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Project Summary

Third Symposium on the Transfer and Utilization of Particulate Control Technology: Volume I. Control of Emissions from Coal-Fired Boilers

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

Summarized herein is Volume I of the four volumes of proceedings of the Third Symposium on the Transfer and Utilization of Particulate Control Technology held in Orlando, FL, March 9-12, 1981. Volume I papers discuss control of emissions from coal-fired boilers. Most of the papers deal with fabric filters and electrostatic precipitators (ESPs); also discussed are dry SO_2 scrubbers and conventional scrubbers.

Volumes II, III, and IV 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 Volume I of the 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 I Papers

Volume I, summarized here, consists of papers dealing with the control of emissions from coal-fired boilers. One section of Volume I deals with fabric filters and covers the characterization, or modeling, of a fabric filter, operating experiences with fabric filters on coal-fired plants, electrostatically augmented fabric filters, and pulse jet filtration under conventional and electrostatic-charge conditions. The second section of Volume I is dedicated to the use of ESPs. It covers two-stage ESP demonstrations and evaluations, resistivity studies, pulse-energized ESPs, and conditioning to improve hot- and cold-side ESP performance. The third section of this volume deals with dry SO_2 scrubbers and treats dry injection, two-stage cleaning, and the applications of SO_2 scrubbing in bag house systems. One paper was devoted to the use of a venturi scrubber and the operating experiences encountered.

Section A—Fabric Filters

Coal Properties and Flyash Filterability

R. Dennis,
GCA Corporation Technology Division

The results of a survey of U.S. coal sources, types, compositions, production, and use are described. Coals most likely to be burned in applications where fabric filters are used were identified. Physical and chemical properties of these coals and their mineral constituents were evaluated for potential impact on resultant flyashes. Several ASTM criteria commonly used to delineate coal fouling and slagging properties were examined for probable impact upon flyash size and surface properties. Consideration was also given to the method of coal combustion, operating temperatures, fusion and hardness properties of mineral constituents, and slag viscosity as possible factors in determining flyash filtration characteristics. High alkalinity contents were examined for their potential to increase flyash gas and moisture absorption. A major purpose of the survey was to provide a rationale for selecting representative flyash samples for laboratory determination of the specific resistance coefficient (K_2) and the cleaning parameter (a_c).

Pulse-Jet Filtration with Electrically Charged Flyash

R. P. Donovan,
Research Triangle Institute

Pulse-jet performance equations differ from those of reverse-air cleaned or shaker baghouses, especially when operated at high air-to-cloth ratios, as has been described by Leith, Ellenbecker, Dennis, and others. These differing performance equations imply that dust electrical charge should influence pulse-jet performance differently than, say, shaker-baghouse performance. Measurements exploring this prediction are presented and the observed performance effects of dust electrical charge are interpreted in terms of contemporary pulse-jet models. Comparisons with the shaker baghouse are emphasized.

Electrically Charged Flyash Experiments in a Laboratory Shaker Baghouse

L. S. Hovis, USEPA

As has been demonstrated for numerous dust/fabric systems, increasing the electrical charge of the dust particles dramatically reduces the K_2 values of the dust cake formed by such particles. This demonstration has been repeated in a room-temperature-operated shaker baghouse, using redispersed flyash from Southwestern Public Service with silicone-graphite finished fiberglass bags. The observed dependencies of this effect on operating time and relative humidity are presented.

Prolonged operation with a charged flyash gas stream at 50% relative humidity causes the low K_2 values, characteristic of highly charged dust, to gradually increase to the range characteristic of uncharged dusts. Increasing the operating relative humidity to 70% rapidly restores the low K_2 operation. These observations are interpreted in terms of flyash electrical resistivity and its role in electrically enhanced dust filtration.

Electrostatic Augmentation of Fabric Filtration

D. VanOsdell, Research Triangle Institute

The performance of fabric filters can be substantially improved through the use of an electric field parallel to the collector surface. The field is created by parallel wires adjacent to the fabric, with alternating electrical polarity and relatively high potentials. The electric field leads to improved collection efficiency and a modified dust cake which has a lower resistance to gas flow.

