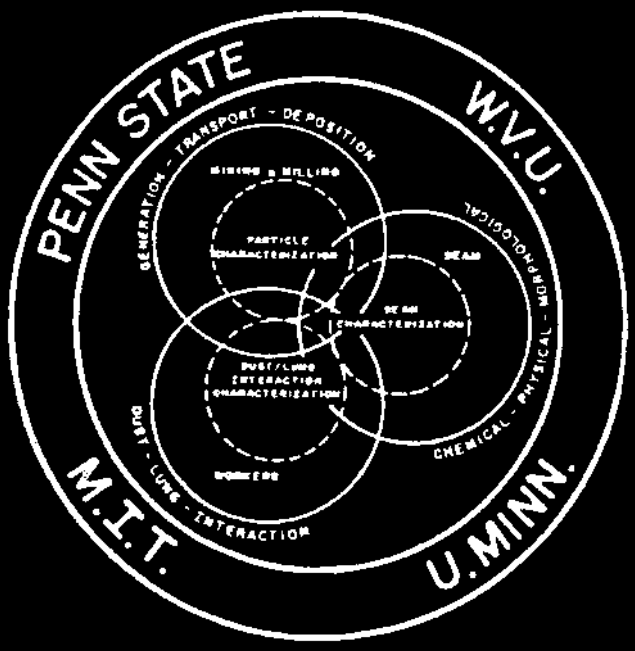
RESPIRABLE DUST CENTER RESEARCH PROGRAM REVIEW 1988

Edited by
ROBERT L. FRANTZ
and
RAJA V. RAMANI



GENERIC MINERAL TECHNOLOGY CENTER FOR RESPIRABLE DUST

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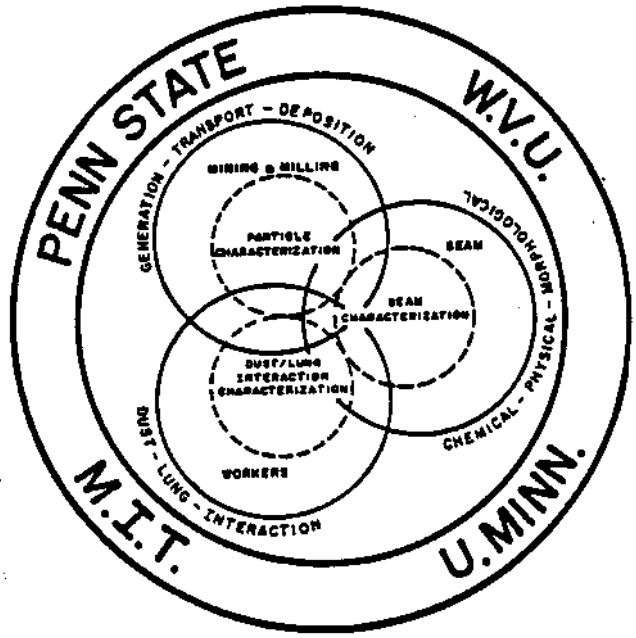
RESEARCH PROGRAM REVIEW



GENERIC MINERAL TECHNOLOGY CENTER FOR RESPIRABLE DUST

The Pennsylvania State University
West Virginia University
University of Minnesota
Massachusetts Institute of Technology
Michigan Technological University

Submitted to the
Advisory Committee on Mining and Mineral
Resources Research
Office of Mineral Institutes
U.S. Bureau of Mines
Washington, D.C.

August 31, 1989

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RESPIRABLE DUST CENTER
RESEARCH PROGRAM REVIEW

THE GENERIC MINERAL TECHNOLOGY CENTER FOR RESPIRABLE DUST

Edited by
Robert L. Frantz
and
Raja V. Ramani

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Reference Books

published by

The Generic Mineral Technology Center for Respirable Dust

Report to the Committee on Mining and Mineral Resources, Volume 1, edited by *Robert L. Frantz and Raja V. Ramani*, The Pennsylvania State University, University Park, PA, 1988, pp. 438.

Status Report, 1984-1988, Volume 2, edited by *Robert L. Frantz and Raja V. Ramani*, The Pennsylvania State University, University Park, PA, 1988, pp. 129.

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Review of the Generic Mineral Technology Center for Respirable Dust, Volume 7, edited *Robert L. Frantz and Raja V. Ramani*, The Pennsylvania State University, University Park, PA, 1989, pp. 204.

Publications - 1988, Volume 8, edited by *Robert L. Frantz and Raja V. Ramani*, The Pennsylvania State University, University Park, PA, 1989, pp. 282.

Conference Proceedings

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Coal Mine Dust Conference, edited by *Sid S. Peng*, University of West Virginia, Morgantown, WV, 1987, pp. 267.

Respirable Dust in the Mineral Industries: Health Effects, Characterization and Control, edited by *Robert L. Frantz and Raja V. Ramani*, The Pennsylvania State University, University Park, PA, 1986, pp. 378.

THE RESPIRABLE DUST CENTER

Excerpted From The

1988 UPDATE TO THE NATIONAL PLAN FOR RESEARCH IN MINING AND MINERAL RESEARCH

December 15, 1987

Report to:

The Secretary of the Interior
The President of the United States
The President of the Senate
The Speaker of the House of Representatives

Section 9(e) of Public Law 98-409 of August 29, 1984, (98 Stat. 1536 et seq.) mandates that the Committee on Mining and Mineral Resources Research submit an annual update to the National Plan for Research in Mining and Mineral Resources: "Improving Research and Education in Mineral Science and Technology through Government-(Federal, State and Local), Industry, and University Cooperation."

.....

Respirable Dust (centered at Pennsylvania State U. and West Virginia U., with affiliates at U. of Minnesota and Massachusetts Institute of Technology): brings together experts concerned with particles causing potentially disabling or fatal diseases, including pneumoconiosis ("black lung"), silicosis, and asbestosis, the latter of deep concern not just to workers in the mineral sector of the economy but also to the general populace.

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EXECUTIVE SUMMARY

The U.S. Bureau of Mines established, on August 15, 1983, the Generic Mineral Technology Center for Respirable Dust within the Mining and Mineral Resources Institutes (MRIs) at The Pennsylvania State University and West Virginia University in association with participating MRIs at Massachusetts Institute of Technology , the University of Minnesota and later, Michigan Technological University. Penn State serves as the administrative unit for the Center. Funding, to date, is more than 11 million dollars. The Center's research program has been developed with recognition of the stated objective of the Federal Mine Safety and Health laws which is to ". . .permit each miner the opportunity to work underground during the period of his or her entire adult working life without incurring any disability from pneumoconioses or any other occupation-related disease . . . ." The Center's program is designed to permit an accelerated attack on the fundamental research problems for the control of respirable dust in mines.

The primary goal of the Center is to reduce the incidence and severity of respirable dust disease through advancing the fundamental understanding of all aspects of respirable dust associated with mining and milling and the interaction of dust and lungs. The Generic Technology Center's research program explores these concerns with the objective of refining existing strategies and developing new respirable dust control techniques that are consistent with the fundamental dust-lung interaction processes that lead to mine worker disability. The work concentrates on the following areas: (1) control of dust and particulate matter generation; (2) dilution, dispersion and collection in mine airways; (3) characterization of dust particles; (4) interaction of dust and lungs; and (5) relationship of mine environment, geology, and seam characteristics to dust generation and mobility. The specific projects in the research areas are a result of a careful evaluation of the past and ongoing research activities, the identification of areas where data and information are scarce, and awareness of the recommendation of the National Academy of Sciences Study on the Measurement and Control of Respirable Dust. The fundamental aspects of this work are applicable to the control of respirable dust problems in both hard rock mines and coal mines and to other dusts such as diesel-generated. The Center activities involve the training of engineers and scientists, graduate students and undergraduate students through their respective institutions, and the technology transfer to the industry. The Center also serves as the reference center for publications in the respirable dust area.

The Center is composed of faculty from the five universities/institutes previously mentioned. The personnel, facilities and equipment that are available to the Center from these entities are diverse, complementary and comprehensive. More than one hundred scientists, engineers, medical personnel, and graduate students in the Center are engaged in respirable dust research. Additionally, the expertise and facilities of the National Institute for Occupational Safety and Health (NIOSH)--Division of Respirable Disease Studies are available as a result of the existing relationship between NIOSH and West Virginia University.

The breakdown of the dust research program into the five areas mentioned above recognizes the importance of an integrated, fundamental research approach to the respirable dust program which is compatible with and complementary to existing and ongoing U.S. Bureau of Mines activities. Towards this end, the Center cooperates in an annual assessment by the members of the advisory council. This report, Respirable Dust Center Research Program Review, was a response to the 1988 questionnaire prepared by MRI for submission to the Advisory Committe on Mining and Mineral Resources Research.

INTRODUCTION

The fundamental aspects of the Center's research on respirable dust generation, characterization, transport, health effects and worker environment relationships are applicable to all branches of the mining industry, including the surface and underground metal mining industry, as well as the mills that produce coal, metallic and non-metallic ores and the various utilization plants. However, keeping in mind the goal of the Center - - *to reduce the incidence and severity of respirable dust disease through advancing the fundamental understanding of all aspects of respirable dust associated with mining and milling and the interaction of dust and lungs* - - emphasis in each area will be adapted to address current and emerging industry concerns. A brief description of each of the five programatic areas follows.

Interaction of Dust and Lungs

Suite of Medical Tests

The goal of reducing the incidence and severity of respirable dust disease in people involves a number of dust/lung interaction research projects across the spectrum of medical/cellular, medical/animal, medical/huamn and medical/engineering areas. These projects utilize a variety of animals including rats, guinea pigs, hampsters, and dogs exposed in-vivo in inhalation chambers and also investigated in-vitro (FIGURE 1). Examples of medical research projects utilizing small animals include the following:

- Rats and guinea pig cells are used to investigate how coal mine dusts injure the lungs including the effects of dusts and dust-exposed pulmonary alveolar macrophages on the growth of lung fibroblasts.

- Rats and guinea pig cell are used in-vitro to assess a specific family of mediator substances produced by the PAM from arachidonic acid when these cells are in contact with activating substances such as coal dust.

- Electro-optical techniques are used to quantitatively measure the amount of superoxide released from single rat lung cells which have been obtained from rats exposed in-vivo in inhalation chambers or in-vitro to respirable quartz or in-vitro to kaolin dusts.

- Rats are exposed in-vivo to coal dust to determine the distribution of mucus secreted by control and coal dust treated rat trachea.

The findings developed in small aniaml investigations are being extended to non-human primates by utilizing members of the monkey colony at the Penn State Hershey Medical Center. The non-human primate is considered an experimental "bridge" between the small laboratory animals that can be used only once and the repeatable procedures being developed for the monkey lungs (FIGURE 2). Methods of mapping the bronchial tree of the individual monkey has been developed making it possible to deposit respirable dust particles in a selected lung location in a reproducable fashion. Utilizing the equipment and procedures that have been standardized from bronchoscopy and alveolar lavage of pulmonary alveolar macrophages (PAM) the cells recovered from the monkey will be studied (FIGURE 3). As an ultimate extension to human beings, cells from these monkey lung experiments can be compared to cells lavaged from healthy people as well as Black Lung victims.

Medical Research Projects

SUITE OF MEDICAL TESTS

1. **Rats**
2. **Guinea Pigs**
3. **Dogs**
4. **Non-Human Primates**
5. **Black Lung Patients**
6. **Healthy People**

FIGURE 1 Non-human primates as an experimental "bridge".

FIGURE 2

Bronchalveolar lavage with the fibroptic bronchoscope using an anesteticized nonhuman primate.

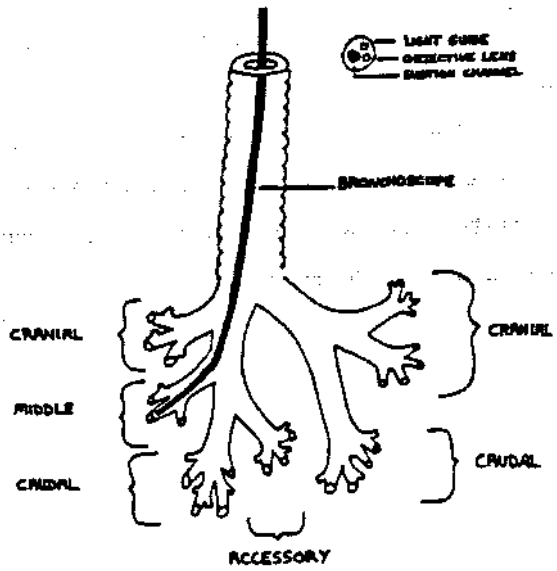


FIGURE 3

Schematic of the location of bronchoscope following introduction into the bronchial tree.

