further define transportation-related TSP emissions in Waterbury, CT, are summarized, and preliminary conclusions regarding control strategies are discussed.

Control programs include both exhaust controls for exhaust emissions and fugitive controls for reentrained particulate material.

The success and cost of these controls are of interest, both as a means of achieving air quality standards and as a potential source of reductions for "offset" and "banking" programs. Potential interaction of mobile and stationary source controls exists.

F. P. Venditti, J. A. Armstrong, and M. Durham are with the Denver Research Institute, Denver, CO 80208.
***Dale L. Harmon** is the EPA Project Officer (see below).*
The complete report, entitled "Third Symposium on the Transfer and Utilization of Particulate Control Technology: Volume IV. Atypical Applications," (Order No. PB 83-149 617; Cost: $32.50, subject to change) will be available only from:
National Technical Information Service
5285 Port Royal Road
Springfield, VA 22161
Telephone: 703-487-4650
The EPA Project Officer can be contacted at:
Industrial Environmental Research Laboratory
U.S. Environmental Protection Agency
Research Triangle Park, NC 27711