A project team composed of RTI, ETS, and TRI, under the sponsorship of EPA, reports on the process at pilot scale, utilizing a slipstream from a coal-fired boiler. This paper discusses the design and implementation of the pilot unit, test methods and results, conclusions, economic projections, and future plans for this continuing study.

Fabric Wear Studies at Harrington Station

R. Chambers,
Southwestern Public Service Co. (SPS)

SPS, among several other utilities, conducted a fabric evaluation program in conjunction with an EPA study at its Harrington Station. This paper discusses SPS's experience with fabrics and some of the conclusions that have been drawn from (1) the use of systematic physical testing on fabrics to monitor fabric wear and eventually predict fabric life, (2) an analysis of fabric wear mechanisms at Harrington Station, (3) results of individual compartment throughput measurements for various fabrics, and (4) fabric failures by compartment position.

SPS Pilot Baghouse Operation

W. Hooks,
Southwestern Public Service Co.

In 1977, EPA contracted with SPS to assess the performance of a large fabric filter system used on a new utility boiler burning low sulfur Western coal. One option provided for the installation of a pilot filter system on-stream with Harrington Station Unit 2. This paper outlines the overall objectives of the pilot unit program. In addition, proper system design, problems in start-up and operation, and a fabric evaluation program are discussed.

A Review of SPS Investigation of Harrington Unit 2 Fabric Filter System

K. Ladd,
Southwestern Public Service Co.

For the last 3 years, SPS has tested and monitored the Harrington Station Unit 2 fabric filter system to characterize its operation. The unit was one of the first

large air quality control devices to be used in association with a low sulfur, coal-fired boiler. This paper reviews the start-up, monitoring, testing, and operation of the fabric filter system since an EPA sponsored program began in October 1977.

Numerous operation and maintenance problems encountered in the first year of the program are discussed. Also, a summary of the extensive flue gas and particulate sampling performed by both SPS and GCA in an effort to characterize the baghouses is presented.

A Summary of Performance Testing of the Apitron Electrostatically Augmented Fabric Filter

D. J. Helfritch, Apitron

The Apitron filter is currently the only commercially operating electrostatically augmented fabric filter. As such, it has been intensively investigated by industry and governmental agencies over the past several years. A large amount of performance data has been gathered. Following a brief description of Apitron operating principles, these data are reviewed and compared for consistency. General conclusions are drawn from the data regarding performance improvements which result from electrostatic augmentation. These conclusions are compared to those predicted by available theory.

Fabric Filter Operating Experience from Several Major Utility Units

O. Fortune, Buell Envirotech Corp.

This paper presents operating experience with several reverse-air fabric filter units operating with pulverized-coal and cyclone-type boilers. Start-up experience with different firing techniques (coal, oil assist, gas) is presented.

Field pressure drop data are correlated with a model. This field correlation demonstrates the dependence of pressure drop on the flyash particle size distribution, grain loading density, cleaning, and air-to-cloth ratio. This model explains the high pressure drop experienced by some units on lignite coal. The impact of alternative cleaning cycles upon pressure drop is compared based on modeling. The impact of various cleaning cycles on pressure drop is verified by field test data.

Flyash particle size distributions from various compartments and within compartments are compared for a few units to investigate industry's conjecture of variable particle size in different compartments.

Evaluation of the 25 MW Kramer Station Baghouse: Trace Element Emission Control

M. W. McElroy,
Electric Power Research Institute (EPRI)

This paper describes a major EPRI research program characterizing the emission control performance of fabric filter baghouses in coal-fired utility boiler applications. An integral part of this program is the determination of particulate matter chemical composition and collection. The effort reported here is an evaluation of the Kramer Station baghouses of the Nebraska Public Power District. These units represent the first application of fabric filter control technology to pulverized-coal-fired utility boilers burning a western, low-sulfur, subbituminous coal.

The collection efficiency of over 35 individual trace elements was essentially equivalent to that of total mass. Size-dependent chemical analysis for nearly 30 elements over a 0.50-10 μm diameter size range further reveals that the vast majority of elements exhibit penetration profiles remarkably similar to total mass. A notable exception was selenium, which exhibited much higher penetration. Inlet size distributions indicated fine particle enrichment for several elements relative to the matrix elements. This behavior was still evident at the outlet of the baghouse, despite very low outlet emissions.