Characterization of Dust Particles

Suite of Characterized Dust Samples

A major hypothesis of the respirable dust center is that dust characteristics do make a difference in the incidence and severity of respirable dust disease in people. Therefore, to establish a common denominator or foundation for research investigations there is a need for standardized respirable dusts with consistent, reproducible characteristics which simulate those of actual mine dust. The availability of such materials should be a significant factor in promoting coordinated research into dust characterization, dust control, and the biomedical aspects of dust toxicology. To achieve this goal an opposed-jet, fluid-energy grinding system in closed circuit with a cross-flow, centrifugal air classifier for preparing bulk quantities have been established. By stage-crushing, screening, and fine-grinding with a Donaldson Acucut classifier/mini-grinder system (FIGURE 6). It is possible to produce bulk quantities of respirable dust a relatively high rates for supplying center researchers. Using minor modifications to the system, broader or narrower size distributions can be prepared. The system has been shown to reach steady-state with respect to product size distribution very rapidly. However, preferential grinding/classification effects appear to lead to a slow build-up of mineral matter in the circulating load with a corresponding slow change in product composition with time. In those applications where the dust composition is required to match that of the feed coal, it has been necessary to allow considerable time for a true steady-state to be established.

Standard respirable dust samples have been prepared from coals representing the western (high volitile A bituminous), central (medium volatile bituminous) and (eastern) low volitile eastern anthracite mining areas of Pennsylvania. Silica (quartz), limestone (rockdust), and kaolin (clay) samples, representing important mineral constituents of coal dust have been prepared (FIGURE 4). Extensive characterization studies have been performed on the samples to evaluate chemical and mineralogical composition and the distributions of particle size and specific gravity (FIGURE 5). Detailed information on the original coals is available from the thirteen hundred sample Penn State Coal Data Base. The standard respirable dusts have been characterized in terms of overall particle size distribution, size-specific gravity distribution, ash content and chemical and mineralogical composition. The standard coal dust samples appear to simulate actual mine dust very well with respect of particle size and shape, but generally have somewhat lower ash content. Samples of these standard dusts have been made available to center researchers as well as groups concerned with respirable dust in mines.

Particle Characterization Projects

SUITE OF CHARACTERIZED DUST SAMPLES

1. **Anthracite (Low Volatile)**
2. **Bituminous (Medium Volatile)**
3. **Bituminous (High Volatile)**
4. **Firclay**
5. **Silica**
6. **Rockdust**

FIGURE 4 Standard respirable dust samples.

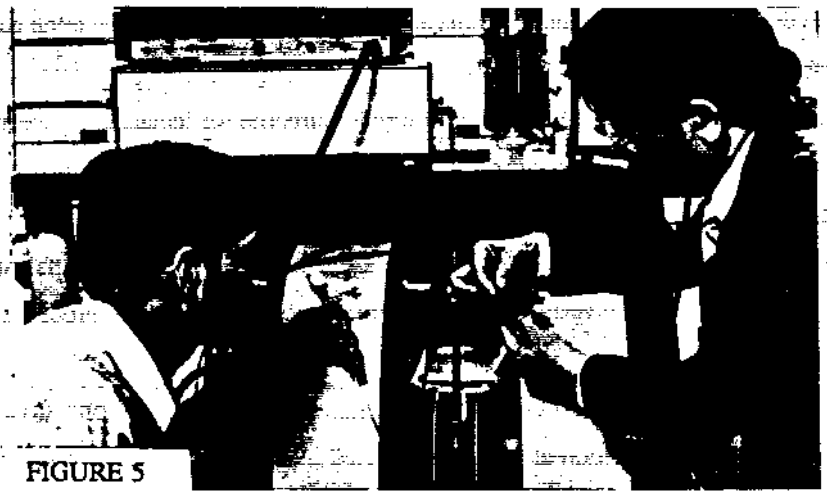


FIGURE 5

Researchers insert a quartz tube containing freshly ground coal dust into an electron paramagnetic resonance spectrometer to measure, via microwave absorption, the energy levels that identify the chemical species known as free radicals.

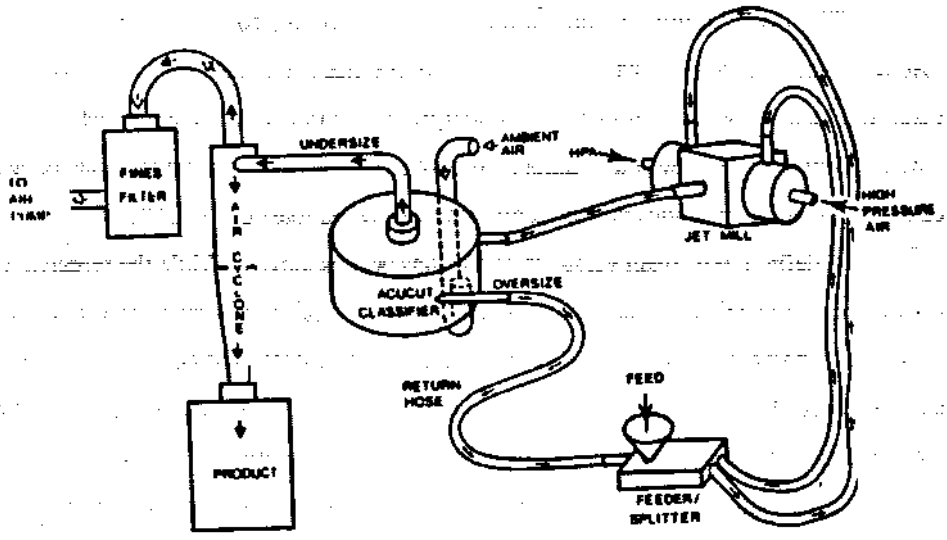


FIGURE 6 Diagram of Donaldson Acucut Classifer with auxilliary jet mill grinding mechanism.

Relationship of Mine Environment, Geology and Seam Characteristics to Dust Generation and Mobility

A major area of investigation in the Dust Center has been the formulation, evaluation, and verification of improved dust sampling and analytical strategies for use in surface and underground mines and preparation plants. A particular concern has been the need for obtaining valid dust samples with a large mass for use in scientific, medical and engineering research studies. Methods of analysis that can improve the reliable determination of dust characteristics are also being studied. This includes the proper method of synthesizing, collecting, storing, and utilizing respirable dusts and the effects of other contaminants and particulates that exist in the mine atmosphere or may be encountered in the laboratory.

Diesel research in the Center involves the engineering control of airborne particulate and gaseous pollutants to which a miner is exposed in a diesel underground coal mine. Pollutant concentrations must accurately be measured in order to control them. This research is directed at the development of both measurement and control techniques. The measurement methods under investigation include Laser Raman Quantitative Analysis (LRQA) (FIGURE 7) and the control technology under investigation is the Pyroban dry-type explosion-proof safety package and diesel particulate filter (DPF) (FIGURE 9).

Recognizing the uniqueness of underground coal mining, research investigations involving seam characteristics, mining system and worker position are being conducted in the Dust Center to establish standard procedures for characterizing some coal properties that may be involved in workers contracting CWP (Coal Worker's Pneumoconioses). This has been accomplished by the in-mine sampling of airborne dust and diesel particulate at various worker locations and mining systems configurations and by performing laboratory analysis of mined material (coal and rock) taken from the mines.

The investigations include a method of classifying coal seams according to their potential to generate respirable dust. It includes statistical analyses of the size and locational variations of the elemental compositions of respirable coal mine dust in operating underground mines from seams located in the eastern, midwestern, and western United States, and the relationship between the elemental compositions of respirable dust sampled near a continuous-mining machine and laboratory-produced respirable dust (FIGURE 8).

A definition of fresh versus stale dust has been achieved. While the research group has been concentrating initial efforts on coal dusts, the ramifications of silica, diesel particulates, asbestos, and other confounding variables have been a major topic of concern for characterized and standardized field investigations. After standard procedures have been established, certain factors contributing to increased CWP may be identified and prevented during pre-mine planning, or remedied by engineering controls in an operating mine.

In summary, this area of research will help understand the inter-relationship between respirable dust expisure levels, mineral types, work positions, and the development of CWP in various mine environments as the findings are related to the more fundamental knowledge gained in medical and scientific investigations concerning the potential toxicity of various mine dust components.

Mine Workers, Mining System,and Seam Geology Dust Relationship Projects

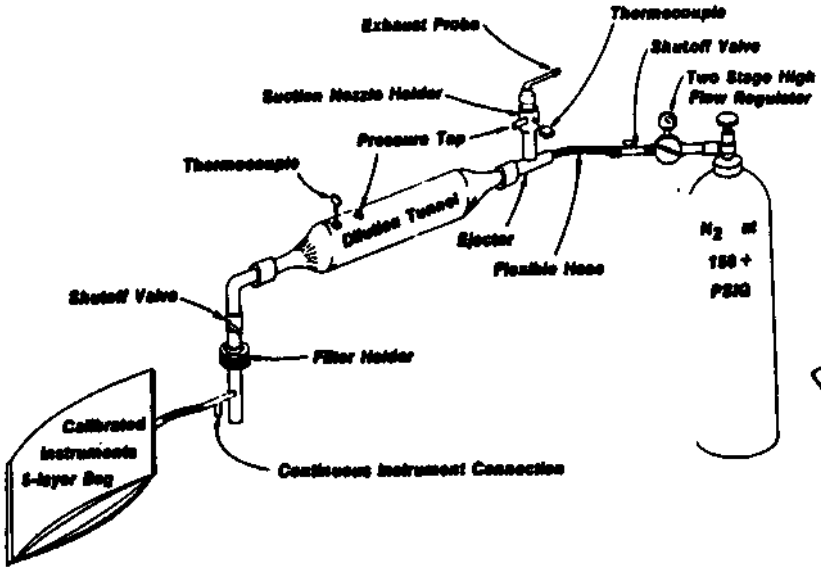


FIGURE 7

Apparatus used to collect diesel-only tailpipe samples for laser Raman quantitative analysis of coal/diesel particulate mixtures.

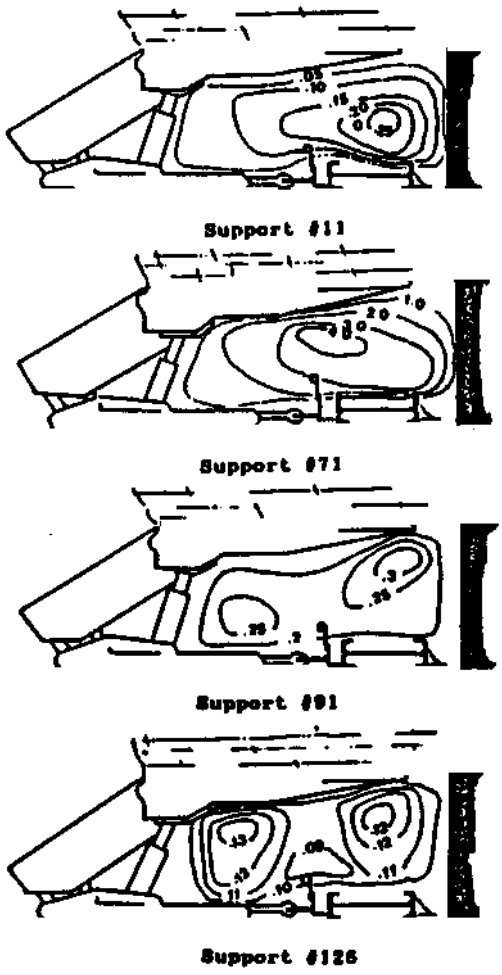


FIGURE 8

Actual dust concentration for various cross-sections along the longwall.