Characterization of a 10 MW Fabric Filter Pilot Plant

R. C. Carr,
Electric Power Research Institute (EPRI)

EPRI is conducting a baghouse pilot plant program to define design and operating parameters which will improve the reliability, economics, and collection efficiency of fabric filters. This paper reports results of the air-load and start-up tests. Air-load test results include the effects of hopper inlet design on the gas flow distribution and dust stratification in the inlet duct, hopper region below the tube sheet, and through the tube sheet from bag to bag. In addition, data are reported illustrating the reverse-air-flow distribution from bag to bag, and the re-entrainment of dust from the hoppers under several inlet-flow conditions. Start-up test results show the effects of bag precoat, cleaning method and cycle, and gas/dust flow distributions on operating pressure drop and particulate matter penetration.

Specifying a Fabric Filter System

R. L. Ostop, City of Colorado Springs

Fabric filtration is emerging as an alternative to hot-side precipitators and flue gas conditioning for control of flyash from low sulfur coal. With the new application of this old technology, fabric filter baghouse applications have resulted in many successes; and in some instances, systems that were not so successful. This paper presents the basic information needed to specify a fabric filter system that will provide cost-effective operation. The discussion includes the conceptual requirements for specifying such parameters as air-to-cloth ratio, pressure drop, by-pass capability, inlet and outlet valve requirements, pneumatic and electronic control systems, and emergency control instrumentation.

Evaluation of the 25 MW Kramer Station Baghouse: Operational Factors in Particulate Matter Emission Control

R. C. Carr,
Electric Power Research Institute (EPRI)

The effort reported here is an evaluation of emission control performance of the Kramer Station baghouse of the Nebraska Public Power District. Results show that the baghouse cleaning cycle had the greatest effect on particulate matter removal efficiency compared to any other operational parameters. Implementation of a "preferred" 100-minute cleaning cycle, obtained by extending the time between compartment cleaning from zero to 8 minutes, reduced particulate matter penetration by 50% without an increase in pressure drop. Total particulate matter collection efficiency measured for the baghouse with the preferred cycle in effect averaged 99.93%, with associated outlet emissions and stack opacity of 0.002 lb/10^6 Btu and 0.07%, respectively. In addition, the baghouse size-dependent mass collection efficiency exceeded 99% over the 0.02-10 μm size range.

Pulse-Jet Type Fabric Filter Experience at Air-to-Cloth Ratios of 5 to 1 on a Boiler Firing Pulverized Coal

G. L. Pearson, Adolph Coors Co.

Since November 1979, a modular baghouse of Carter-Day design has been in operation controlling emissions from the Boiler No. 5 pulverized-coal-fired unit rated at 450,000 lb/hr. Bags are made of felted Ryton and are cleaned using the pulse-jet technique.

An overview of the system and operating experience with this 12 module unit is presented. Data on outlet particulate emission, pressure drop, cleaning cycles, and cleaning frequency are reviewed.

Selection and Operation of Baghouses at R. D. Nixon Station, Unit 1

R. C. Hyde, Joy Industrial Equipment Co.

This paper discusses the selection criteria and the subsequent successful operation of two baghouses which have been in continuous service since April 1980, at the R. D. Nixon Station, Unit 1, servicing a 220 MW boiler.

The paper identifies the specification criteria deemed most important for a successful baghouse installation and reviews the architect's decision-making process in selection of this type of air pollution control equipment. Results from the first 6 months of operation are presented, including pressure drop, opacity, and outlet emission. To date, the unit has operated with low outlet emissions and low-pressure drop (3-4 in., W.C.). Additionally, start-up, shutdown, and maintenance procedures are discussed.