DPF + DRY SYSTEM: INTEGRATED CONTROL SYSTEM

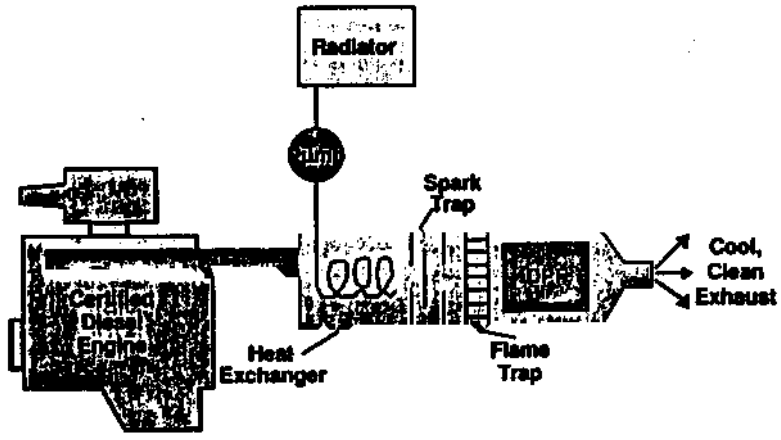


FIGURE 9 DPF + DRY system: integrated control system.

Dilution, Dispersion and Collection in Mine Airways

The U.S. Bureau of Mines research has shown that only a small fraction of the respirable dust produced at the face becomes airborne. Experimental determinations have placed the amount of non-airborne respirable dust as ranging from 100 to 1,000 times that of airborne dust. There are several fundamental and applied studies in this area to understand more fully the role of mine ventilation and dust control practices in respirable dust control and its relationship to dust particle characteristics. The depositional characteristics of dust particles in mine airways and the velocities at which these deposited dusts may become airborne are being studied (FIGURE 10). These studies are important for the design of equipment and the development of operating practices to remove dust from the worker zone or the worker from the dust zone and must include theoretical, laboratory, and field components.

Investigations have encompassed both experimental and theoretical research into the behavior of dust in mine airways. Experiments have been performed in mine airways under both controlled an normal operating conditions. On the theoretical front, a convection-diffusion model of the dust flow phenomenon in mine airways has been developed considering dominant mechanisms affecting dust transport and deposition in mine airways. Mechanisms modeled include turbulent and gravatational deposition, coagulation, and dispersion. Comparative analyses of results of the controlled experiments with the predictions of the mathematical model were carried out. In addition to the overall validity, the adequacy of the individual components of the model, such as deposition in the total and respirable range, and dispersion were examined in light of the experimental observations. Potential applications of the model include prediction of ambient dust concentrations and depositions in straight sections of airways. This can be helpful in designing mine ventilation systems and estimating rock dusting requirements. The impact of multiple dust sources can be studied using the superimposition concepts.

The objective of several studies is to contribute to a better understanding of longwall ventilation schemes with particular reference to respirable dust concentrations along longwall faces. One research project has developed longwall dust distribution maps from extensive underground experiments. In another project, the research includes experimental design and underground experiments in both operating longwall faces and the Lake Lynn Laboratory Mine of U.S. Bureau of Mines, development of a mathematical and computer model for describing and predicting airborne dust concentration in longwall face, and comparative analysis of the computer model outputs and experimental results (FIGURE 11). The moving dust generation source makes the longwall dust problem unique and complex. Therefore, time study data of cutting activities in longwall face become extremely important when interpreting RAM-1 respirable dust data. The mine ventilation system design is an engineering design problem involving not only numerical calculations to solve the pressure/quantity relationships, but also requires substantial judgement and expertise to analyze a specific problem situation and interpret the results of an algorithmic program. Therefore one of the Dust Center's projects has the objective to develop a knowledge based expert system for aiding the planning and designing of mine ventilation systems considering the problems of respirable dust (FIGURE 12).

Respirable Dust Dilution, Transport, and Deposition Projects

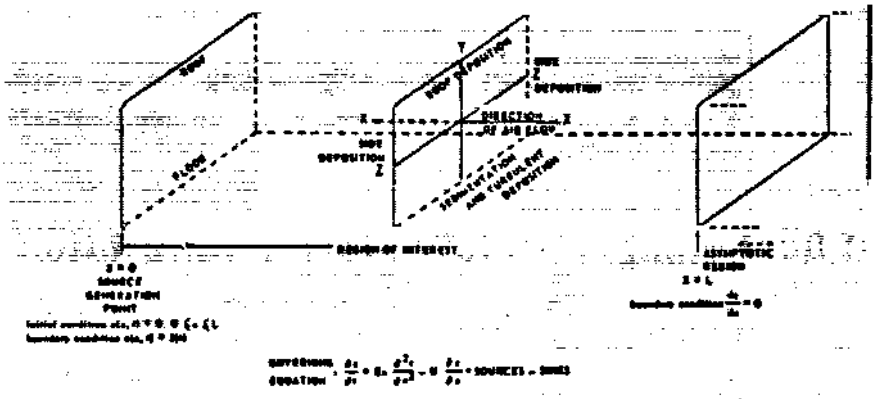


FIGURE 10

Schematic of dust flow in mine airways.

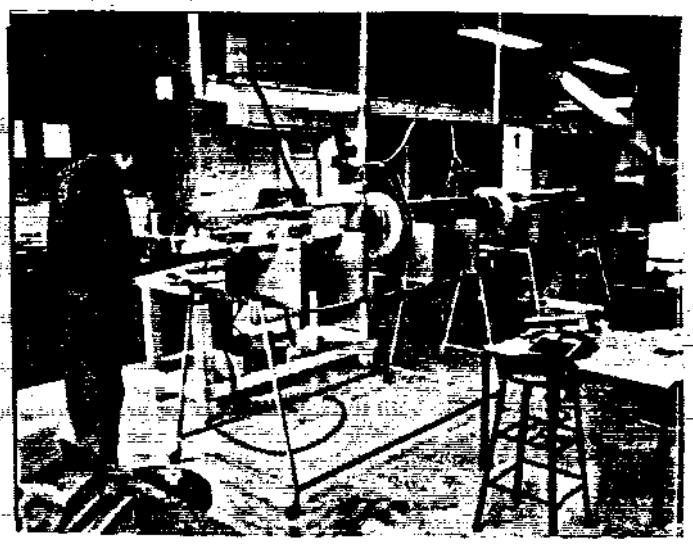


FIGURE 11

The wind tunnel in the Particle Laboratory at the University of Minnesota.

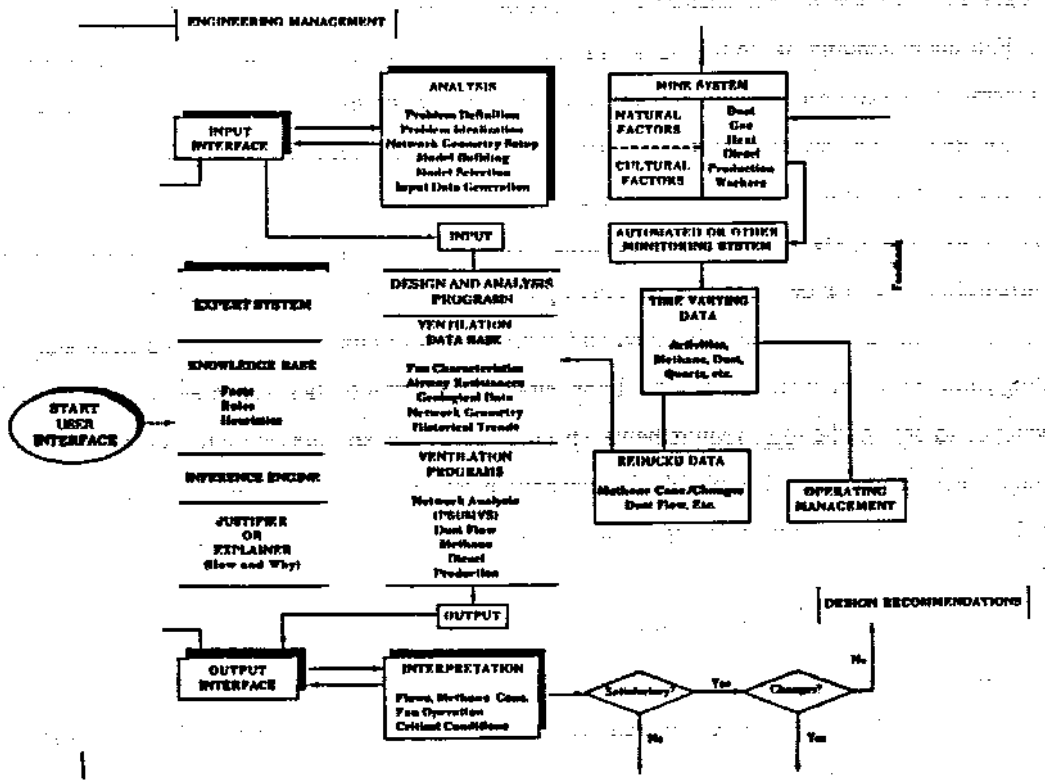


FIGURE 12 A logic flow diagram of a knowledge based system for planning mine ventilation systems.

Control of Dust and Particulate Matter Generation

In any fragmentation process, particles will be produced in all size ranges below a top size. Fragmentation in underground mines occurs as a result of many processes: impact, crushing, grinding, blasting, etc. There has been a considerable body of literature developed that describes the results of research on respirable dust production by coal cutting machines (continuous miners/shearers, etc.). The influence of factors such as depth of cut, pick design, pick lacing, and cutting speed have been studied extensively both in the U.K. and the U.S.A. In reviewing these results, the National Academy of Sciences study found many disparities and recommended that studies on these factors be undertaken with the objective of understanding the fragmentation process and its relationship to respirable dust particle generation and characterization. Research on coal fragmentation and dust particle generation is vitally important to both fully understand the generation and entrainment of respirable dust and to develop control measures to reduce dust generation in the mine or the mill.

The main objective of the Dust Center's research is to identify the mechanisms of control of respirable dust generation in coal mines. In one project, fracture toughness tests were conducted, and fracture propagation velocity was discussed. Full understanding of the mechanics of crack propagation in coal is of fundamental importance in studies of the generation and control of respirable dust (FIGURE 15). Other respirable dust generation investigations involve three major areas: (1) indentation tests [FIGURE 14], (2) rotary coal cutting tests [FIGURE 13], and (3) and analytical study to examine the dust effects of plunging a tool into a coal block.

Parametric study suggests that by applying optimum energy by a sharper tip angled bit which has a narrow and smooth configuration, coal can be cut efficiently and respirable dust can be reduced significantly.

A rotary coal cutting device was fabricated and instrumented to monitor and vary the simulated mining machine operating parameters and in-situ conditions. Parametric experimental studies were conducted and a statistical model was developed to predict the force requirements, specific energy and size distribution. It was concluded that efficient coal fragmentation and reduced respirable dust generation can be achieved by limiting the degree of bit-coal interaction, by choosing the optimum machine operating parameter predicted, and by using the statistical model for seam specific in-situ conditions.

Investigations of the fundamental bit-coal interaction which is believed to be the major source of respirable dust generation resulted in the conclusion that research on secondary dust generation was also necessary. Therefore, the subject of regrinding is the focus of one research project. Modification of the test facilities to carry out the necessary experiments has been completed.

Control of Dust and Particulate Matter Projects

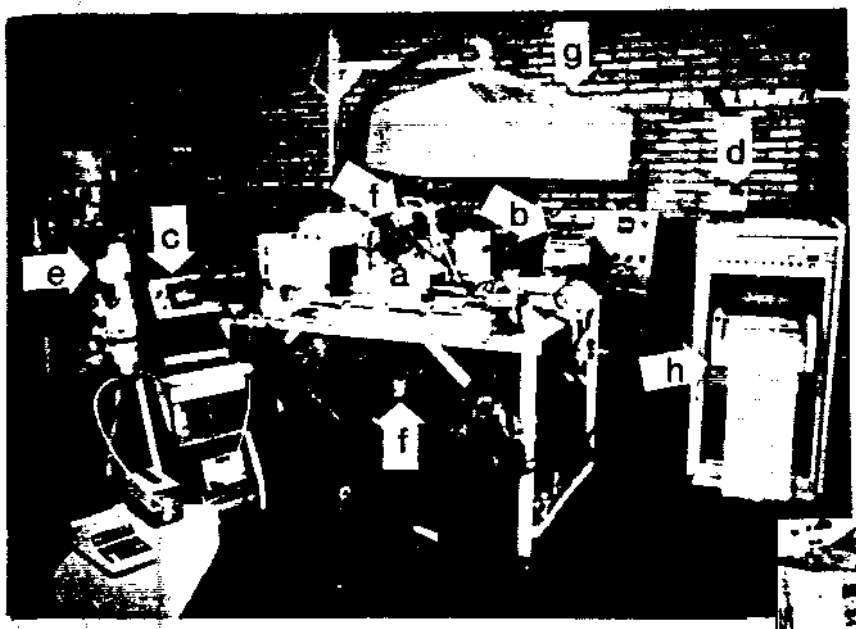


FIGURE 13 Test and monitoring equipment facilities (a) automated rotary coal cutting simulator. (b) programmable control and monitoring unit, (c) sonic testing unit, (d) acoustic emission, (e) microscope and the attached camera unit, (f)cascade impactors, (g) hood and air current generating unit and (h) data acquisition and recording unit.

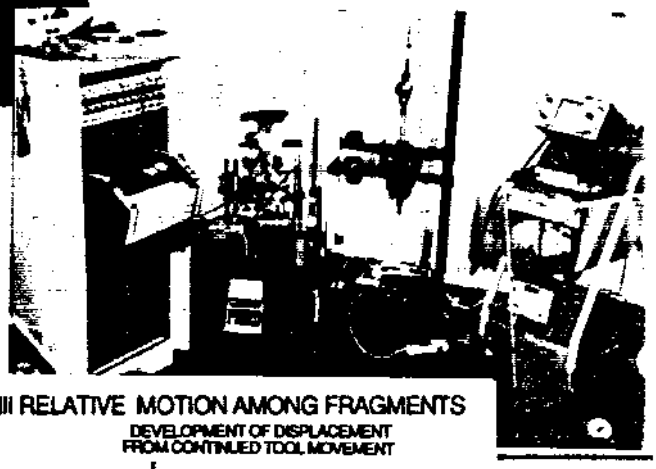


FIGURE 14 Test and monitoring facilities for dynamic indentation.
(a) sonic testing unit, (b) data acquisition and recording unit, (c) A.E. monitoring unit, (d) microscope with and attached camera.

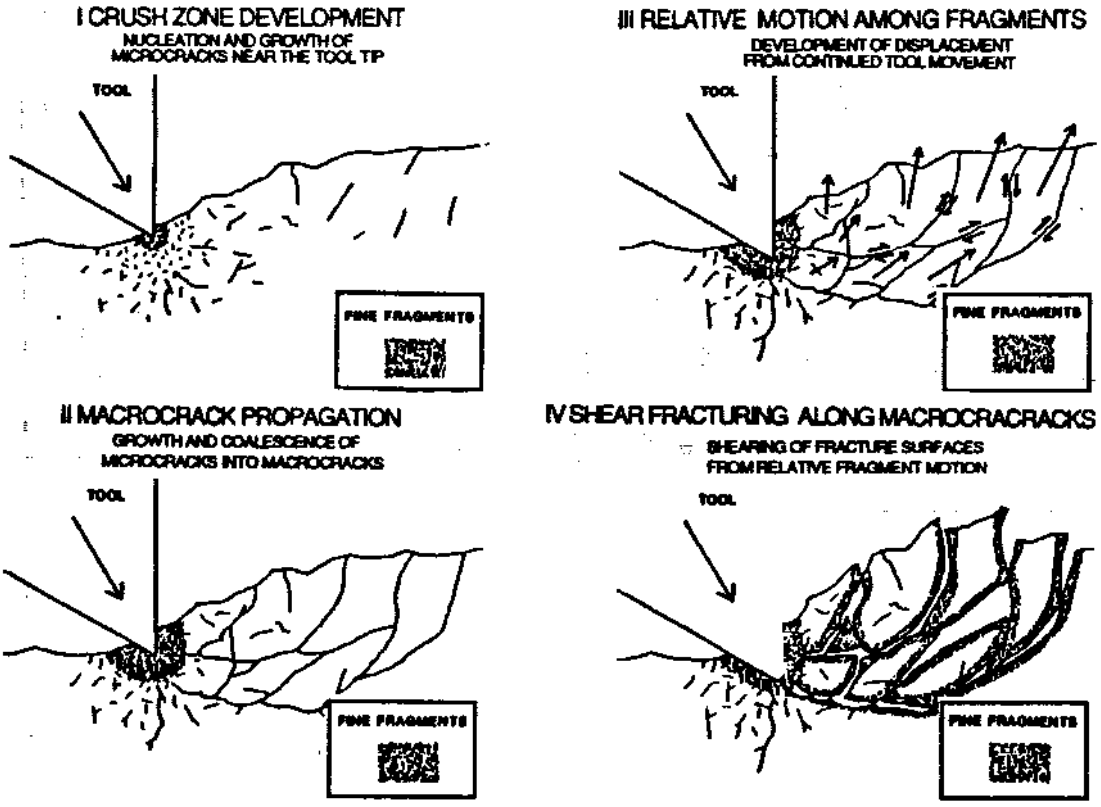
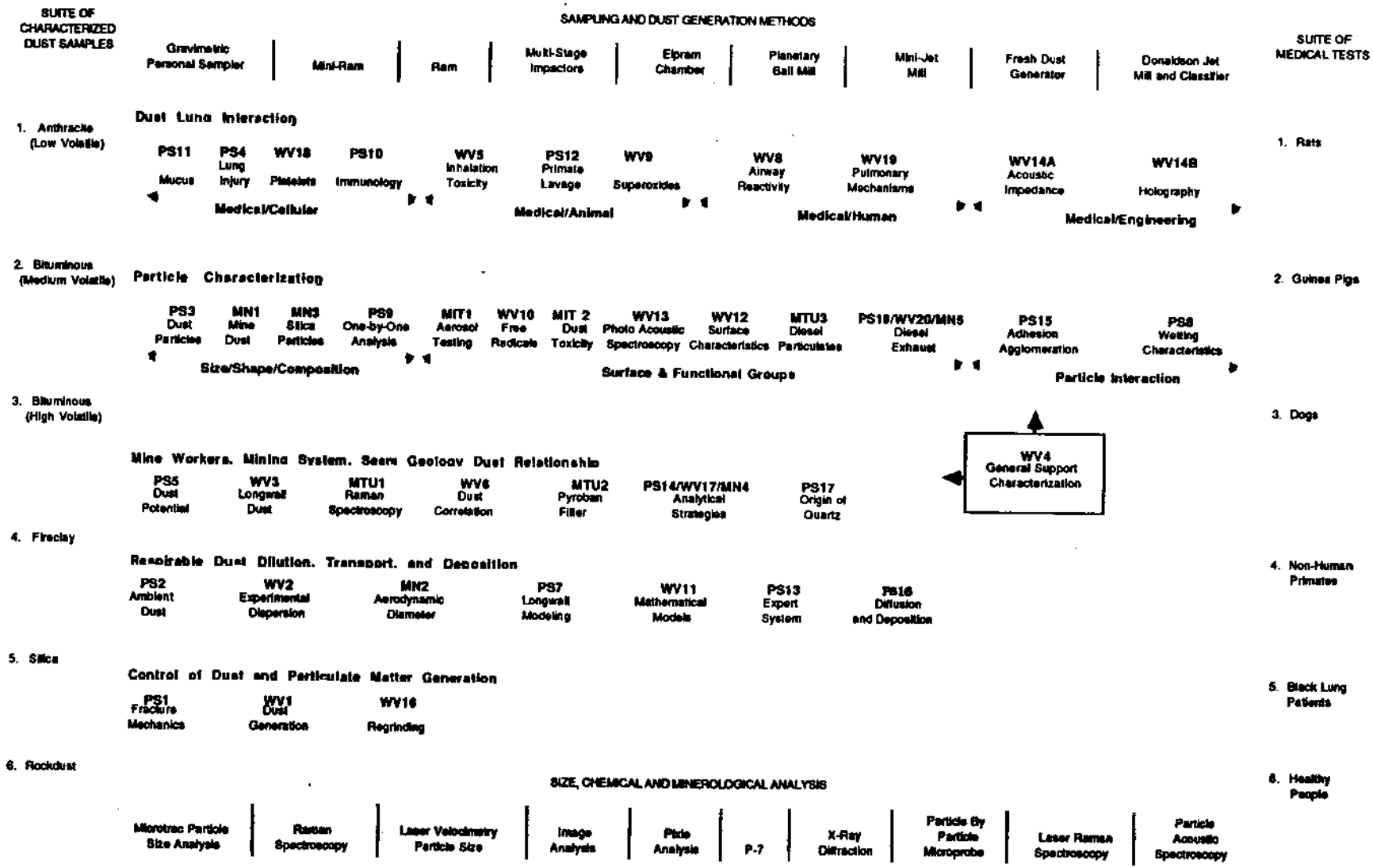


FIGURE 15 The fine fragment formation mechanism.

1988



The integration of scientific, engineering, and medical research findings into on-going projects.

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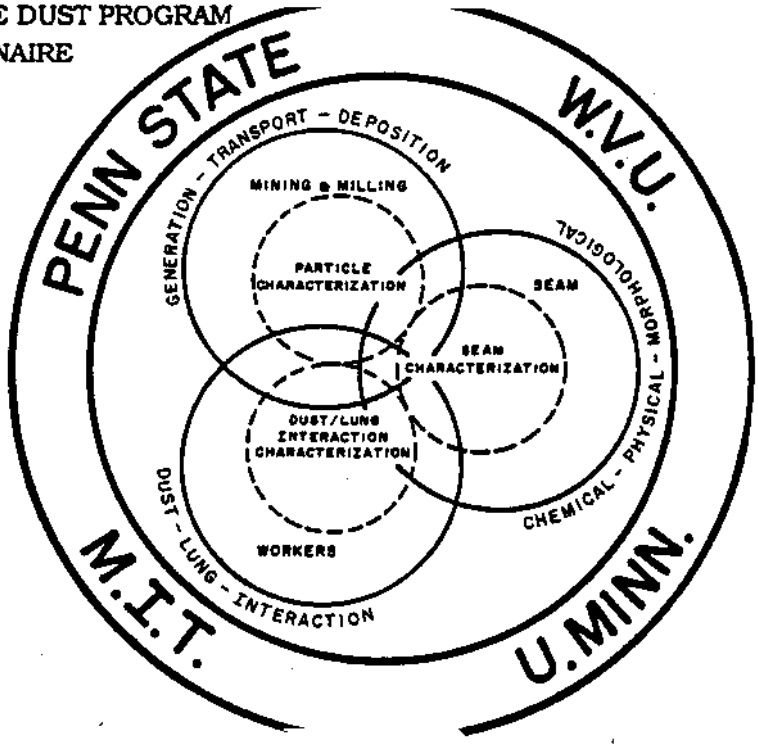
I

GENERIC MINERAL TECHNOLOGY

1988 Questionnaire

Chapter 1



INTRODUCTION

The House/Senate Joint Conference Committee has instructed the Bureau of Mines to have the Advisory Committee on Mining And Mineral Resources Research review on an annual and simultaneous basis each generic mineral technology research center (GMTC). In order to accomplish that review promptly and uniformly, committee members have revised and approved an in-depth questionnaire. That document formed the basis of their review. The information provided by that questionnaire was an important factor in their recommendations concerning the future direction of the program; a presentation was made at the last National Plan Update.

The comprehensive nature of the questionnaire and the scope of the information contained therein make it an excellent retrospective of the Center. Having a clear vision of where the Center has been and knowing where it is now will help guide it into the future. It is felt that such a detailed view of the Center's facilities and research program will be of value to Center personnel and Advisory Committee members.

Each aspect of the questionnaire has been examined, answered in detail, and documented throughly. With the completed questionnaire as a guide, this volume examines the research program, Center personnel presently active on GMTC projects, number of graduate degrees granted with GMTC support, GMTC publications, degree of individual interaction, technology transfer, the reference center, GMTC equipment and facilities, and any envisioned plans for future research. It is hoped that this volume will serve as a review of the years 1984-1988, the first four years of the Center's operation.