Potential for Improvement in Baghouse Design

R. Jensen, Bechtel Power Corp.

This paper describes design deficiencies of large, structural, reverse-air baghouses of the type now being applied to remove flyash from large coal-fired power plants. Analyses, curves, and data show that some of the currently acceptable and recommended design details cause unnecessary pressure loss, increase the energy required for cleaning, and decrease bag life. The paper also demonstrates that cloth ratio has no real meaning: it is nothing more than a sizing parameter and, in fact, actual cloth ratios exceed the design cloth ratio. The consequences of the design deficiencies are more important to the utility industry than to industrial users because of the differences in evaluation methods. Correction of the deficiencies would be of value to both.

Review of Operating and Maintenance Experiences with High-Temperature Filter Media on Coal-Fired Boilers

L. K. Crippen and H. H. Forsten
E. I. DuPont de Nemours & Co.

Operating and maintenance procedures which can affect bag life and performance at high operating temperatures in dry gas filtration are reviewed using case histories for Teflon and Nomex fibers in a variety of applications. Maintenance experiences are examined from both a preventive and a problem-solving orientation. Operating problems and their solutions are included. Bag refurbishment is outlined. The review of experiences on full-scale coal-fired industrial boiler applications using Teflon fiber includes an installation in operation for more than 5 years.

Section B—Electrostatic Precipitators

Pilot Demonstration of the Precharger-Collector System

P. V. Bush, Southern Research Institute

Results from the evaluation of a 1000 acfm pilot scale precharger-collector system in September 1979, justified the development of a larger scale two-stage ESP system. A pilot demonstration system with a 30,000 acfm gas volume capacity was designed, fabricated, and installed at TVA's Bull Run steam plant. Continuous monitors interface to a computer/data acquisition system to provide real-time mass efficiency, outlet particle-size distribution, SO_2 concentration, and ESP voltages and currents. These measurements are supplemented with standard stack sampling techniques for selected ESP conditions. Start-up information and preliminary data are presented.

Remedial Treatments for Deteriorated Hot-Side Precipitator Performance

R. E. Bickelhaupt,
Southern Research Institute

Adding a sodium compound to the coal feed of a steam generating system with a poorly operating hot-side ESP greatly improved the performance of the ESP. This report describes laboratory work conducted to: (1) re-create and examine the conditions prevailing when the hot-side ESP was in a deteriorated condition, (2) substantiate earlier evidence for the sodium depletion hypothesis, and (3) determine the effect of the sodium addition and the mechanisms whereby sodium addition is beneficial.

The data show that 1 X 10^{10} ohm cm resistivity ash can develop high resistivity (1 X 10^{12} ohm cm) when held for a long time under electrical stress on a collection plate. Furthermore, it has been confirmed that the sodium concentration in the thin film of ash contiguous to the collection electrode is reduced. The circumstantial evidence suggests that conditioned ash acts as a source of sodium that diffuses toward the sodium depleted zone under the influence of the concentration gradient.

Evaluation of the United-McGill Electrostatic Precipitator

D. S. Ensor, Research Triangle Institute

A United-McGill ESP installed on an industrial coal-fired boiler was field tested. Included in the testing were measurements of particle-size distribution from 0.05 to 10 μm, opacity, charge-to-mass concentration, mass concentration, resistivity, and plant parameters. The particle-size dependent efficiency, rapping losses, and power requirements are reported for the unit. A mathematical model describing the performance is presented.

Predicting the Effect of Proprietary Conditioning Agents on Flyash Resistivity

R. J. Jaworowski,
Apollo Technologies, Inc.

Flyash resistivity plays an important role in the performance of ESPs. As ash resistivities approach approximately 5 X 10^{10} ohm-cm, operational problems occur.

Recognition of flue gas conditioning agents as a means to lower ash resistivity has placed increased emphasis on the development of predictive methods to determine how the resistivity will be influenced by a specific chemical.

Based on previous work by Bickelhaupt and Sparks, a correlation has been developed to predict the effect of proprietary chemicals in flyash resistivity. The corre-

lation is relatively insensitive to temperature, field strength, and coal type.

Data obtained from field trials are used to demonstrate the effectiveness of this approach. A comparison of predicted results with field data yields favorable agreement.