ADVISORY COMMITTEE ON MINING AND MINERAL RESOURCES RESEARCH
ANNUAL REVIEW OF GENERIC MINERAL TECHNOLOGY CENTERS (GMTC'S)
1988 QUESTIONNAIRE

Center Name	:	Generic Mineral Technology Center for Respirable Dust (GTCRD)
Center Director	:	Dean Robert L. Frantz/Dr. Raja V. Ramani/Dr. Richard A. Bajura
Lead Institution	:	The Pennsylvania State University (PSU) West Virginia University (WVU)
Affiliate Institutions	:	University of Minnesota (UM) Massachusetts Institute of Technology (MIT) Michigan Technological University (MTU)

A. Funding (dollars)

	Lead Institution	Affiliates
1982-1988 (Total for the GMTC)	$3,763,747 - PSU $3,784,443 - WVU	$698,860 - UM $381,216 - MIT $150,023 - MTU
TOTAL - $8,778,289		

B. Research program (See Chapter VII, Respirable Dust Program, for details)
Provide a short statement of program goals and scope of the generic center (list no more than 10 major research areas covered)

The primary goal of the Center is to reduce the incidence and severity of respirable dust disease through advancing the fundamental understanding of all aspects of respirable dust associated with mining and milling and the interaction of dust and lungs. The GTCRD's research program explores these concerns with the objective of refining existing strategies and developing new respirable dust control techniques that are consistent with the fundamental dust-lung interaction processes that lead to mine worker disability. The work concentrates on (1) control of dust generation; (2) dilution, dispersion and collection in mine airways; (3) characterization of dust particles; (4) interaction of dust and lungs; and (5) relationship of mine environment, geology and seam characteristics to dust generation and mobility. The fundamental aspects of this work are applicable to the control of respirable dust problems in both hard rock mines and coal mines and to other dusts, such as diesel-generated.

The Center's activities involve the training of engineers and scientists, graduate students and undergraduate students through their respective institutions and technology transfer to the industry. The Center research is fully compatible and complementary with the existing and ongoing U.S. Bureau of Mines activities.

C. Number of personnel currently active on your GMTC projects
(See Chaper III, Personnel, for details)

	Lead Institution		Affiliates		
	PSU	WVU	MIT	UM	MTU
1. Faculty	15	26	4	5	3
2. Masters Candidates	8	6	0	5	2
3. Doctoral Candidates	6	15	0	4	1
4. Post-doctoral	0	9	0	0	0
5. Faculty who have transferred as a result of the existence of this center	0	0	0	0	0

D. Number of degrees granted with GMTC support
(See Chapter IV, Graduate Degrees, for details)

	Lead Institution		Affilitates
	PSU	WVU	UM
1. Doctorates	4	6	1
2. Masters	5	16	2
3. Graduates who got jobs in the mineral sector of the economy	5	9	1

E. Number of publications supported by GMTC
(See Chapter VI, Publications, for details)

	Lead Institution	Affiliates
1. In refereed professional journals	13	4
2. In non-refereed periodicals	58	6
3. Presentations at technical meetings but not otherwise published	7	0
4. Presentations at last annual GMTC seminar only	28	6

F. Number of projects that have the indicated degree of industrial interaction
(Choose one category that best fits each project) (See Chapter VII, Research Effort, for details)

	Lead Institution	Affiliates
1. Experimental project, all measurements industrial/mining site	5	0
2. Experimental project, some measurements at industrial/mining site; most experiment at University	2	3

3. Experimental project, industry provided samples or equipment; all data taken at University	6	2
4. Experimental project; industrial involvement limited to advice or information	4	1
5. Experimental project; no direct industrial interaction	13	2
6. Non-experimental project; library or computer studies only	2	0
Total	32	8

G Specific industrial funding of this GMTC's projects: source, amount, and application

No specific industrial cash contributions were received for the GTCRD activities. However, sixty percent of the Center's projects had various kinds of industrial interaction and cooperation. The contributions during these interactions have included collection of samples for the Center's activities, company personnel support for data collection in the field, provision of equipment, crew and supervision for research activities and supply of specialized equipment. These contributions-in-kind are significant cash expenditures by the company to the achievement of the objective of the research projects and the Center's goals.

H Number of patents applied for:

NONE

I. Technology transfer
List technology transferred and receiving organization. (See Chapter VIII, Technology Transfer, for details)

1. Technology requiring investment in equipment

NONE

2. Technology requiring change in operating conditions or procedures

Fundamental studies utilizing the GTCRD samples (see part 4 below) have shown that varying dust characteristics have widely varying responses in such areas as particle control and dust-lung interactions. It has also been determined that free redical characteristics of coal particles vary significantly with age. These findings have impacts on engineering design and operations control. Also, UM has developed a modification to the inlet of the APS instrument for TSI, Inc.

3. Supply of computer software or educational materials

   There have been several requests for educational and informational material from the Center. Information on Center-generated software has been provided to MSHA and CANMET and the Center's expertise was used in the development of a computer program for particle distribution model (DISFIT).

4. Establishment of data bank/bulletin board

   The GTCRD has established a data bank of respirable dust samples having widely varying characteristics (low volatile, medium volatile, high volatile, silica fireclay, rockdust) that have been utilized by Center researchers in a suite of medical, scientific and engineering tests.

5. Conferences sponsored (other than annual GMTC seminar) for transfer of GMTC technology

   a. WVU - 1984 - Coal Mine Dust Conference - Morgantown, West Virginia
   b. PSU - 1986 - Respirable Dust in the Mineral Industries: Health Effects, Characterization and Control - University Park, Pa.
   c. ILO - 1988 - VIIth International Pneumoconioses Conference, Pittsburgh, Pa. (while not a co-sponsor, had significant involvement with 16 papers from GTCRD)

J. Reference center (See Chapter IX, Reference Center, for details)

1. Number of outside publications:
   There are 47 outside publications in the Reference Center publications.
2. Number of dissertations, publications from generic research center:
   There are 34 theses and 88 publications from GTCRD personnel.
3. Number of literature articles abstracted:
   As a part of the Master Degree and Ph.D. dissertations developed in the dust center, prior research relevant to the subject has been reviewed. An example of such a review is provided.
4. List nature of highest degree for each reference center employee:

   Raja V. Ramani - Ph.D. in Mining Engineering

   Richard A. Bajura - Ph.D. in Mechanical Engineering

   Robert L. Frantz - M.S. in Mining Engineering

   Nancy J. Rishel - Accredited Medical Records Technician, Business Courses

5. Brief description of location and operation including relation to the main university library and how the reference center is accessed by outside parties.

   The Center is located in 111 M.S. Bldg. and staffed from 8:00am to 5:00pm, Monday through Friday. Outside parties can access the Reference Center through

the computer access system, FAX and telephone services. The access to the library and resources at other GTCRD institutions are provided by these telecommunications and computer facilities. The College of Earth and Mineral Sciences Library, located in 105 Deike Bldg. (adjacent and connected to the M.S. Bldg.) is a major reference center for earth related disciplines including geology, mining and mineral processing. Through the PSU-LIAS (Library information Access System), a quick and comprehensive key-word search can be made on all holdings in the Penn State Library System.

K Equipment: List critical equipment or facilities unique to your generic center that are unavailable at other research facilities. (See Chaper X. Equipment and Facilities, for details)

Major equipment and facilities available to the GTCRD are unique and are unavailable at other research facilities. A sample bank of 1300 U.S. coal samples, extensively characterized for the physical, elemental, mineralogical and maceral compositions was used to initiate a study of the relationship between pneumoconioses and coal properties. Selected samples from this bank were also used for preparing samples for animal studies at Hershey and West Virginia Medical Centers. The laboratory facilities at PSU and WVU for the fundamental studies on dust generation and characterization are extensive. The research facilities for biological and medical research at WVU and PSU are state-of-the-art including a primate colony where dust research is currently underway on a primate. In addition, the modern facilities at NIOSH, Morgantown, WV are also readily available to the Center. The mine particle laboratory at the University of Minnesota and the diesel engine laboratory at Michigan Technological University have been developed over a period of years and have unique equipment and instrumentation for fine particles measurement. characterization and analysis.

L. Should any of the present affiliates be replaced or eliminated or new affiliates added? Why?

The GTC on Respirable Dust started with addressing high priority research issues and problems identified in the National Academy of Sciences study, Measurement and Control of Respirable Dust in Mines. in the characterization and control of respirable dust from both the scientific and engineering aspects in mine atmospheres and the medical and biomedical aspects in animal and human lungs. the Center's expertise in physical sciences and mining engineering and medical fields is provided mainly by the lead institutions, The Pennsylvania State University and West Virginia University. The affiliate institutions - University of Minnesota, Massachusetts Institute of Technology, and Michigan Technological University - provide expertise in specific areas of respirable dust collection

equipment, particle characterization and diesel particulates, respectively. This expertise should be preserved and no member should be replaced or eliminated. The addition of new affiliates must be on the basis of new strengths needed and the ability to support these needs without fragmenting existing research programs. The Center's work has recently been extended to studying the safety and health effects of diesel particulate contaminants in mine atmospheres. At the present time, there are five universities working in five major areas of respirable dust research on very limited funding. No new affiliates should be added.

M. If this GMTC continues with approximately its present funding, what major research areas should receive continuing attention? What new areas should be investigated? What areas should be phased out or reduced? How can your program be improved?

The major thrust of the GTCRD research program is in the fundamental understanding of the respirable dust generation, dust characterization, health effects and worker seam, mining system and environment relationship. While the work initially has been directed towards the problem of respirable dust in underground coal mines, more recently the Center's activities have expanded into diesel particulates. In view of the emerging problems with airborne asbestos related particulates in the quarrying industry, it is necessary for the Center to consider initiating research into this area. The respirable dust problem in the surface coal industry and the surface and underground metal mining industry has not received specific research attention in the Center. The same is true of the problem in mills processing metallic and non-metallic ores and plants for coal preparation and utilization. However, the fundamental aspects of the Center's research on generation, characterization, transport, health effects and worker environment relationships are applicable to these segments of the mineral industry as well.

As such, no research area should be phased out, but emphasis in each area may be altered to improve the program content and focus. The addition of research on diesel particulates in coal mines is a case in point.

N. Please identify a lead University official not connected directly with the GMTC who could be contacted for an evaluation of the GMTC.

Dr. Charles L. Hosler
Senior Vice-President for Research
and Dean of the Graduate School
The Pennsylvania State University
114 Kern Building
University Park, PA 16802

Phone - 814/865-2516

I certify that the information provided in this questionnaire and accompanying supporting chapters is correct to the best of my knowledge

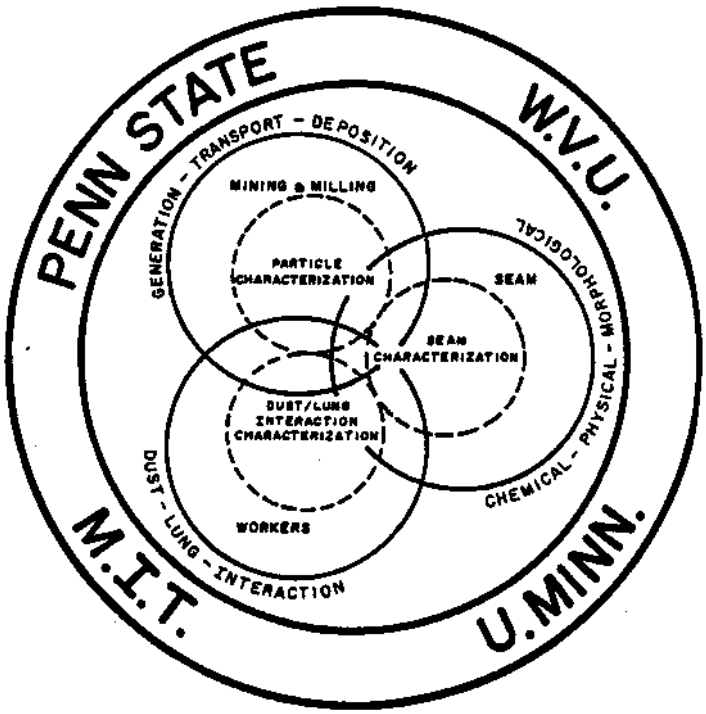
Robert L. Frantz/Raja V. Ramani	October 19, 1988
NAME	DATE

II

RESPIRABLE DUST PROGRAM
Promotional Materials

PROMOTIONAL MATERIALS

Chapter 2



INTRODUCTION

Several methods are employed in the promotion of the Generic Mineral Technology Center for Respirable Dust and its activities to the general public and to scientists at other universities and research facilities. Technical and informational papers have been presented by researchers at various professional meetings such as the fine particles symposiums, Society of Mining Engineers meetings, ACGIH conferences, international mine ventilation and U.S. mine ventilation symposiums, and the international inhaled particles symposiums. The Co-directors of the Center have prepared a general, informative paper which profiles the Center and a technical paper which outlines the research activities.

The Industrial Research Office, The Pennsylvania State University has assembled an informational packet which is distributed by the Industrial Research Office to major corporations in Pennsylvania. The Center has been included in this publication.