SO_3 Conditioning to Enable Electrostatic Precipitators to Meet Design Efficiencies

J. J. Ferrigan, Wahlco, Inc.

This paper deals with a case study to choose an effective and reliable method of increasing the collection efficiencies of two new ESPs, plagued with high resistivity flyash. The study is traced from the time of erection of the two cold-side ESPs in the early 1970's to the final solution (SO_3 flue gas conditioning) in 1979.

The paper goes into detail on mechanical modifications and consultants' recommendations, which were undertaken to no avail. It then points out that, after all possible mechanical "fixes" had been completed, proprietary chemical conditioning of the flue gas was tried, which proved to be more detrimental than good. As a last resort, SO_3 flue gas conditioning was tried, and it brought both cold-side ESPs into design compliance. These facts are supported by ESP outlet grain loading tests, which show that the proprietary chemical conditioning would not come within a factor of 10 when trying to meet the guarantee of 0.02 gr/scf, while SO_3 flue gas conditioning enabled the ESPs to operate under the 0.02 gr/scf limit.

Enhanced Precipitator Collection Efficiencies Through Resistivity Modification

D. Mahoney, Apollo Technologies, Inc.

High resistivity process dusts and flyashes from low-sulfur coal may be modified by chemical treatment to improve cold-side ESP performance. A new series of noncorrosive, neutral pH additives have been developed which are effective in lowering resistivity. Studies have shown that treatment is insensitive to coal variations. Furthermore, resistivities of 10^{11}-10^{12} ohm-cm may be lowered to less than 10^{8}-10^{10} ohm-cm, depending on the additive choice and treatment level.

This paper discusses laboratory data and actual field results during treatment of a 100 MW boiler. It reviews the detailed mechanism of the resistivity modification and the practical effects of conditioning levels on ESP performance.

Development of a New Sulfur Type Ash Conditioning

R. H. Gaunt,
Air Correction Division, UOP, Inc.

Various types of chemical ash conditioning agents are used to alter flyash resistivity, and thereby improve ESP performance. ACD/UOP has had experience with many chemicals and processes on a pilot and full scale basis. Sulfuric acid conditioning has advantages over other sulfur conditioning systems in availability, cost of chemical, process control, ease of handling, and relative lack of corrosion problems. In the past, operating costs (power consumption) of sulfuric acid systems have not been particularly attractive, especially in large power plants. Now, ACD/UOP has developed a new system that utilizes sulfuric acid with its advantages and also reduces the capital and operating costs to be competitive with other systems. This system utilizes existing energy in the compressed and heated plant combustion air. A prototype unit at a 46 MW station improved ESP collection efficiency to 99.8% from 85.0% at an operating cost of $40 per day.

Operating Experience with Flue Gas Conditioning Systems at Commonwealth Edison Company

L. L. Weyers, Commonwealth Edison Co.

To restore ESP performance, a flue gas conditioning program was established by Commonwealth Edison in the early 1970s.

This paper is a history of its experience with flue gas conditioning agents over the last 8 years. Extensive testing of these systems has supplied valuable information which is currently being used as a basis in design of future plant additions.

The Application of a Tubular Wet Electrostatic Precipitator for Fine Particulate Control and Demisting in an Integrated Fly Ash and SO_2 Removal System on Coal-Fired Boilers

E. Bakke, Peabody Process Systems

The development of a combined, tubular, wet electrostatic precipitator (WESP) and vapor condensing heat exchanger mounted in the top section of an SO_2 absorber is discussed.

Pilot plant data on an integrated flyash and SO_2 removal system with a variable pressure drop venturi, a high velocity spray tower, and the WESP show that it is possible to operate with a specific collection area in the WESP of only 20-30 ft^2/1000 acfm, tube velocities of 16-20 ft/sec., and overall system pressure drop of 4-8 in. W.G., and still have flyash removal efficiencies of 99.25-99.65% or outlet emissions of 0.015-0.006 gr/scfd.

Heat recovery and flue gas reheat options made possible by the WESP/heat exchanger combination are discussed, and installations of this system on industrial boilers are reviewed. Initial and annualized costs and space-saving benefits are presented.