An Overview of the General Mineral Technology Center for the Generic Technology Area of Respirable Dust

Robert L. Frantz and Raja V. Ramani
Co-directors, The Generic Mineral Technology
Center for Respirable Dust,
The Pennsylvania State University

In response to the U.S. Bureau of Mines (USBM) Request for Proposal (RFP) for " the establishment of a Generic Mineral Technology Center (GTC) in Respirable Dust," the Mining and Mineral Resources Research Institutes (MRIs) at The Pennsylvania State University (PSU) and West Virginia University (WVU) in association with participating MRIs at Massachusetts Institute of Technology (MIT), and the University of Minnesota (UMN) have prepared the comprehensive research program described herein. Michigan Technological University (MTU) joined the Center as an affiliate after its inception. This program was developed with recognition of the stated objective of the Federal Mine Safety and Health laws which is to ". . . permit each miner the opportunity to work underground during the period of his entire adult working life without incurring any disability from pneumoconiosis or any other occupation-related disease . . . ."

Exposure to respirable contaminants in mine atmospheres has long posed a serious hazard to miners. The control of these hazards, some of which can have sudden and catastrophic consequences and some others, slow and long enduring, has been a major concern for labor, management and the government. This concern has manifested itself in four mechanisms of control -- (1) regulatory control through minimum standard setting by the passage of mine health and safety laws, (2) engineering control through design and operation of mines according to the best recommended practices, (3) interaction of dust and lung control through periodic physical examinations, wearing personal protection devices, etc., and (4) legal and social control through workman's compensation laws for occupation related health deterioration.

The National Academy of Sciences (NAS) Study, Measurement and Control of Respirable Dust in Mines, proposed a significant increase in U.S. Bureau of Mines funding "for obtaining fundamental understanding of the origin, transport and characteristics of respirable coal mine dust." This recommendation was based on the impact on society of mine worker's pneumoconioses and the magnitude of the research and development effort needed to bridge the information gaps identified by the NAS study research group. The NAS committee further stated that "even if funding for these purposes were trebled it would still be small compared with the total annual costs associated with coal mine worker pnuemoconioses , which exceeds $1 billion dollars a year." It is within this context that the comprehensive program is designed to permit an accelerated attack on the fundamental research problems for the control of respirable dust in mines.

Significant progress has been made in lowering the dust levels in mines since the inception of the Bureau's respirable dust research program (FIGURE 16). It is generally agreed that mines are less dusty today than they were a decade ago. However, the most serious hazard for workers in the mining and minerals processing industries is still the exposure to respirable dust, and solutions to the problem of respirable dust disease remain to be found.

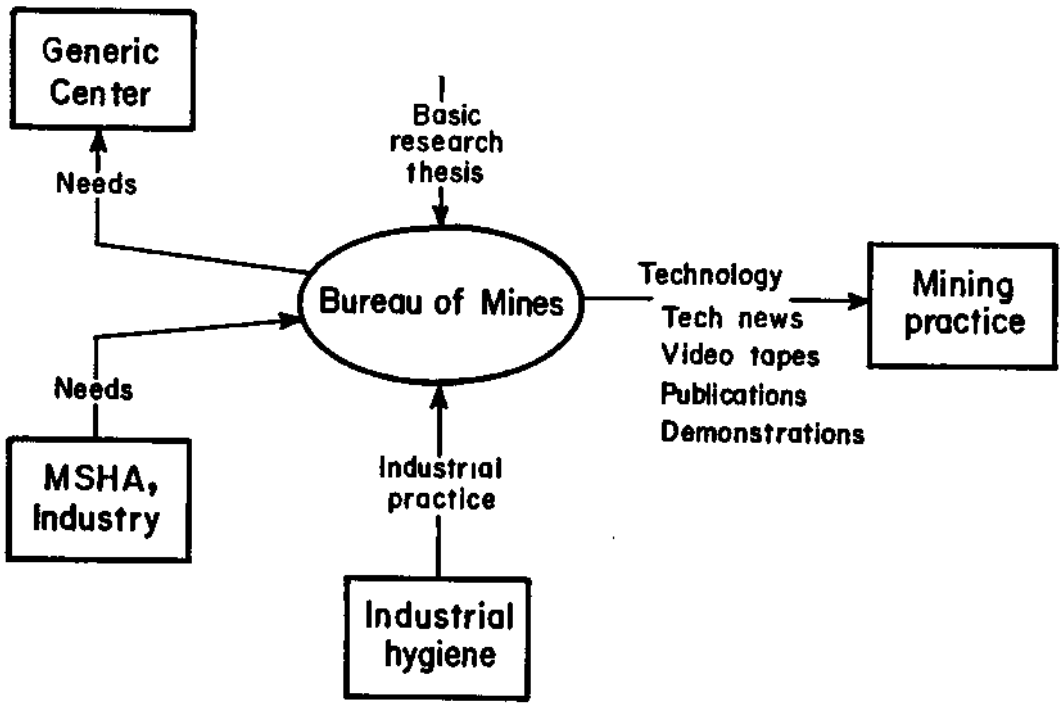


FIGURE 16 Bureau of Mines Respirable Dust Research structure.

Goals

The primary goal of the proposed Center is to reduce the incidence and severity of respirable dust disease through advancing the fundamental understanding of all aspects of respirable dust associated with mining and milling and the interaction of dust and lungs.

A comprehensive research program is proposed to explore these concerns with the objective of refining existing strategies and developing new respirable dust control techniques that are consistent with the fundamental dust-lung interaction processes that lead to mine worker disability. The work will concentrate on control of dust generation; dilution, dispersion and collection in mine airways; characterization of dust particles; interaction of dust and lungs; and relationship of mine environment, geology, and seam characteristics to dust generation and mobility. The fundamental aspects of this work will be applicable to the control of respirable dust problems in both hard rock mines and coal mines and to other dusts such as diesel-generated (FIGURE 17).

Means to be Employed

The Center will conduct research in the five specified areas with primary emphasis on the engineering control of dust in mines and the interaction of dust and lungs. The unique resources of five institutions of higher education are being brought together to address the complex problems, not only in the described research areas, but also to foster industrial cooperation and to facilitate technology transfer. Research results will be integrated into existing mining engineering curricula, short courses and seminar programs. Publication of papers in mining industry journals and presentations to professional meetings will report on specific findings. It is anticipated that the Center will sponsor an annual international conference on respirable dust in mining. The Center will also serve as the reference center for publications in the respirable dust area. The Center activities will involve the training of engineers and scientists, graduate students and undergraduate students through their respective institutions (FIGURE 18), and the technology transfer to the industry. The research results will be fully integrated with ongoing projects on development and refinement of control strategies in the mines. The technology transfer process will be enhanced by conducting the research at five universities with major mining and other engineering programs and with unique facilities and records of cooperative research with the mining industry.

RESOURCES

Participating Entities

The GTC will be composed of faculty from PSU, WVU, UMN, MIT and MTU (FIGURE 19). The personnel, facilities and equipment that are available to the Center from these entities are diverse, complementary and comprehensive. Additionally, the expertise and

RESPIRABLE DUST PROGRAM

The Generic Mineral Technology Center for Respirable Dust

SUITE OF CHARACTERIZED DUST SAMPLES	SAMPLING AND DUST GENERATION METHODS	SUITE OF MEDICAL TESTS
1. Anthracite (Low Volatile)	Dust/Lung Interaction	1. Rats
2. Bituminous (Medium Volatile)	Particle Characterization	2. Guinea Pigs
3. Bituminous (High Volatile)	Mine Workers Mining System Seam Geology Dust Relationship	3. Dogs
4. Fireclay	Respirable Dust Dilution Transport and Deposition	4. Non-Human Primates
5. Silica	Control of Dust Generation	5. Black Lung Patients
6. Rockdust		6. Healthy People
	SIZE, CHEMICAL AND MINERALOGICAL ANALYSIS	

STATEMENT OF GOAL

The primary goal of the Generic Mineral Technology Center for Respirable Dust is to reduce the incidence and severity of respirable dust disease through advancing the fundamental understanding of all aspects of respirable dust associated with mining and milling and the interaction of dust and lungs.

FIGURE 17 The holistic approach to standardized protocols and procedures.

facilities of the National Institute for Occupational Safety and Health (NIOSH)- Division of Respirable Disease Studies will be available as a result of the existing relationship between NIOSH and WVU.

The Pennsylvania State University has a nationally recognized Coal Data Base and Coal Sample Bank of 1300 U.S. coal samples. The method of coal seam component characteristics developed at PSU is internationally used. The expertise in particle characterization including aspects of surface chemistry, reactivity, chemical and physical characterisics is extensive. Major studies have encompassed liberation potential due to comminution and behavior of fine studies in rock and coal properties, fracture and failure mechanisms, and fracture propagation. The mine ventilation research at Penn State is

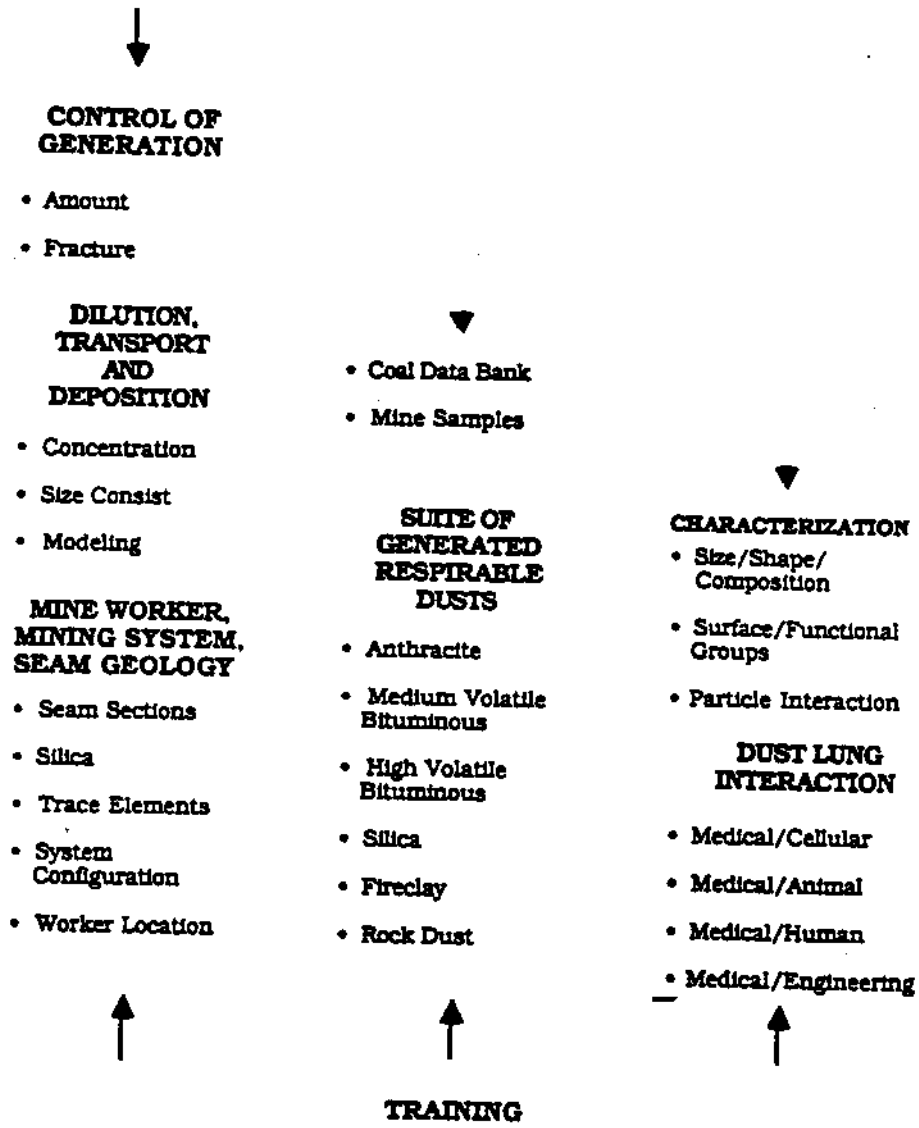


FIGURE 18 Training engineers, scientists, medical personnel, graduate students and undergraduate students in the interdisiplinary aspects of respirable dust.

extensive, encompassing such areas as air flow, dilution and dispersion of contaminants, mathmatical modeling and computer simulation, plus field and laboratory studies. The lung/dust interaction experts have extensive background in immunology, toxicology, microbiology, pathology, pharmacology, and other related fields. The Mineral Engineering Department has extensive continuing education facilities and experience. In fact in 1973-74, with support from USBM and in association with UMWA, MSHA and NIOSH, the department conducted 31 dust-related seminars nationwide to miners' health and safety representatives. Since 1974 PSU has an extensive ongoing training program for the miners and has trained, thus far, over 20,000 miners. The PSU educational television network and the statewide commonwealth campus system are available to conduct dust health and safety continuing education seminars. The PSU library, in general, and the College of Earth and Mineral Sciences Library, in particular,

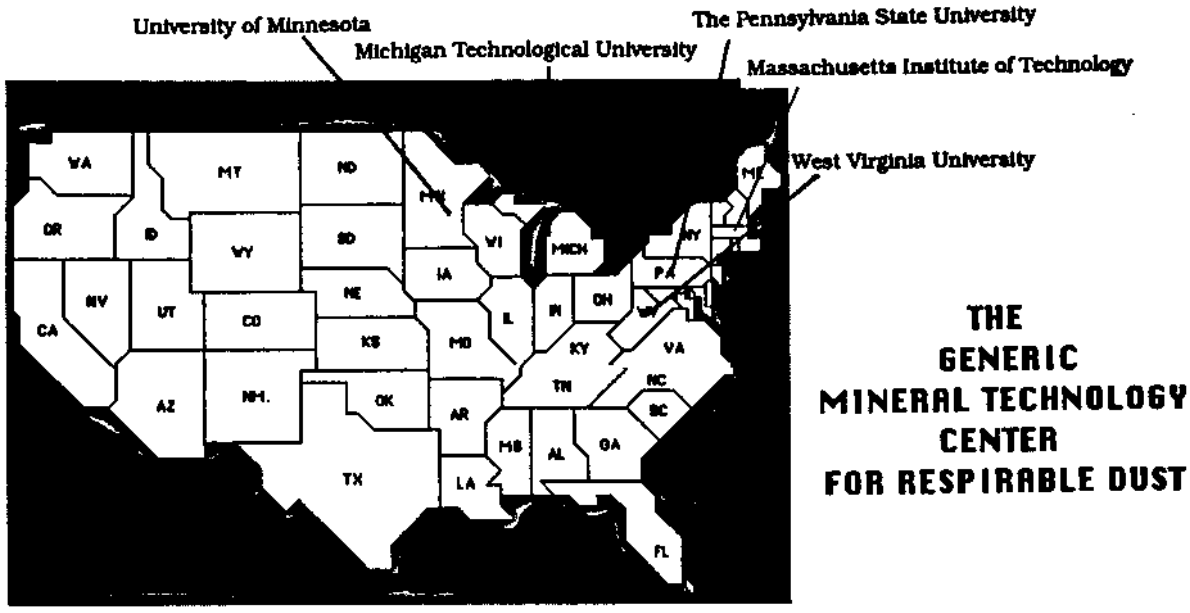


FIGURE 19 Generic Mineral Technology Center for Respirable Dust university locations.

provide outstanding research support with their extensive collection of books, journals, and research publications in the mineral sciences, engineering, and technology fields.

West Virginia University has a wide array of specialized resources necessary for carrying out the proposed research program. The Mining Engineering Department has fully equipped laboratories with special devices for measuring and recording parameters inside mines as well as on laboratory samples. Computer graphics and modeling capabilities in conjunction with the West Virginia Network for Educational Telecomputing are also available. Other departments at WVU that will contribute heavily to the proposed program include Mechanical Engineering, Chemical Engineering, Electrical Engineering, Physics and Chemistry. Of particular significance will be the Pulmonary Disease Section and the Department of Anatomy in the School of Medicine. More generally, West Virginia University has extensive library collections especially in areas related to mining. A complete set of Bureau of Mines Reports of Investigations as well as Department of Energy publications are available. Numerous other periodicals, books and special reports related to all aspects of mining are available. The West Virginia Network for Educational Telecomputing is a centralized service with one Amdahl 470 V/7A, three DEC VAX 11/780's and one DEC PDP 11/44. A wide array of input/output devices is available at the central site (on the WVU campus) as well as at selected locations near the primary users. The close proximity to the Eastern coal fields makes significant and meaningful industrial involvement possible. The mining extension service is nationally recognized for developing various in-mine training programs. The extension instructors are stationed

over the state making it ideal for technology transfer.

The University of Minnesota Particle Technology Laboratory has been involved in aerosol and powder research since the early 1950's. The research has been supported by many government agencies and industrial organizations in the period from the 1950's to the present. As a result of the research, many instruments have been developed, several of which are commercially available, and many scientific breakthroughs have been made. Since 1970 the Particle Technology Laboratory has had a working relationship with the Bureau of Mines under four contracts entitled " Instruments and Techniques for Dynamic Particle Size Measurement of Coal Dust," "Dynamic Particle Size Measurement of Coal Dust," "Instruments and Techniques for Aerodynamic Particle Size Measurement of Coal Dust," and "Respirable Dust Measurement."

AIMS

Center Specific Aims and Relevance to Industry Problems

The specific objective of the center is to reduce the incidence and severity of respirable dust disease through advancement of the fundamental understanding of all aspects of respirable dust associated with mining and milling and the interaction of dust and lungs. (FIGURE 20). Finding effective means to achieve this objective will be the main thrust of the Center's research program.

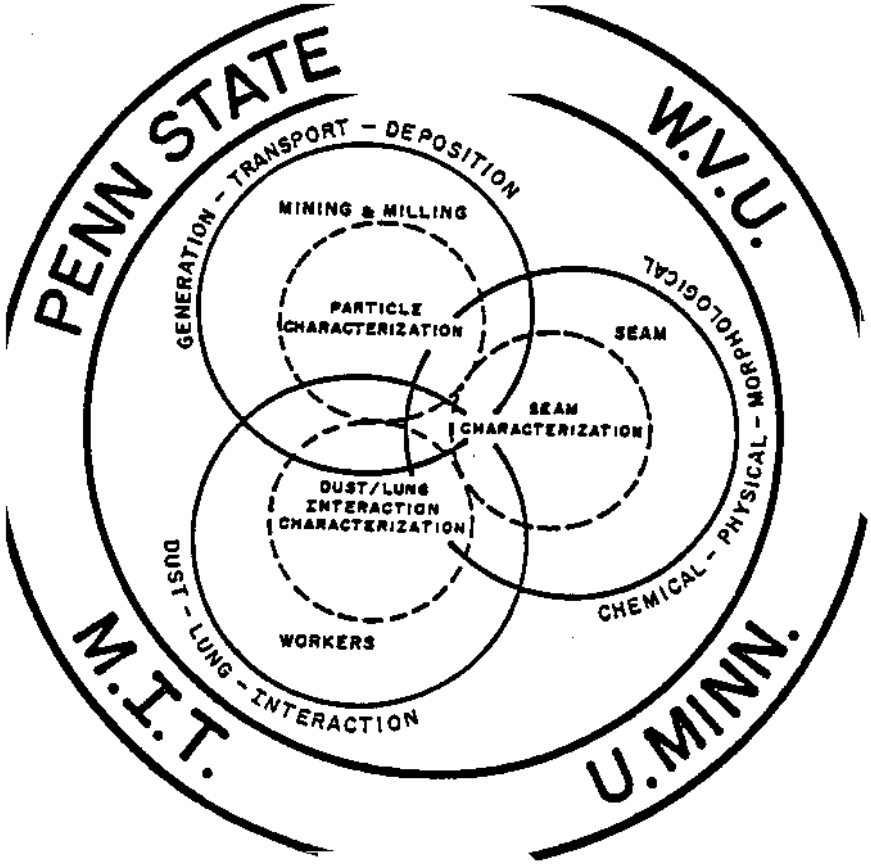


FIGURE 20 The Generic Mineral Technology Center for Respirable Dust

The control of dust-related diseases is supreme from the humane point of view. It is also essential for the economic well-being of the mining industry. While significant progress has been made, and the prevalence of respirable dust illness has been reduced, the problem continues to exist and needs solution. Furthermore, as the nation's demand for coal and other minerals increases, both production and number of miners employed will also increase, demanding an accelerated effort. In short, the relevance of the center's program to the mining industry cannot be overemphasized.

There are five areas of research that are envisioned under this proposal: 1) control of dust generation, 2) dilution, dispersion and collection of dust in mine airways, 3) characterization of dust particles, 4) interaction of dust and lungs and 5) the relationship of mine environment, geology, and seam characteristics to dust generation and mobility (FIGURE 21). The characterization of dust particles will consist of two distinct activities -- a service activity to characterize the dust for and from other research activities and a research activity to improve the state of the art of dust characterization technology. The above breakdown of program areas recognizes the importance of an integrated fundamental research approach to the respirable dust problem compatible and complementary with the existing and ongoing U.S. Bureau of Mines activities. It provides for the exploration of the various control strategies during mining. It emphasizes the need for understanding the role of the lung-dust interaction for respirable dust control. Finally,

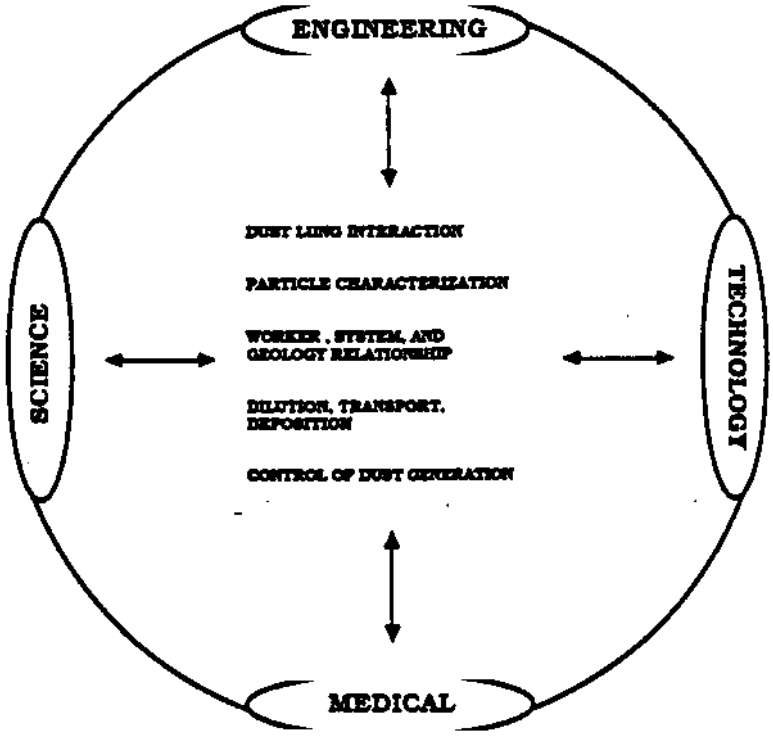


FIGURE 6 Standardized protocals for Respirable Dust Research in scientific, engineering, and medical areas.

it brings to the fore the need to more fully understand the influence of the geological settings on respirable dust generation and characteristics. The specific projects in the research areas are a result of a careful evaluation of the past and ongoing research activities, the identification of areas where data and information are scarce, and awareness of the recommendations of the NAS study. In the rest of this section, a brief description of each of the programmatic areas is provided.

Control of Dust Particle Generation

In any fragmentation process, particles will be produced in all size ranges below a top size. Fragmentation in underground mines occurs as a result of many processes: impact, crushing, grinding, blasting, etc. There has been a considerable body of literature developed that describes the results of research on respirable dust production by coal cutting machines (continuous miners/shearers, etc.). The influence of factors such as depth of cut, pick design, pick lacing, and cutting speed have been studied extensively both in the U.K. and the U.S.A. In reviewing these results, the NAS study found many disparities and recommended that studies on these factors be undertaken with the objective of understanding the fragmentation process and its relationship to respirable dust particle generation and characterization. Research on coal fragmentation and dust entrainment is vitally needed to both fully understand the generation and entrainment of respirable dust and to develop control measures to reduce its generation and entrainment.