Evaluations of Ammonium Sulfate Conditioning for Improvement of Cold-Side Electrostatic Precipitator Performance

E. C. Landham,
Southern Research Institute

Measurement and analysis of the improvement in cold-side ESP performance through the use of ammonium sulfate conditioning agents were conducted at two electric utility generating stations. One plant was burning a low sulfur, high alkali Western coal and the other a moderate sulfur, low alkali Eastern coal. Comprehensive field tests were performed with and without the agents to evaluate the change in performance as well as to determine the mechanisms involved. The measurements included total mass and fractional efficiencies, particle size distributions, rapping emissions, in situ resistivity, ash and flue gas analyses, opacity, and voltage-current characteristics of the power supplies. Measurements were made with a proprietary formulation of ammonium sulfate injected on the hot and cold sides of the air heater and with a generic formulation injected on the cold side. The performance of the ESPs was compared with a theoretical model, and an engineering analysis of the installations was performed.

Evaluation of Performance Enhancement Obtained with Pulse Energization Systems on a Hot-Side Electrostatic Precipitator

W. Piulle,
Electric Power Research Institute

Two pulse energization systems of differing design were temporarily installed on separate chambers of a hot-side ESP. Measurements of overall and size dependent collection efficiency were performed using conventional and pulse energization for transformer-rectifier sets on each of the chambers. The enhancement in performance resulting from the use of pulse energization was evaluated on an overall mass and on a particle-size-dependent basis. The results obtained from the full-scale installation are compared with results obtained in a pilot ESP at EPA's IERL-RTP.

The ESP was performing below design values without sodium conditioning and had experienced a pattern of performance deterioration with accumulated time of operation following plant outages during which the ESP was cleaned by water washing. Sodium conditioning is normally used to maintain desired levels of performance.

A New Microcomputer System and Strategy for the Control of Electrostatic Precipitators

K. J. McLean, University of Wollongong

The paper outlines a new control strategy being developed for ESPs operating with severe back corona. The interface design, the algorithm developed, the control strategy, and some test results are presented. The aim of the system is to maintain optimal efficiency using current and voltage relationships, spark rate, and optical monitor signals. The system is in the development stage and is being currently tested at Munmorah Power Station, N.S.W., Australia.

Assessment of the Commercial Potential for the High Intensity Ionizer to the Electric Utility Industry

John S. Lagarias, Kaiser Engineers, Inc.

EPRI has performed extended laboratory and pilot scale tests of the APS High Intensity Ionizer (HII), which reached a level of performance where projections could be made of its potential commercial application to the electric utility industry. Computer simulations were made of the anticipated performance of a full-scale HII for both high and medium resistivity flyash, and an evaluation was made of the projected cost of commercially sized units. Future ESP performance requirements are forecast, based on an assessment of stricter regulatory requirements for mass emissions, fine particulates, and opacity. An assessment of the technology, including the HII, which could be used by utilities over the next 30 years, for upgrades and new installations, shows that the HII could be used for upgrading ESP's to meet the more stringent regulations.

Application of Energy Conserving Pulse Energization for Precipitators—Practical and Economic Aspects

H. H. Petersen, F. L. Smidth & Co.

Performance of ESPs collecting high resistivity dust can be improved considerably by pulse energization. The energy consumption, however, is a major problem for its application. The system dealt with here solves this problem: the unused energy stored in the ESP during the pulse is recovered to be used for the next pulse. Operating results from full-scale field tests over more than 2 years are presented to demonstrate that the system, utilizing high-power electronic components, has the required degree of reliability for practical applications. The improvement of ESP performance in relation to installation and operating costs makes it an attractive option to new ESPs for high resistivity dust as well as to existing ESPs with resistivity problems. Practical and economic aspects of the installation and preparation of the system are discussed.

Section C—Dry SO_2 Scrubbers

SO_2 Removal by Dry Injection and Spray Absorption Techniques

E. Parsons, Buell Envirotech

A dry injection technique is shown to have removal efficiencies greater than 70% for cost competitive systems by results of a Colorado Springs pilot plant test. The disposal of waste products from the process has been a major problem. The paper presents the most recent results of an EPA sponsored waste disposal study to investigate the effecti ness, including cost impact upon syst process, of processing the waste to eli inate waste disposal problems.

SO_2 removal for the spray absorpt process is summarized. These data based on extensive testing at the Colora Springs facility. Analysis of the by-prod from the spray absorption demonstra that no disposition problems would quire additional processing of the products.

Dry Scrubbing SO_2 and Particulate Control

N. J. Stevens, Research-Cottrell

In dry scrubbing SO_2, the spray dr and fabric filter are used to a signific extent for both SO_2 removal and parti late solids collection. Pilot test resu were obtained on low sulfur fuels elucidate the roles of each control dev in the dry scrubbing system.

SO_2 removal reactions in the spr dryer and fabric filter are compared a the important process variables identifi Particulate collection of flyash/F solids mixtures by the spray dryer a fabric filter is examined. Fabric fil pressure drop variation with time and t effect of dry scrubbing solids on t specific resistance coefficient are scribed. Spray dryer and fabric filter soli are examined for particle size distributi chemical composition, moisture conte and alkalinity. The cementious nature flyash and its effect on SO_2 remov solids collection, and system operabil are also discussed.

Fiber and Fabric Aspects for SO_2 Dry Scrubbing Baghouse Systems

L. Bergmann, Filter Media Consulting

This paper discusses both the chemi reaction in dry scrubbing systems and t role of fibers and filter media in t baghouse. The choice of available fibe and their main characteristics are di cussed, as well as factors influencing t selection of filter media and their pe formance. Specifications for differe fabrics are recommended.

Two-Stage Dry Flue Gas Cleaning Using Calcium Alkali

D. C. Gehri, Rockwell International

Most of the dry flue gas cleaning (FG systems that have been sold to date w use high-calcium lime as the alkali r

actant for SO_2 removal. In a two-stage dry FGC system, optimum performance and utilization of lime is achieved by passing gas around the first stage spray dryer and/or by recycling particulates removed in the second-stage collector.

Three examples of dry FGC system performance with lime, using these techniques, for three types of coals are considered: (1) low-sulfur, western subbituminous, (2) medium-sulfur lignite, and (3) high-sulfur eastern bituminous. The required FGC systems are discussed in terms of the lime preparation equipment, the FGC equipment, and waste disposal techniques. The economics of the three dry FGC systems is compared to that of equivalent ESP wet scrubber combinations.

Control of Sulfur Dioxide, Chlorine, and Trace Element Emissions from Coal-Fired Boilers by Fabric Filtration

R. Demski,
Pittsburgh Energy Technology Center

In studies conducted at DOE's Pittsburgh Energy Technology Center (PETC) in a 500 lb/hr coal-fired furnace equipped with a baghouse, it was found that the baghouse filter cake removed significant portions of the toxic trace elements Hg, As, and Se. When used in combination with injection of dry sorbents such as nahcolite, trona, and sodium bicarbonate, approximately 95% removal of SO_2 and Cl was obtained.

This paper summarizes previously reported studies relating to control of trace elements. Emphasis is placed on the recently completed investigation of SO_2 control by dry sorbent injection. In the latter study, tests were conducted with coals ranging in sulfur content from 1 to 3%. Operating variables considered included baghouse temperature, cleaning cycle time, sorbent particle size, and stoichiometric ratio of alkali to sulfur. Except for baghouse cleaning cycle rate, each parameter had a significant effect on SO_2 removal.

Section D—Scrubbers

Flyash Collection Using a Venturi Scrubber—Minnesota Power's Commercial Operating Experience

C. A. Johnson, Peabody Process Systems

Minnesota Power and Light elected to use a venturi scrubber as a particulate removal device for Clay Boswell Station, Unit 4 (500 MW). The selection had been based on significant cost savings compared to conventional ESP technology.

Prior to start-up of the full scale system, extensive pilot plant test work was done to determine performance characteristics with regard to both particulate removal and opacity. Unit 4 is now in commercial operation. This allows comparison of predicted performance based upon pilot plant data with full scale system performance.

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***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 I. Control of Emissions from Coal-Fired Boilers," (Order No. PB 83-149 583; Cost: $29.50, subject to change) will be available only from:
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