Dilution, Dispersion and Collection in Mine Airways

The U.S. Bureau of Mines research has shown that only a small fraction of the respirable dust produced at the face becomes airborne. Experimental determinations have placed the amount of non-airborne respirable dust as ranging from 100 to 1,000 times that of airborne dust. There are several fundamental and applied studies needed in this area to understand more fully the role of mine ventilation and dust control practices in respirable dust control and its relationship to dust particle characteristics. The depositional characteristics of dust particles in mine airways and the velocities at which these deposited dusts may become airborne need to be studied. This includes pertinent questions on the chemical and mineralogical characteristics of an aged dust as compared to those of the new dust. It has been hypothesized that newly created dust may be more reactive than aged dusts. Such studies are important for the design of equipment and the development of operating practices to remove dust from the worker zone or the worker from the dust zone and must include theoretical, laboratory and field components.

Characterization of Dust Particles

The importance of identifying the physical, chemical, mineralogical, size consist, shape and surface condition of respirable dust samples can hardly be over-emphasized. None of these characteristics will be single-valued quantities. In any given dust, there will be a distribution of sizes, shapes, etc. The characterization studies will be aimed at evaluating these distributions. Characterization of the dust collected in the various areas of research identified earlier is essential. Again, for dust/lung relationship studies in the laboratory, samples of respirable dust that have been characterized for the particular objective and scope of each study should be utilized. As the ability to characterize these materials increases, more accurate determinations of the impact of respirable dust can be made in specific applications in both hard rock mines and coal mines. Thus, there will be fundamental research aimed at developing better dust characterization methods.

Interaction of Dust and Lungs

Respirable dust disease is a crippling affliction of coal miners and persons in related occupations. Respirable dust injures the lung tissue, resulting in severe pulmonary scarring (fibrosis) and compromise of pulmonary function. Too little is yet known about deposition, cellular or molecular events that lead to pulmonary fibrosis to permit biological or other intervention in the disease process. The characterization of dust-lung interaction is critical for the development of effective engineering control measures in mines and milling operations. Research in this area will concentrate on developing an understanding of the basic processes that occur between the dust and lungs. The objective of research in this area is to characterize dust-lung interrelationships necessary to relate dust control strategies in environments likely to create an occupational lung problem.

Relationship of Mine Environment, Geology and Seam Characteristics to Dust Generation and Mobility

During the mining of a seam, dilution from the roof and floor and from partings and inclusions in the seam, is a standard occurance. In coal mining, since the roof and floor strata and inclusions and partings often have greater strength than coal, the mass of adverse dust generated can be much more than if only coal is cut, especially if quartz or other toxic material is present. The size distribution, chemical and mineralogical properties of the respirable dust can also be different from that obtained from cutting coal only. Therefore, the relationship between the coal and out-of-seam material characteristics and the characteristics of the mine respirable dust must be explored. Underground experiments need to be performed on all the mined components. The dust samples should be characterized for chemical, mineralogical, shape and size consist. For selected respirable size ranges, the chemical and mineralogical composition need to be analyzed. Several projects are proposed in this area including development of comprehensive facilities at both PSU and WVU for performing detailed seam characterization.

Student Involvement in the Center

Graduate education is an integral part of the Center's research. Each proposed project is designed not only to attack an important problem but to train at least one graduate student. Time is projected to allow for a full development of student involvement and to ensure that students fulfill the graduate program requirements. The scope of work and the time duration of each project for the proposed center have been developed taking into account the needs of the graduate research program and training. WVU and PSU have accredited mining engineering curricula and have two of the largest enrollments of graduate students in mining engineering in the nation. During the year 1981-82 , of the 7 Ph.D.s graduated in Mining Engineering in the U.S., 5 were fromWVU and PSU. Similarly, of the 61 master's degrees graduated, 18 were from these two schools. The number of undergraduate students in WVU and PSU account for approximately 20 percent of the total undergraduate enrollment in the U.S. mining schools. PSU and WVU have graduated the largest number of mining engineers in the period 1980-82. The mining engineering section at PSU had in operation for the last three years a research practicum for qualified senior undergraduates designed to acquaint these seniors with research and inspire students in the latest research opportunities. These avenues for student involvement will be greatly strengthened and expanded by the proposed Center.

Program Areas with Time-Phased Objectives

This proposal presents a comprehensive program which will significantly accelerate the attack on the understanding of the origin, generation, transport, dust-lung interaction and particle characteristics in mines. Such a program would be in the spirit of the NAS study and complementary with existing and ongoing USBM respirable dust research activities.

ADMINISTRATION

The center will be geographically dispersed between The Pennsylvania State University and the West Virginia University. The center will reside within the MRIs of the respective institutions and will operate within the existing organizational ties with the College, University and the participating MRIs at UMN and MIT. The existing MRI reporting system will be used to issue progress and final reports on research projects. The direction of the center activities will reside in an Advisory Board.

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PREPRINT NUMBER

A REVIEW OF THE PROGRAMS AND ACTIVITIES OF THE GENERIC MINERAL TECHNOLOGY CENTER FOR RESPIRABLE DUST

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For presentation at the SME-AIME Annual Meeting
New Orleans, Louisiana - March 2-6, 1986

THE RESPIRABLE DUST CENTER

Abstract. The U.S. Bureau of Mines (USBM) established on August 15, 1983, a Generic Mineral Technology Center (GTC) for Respirable Dust within the Mining and Mineral Resources Research Institutes (MRIs) at The Pennsylvania State University (PSU) and West Virginia University (WVU) in association with participating MRIs at Massachusetts Institute of Technology (MIT) and the University of Minnesota (UMN). The primary goal of the Center is to reduce the incidence and severity of respirable dust disease through researching and advancing the fundamental understanding of all aspects of respirable dust associated with mining and milling and the interaction of dust and lungs. Other Center activities include the training of engineers and scientists, graduate students and undergraduate students through their respective institutions, and the technology transfer to the industry. The Center also serves as the reference center for publications in the respirable dust area.

Introduction

Exposure to respirable contaminants in mine atmospheres has long posed a serious hazard to miners. The control of these hazards, some of which can have sudden and catastrophic effects and some others, slow and long enduring consequences, has been a major concern for labor, management and government alike. This concern has manifested itself in four primary mechanisms of control — (1) regulatory control through minimum standard setting by the passage of mine health and safety laws, (2) engineering control through design and operation of mines according to the best recommended practices, (3) interaction of dust and lung control through periodic physical examinations, wearing personal protection devices, etc., and (4) legal and social control through workmen's compensation laws for occupation related health deterioration.

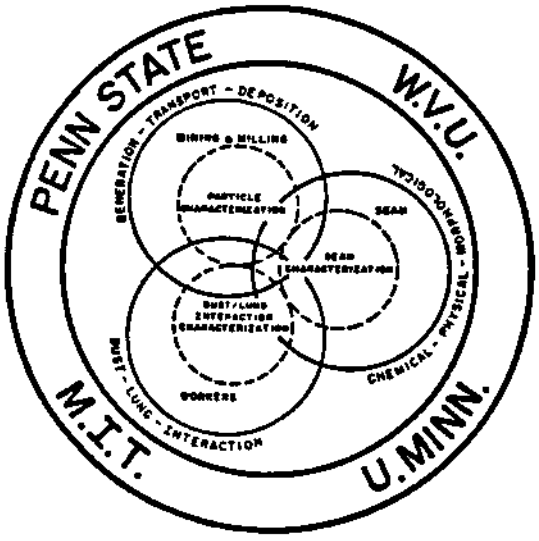
The stated objective of the Federal Mine Safety and Health laws is to "... permit each miner the opportunity to work underground during the period of his entire adult working life without incurring any disability from pneumoconiosis or any other occupation-related disease ...."

Significant progress has been made in lowering the dust levels in mines since the inception of the Bureau's respirable dust research program. It is generally agreed that mines are less dusty today than they were a decade ago. However, the most serious hazard for workers in the mining and minerals processing industries is still the exposure to respirable dust, and solutions to the problem of respirable dust disease remain to be found.

The National Academy of Sciences (NAS) Study, Measurement and Control of Respirable Dust in Mines, proposed a significant increase in research "for obtaining fundamental understanding of the origin, transport and characteristics of respirable coal mine dust." This recommendation considered the impact on society of mine workers' pneumoconiosis and the magnitude of the research and development effort needed to bridge the information gaps identified by the NAS study group. It is within this context that a comprehensive program designed to permit an accelerated attack on the fundamental research problems for the control of respirable dust in mines was initiated in the Center.

Research Program

The Generic Technology Center's research program explores the health and safety concerns of respirable dust with the objective of refining existing strategies and developing new respirable dust control techniques that are consistent with the fundamental dust-lung interaction processes that lead to mine worker disability. The work concentrates on (1) control of dust generation; (2) dilution, dispersion and collection in mine airways; (3) characterization of dust particles; (4) interaction of dust and lungs; and (5) relationship of mine environment, geology, and seam characteristics to dust generation and mobility. The fundamental aspects of this work are applicable to the control of respirable dust problems in both hard rock mines and coal mines and to other dusts such as diesel-generated. The intertwined relationship of dust particle characterization, seam characterization and dust/lung interaction characterization, which is the focus of the Center's activities, is shown in the figure.



At the present time, there are 25 principal investigators and an equal number of graduate students working on 26 projects in the five major areas of the Generic Technology Center. It will be difficult to describe all the activities of the Center in this paper. The bibliography at the end of this paper is a partial listing of the Center's publications in which more details on specific research activities can be found. A brief description of the scope of each of the five major areas and some of the current activities in each area is presented below.

Control of Dust Particle Generation

In any fragmentation process, particles will be produced in all size ranges below a top size. Fragmentation in underground mines occurs as a result of many processes: impact, crushing, grinding, blasting, etc. There has been a considerable body of literature developed that

describes the results of research on respirable dust production by coal cutting machines (continuous miners/shearers, etc.). The influence of factors such as depth of cut, pick design, pick lacing, and cutting speed have been studied extensively both in the U.K. and the U.S. In reviewing these results, the NAS study found many disparities and recommended that studies on these factors be undertaken with the objective of understanding the fragmentation process and its relationship to respirable dust particle generation and characterization. Specific projects in this area include a fracture mechanics study of crack propagation in coal and experimental studies on the mechanism of dust generation and entrainment (4,5,12,13,14,15,16,32).

Dilution, Dispersion and Collection in Mine Airways

The U.S. Bureau of Mines research has shown that only a small fraction of the respirable dust produced at the face becomes airborne. Experimental determinations have placed the amount of non-airborne respirable dust as ranging from 100 to 1,000 times that of airborne dust. There are several fundamental and applied studies needed in this area to understand more fully the role of mine ventilation and dust control practices in respirable dust control and its relationship to dust particle characteristics. The depositional characteristics of dust particles in mine airways and the velocities at which these deposited dusts may become airborne are variable with type of dust. Prediction of ambient dust concentrations using convective-diffusion equations and experimental studies of dispersion and transport of respirable dust in mine atmospheres are research projects in this area (1,2,3,8,24,28). Such studies are important for the design of equipment and the development of operating practices to remove dust from the worker zone or the worker from the dust zone and include theoretical, laboratory, and field components.

Characterization of Dust Particles

The importance of identifying the physical, chemical, mineralogical, size consist, shape and surface condition of respirable dust samples can hardly be over-emphasized. None of these characteristics will be single-valued quantities. In any given dust, there will be a distribution of sizes, shapes, etc. The characterization studies are aimed at evaluating these distributions. Characterization of the dust collected in the various areas of research identified earlier is essential. Thus, there is fundamental research aimed at developing better dust characterization methods. In this area, there are several projects dealing with such topics as wettability of coal mine dust particles; the theoretical and experimental determination of the aerodynamic diameter of coal dust particles; x-ray fluorescence analysis of dust particles on a one-by-one basis in an automated, computer-controlled scanning electron microscope (SEM); magnetic resonance spectroscopic characteristics of paramagnetic ions and free radicals in coal dust, black lung tissues and lung tissue under controlled exposures; shape and surface characterization of respirable mine dust particles; silica particle concentrations in the respirable size range; and investigation of gravity fractionation procedures for determining the specific gravity distribution of respirable dust (7,18,19,20,21, 30,31).

Interaction of Dust and Lungs

The characterization of dust-lung interaction is critical for the development of effective engineering control measures in mines and milling operations. Research in this area is concentrating on developing an understanding of the basic processes that occur with the deposition of dust in the lungs and the interactions that occur between the dust and lungs. The objective of research in this area is to characterize dust-lung interrelationships necessary to relate dust control strategies in environments likely to create an occupational lung problem. The dust-lung interaction studies include, among others, characterization of mechanism of lung injury and morphometric study of the pulmonary inhalation toxicity of respirable coal mine dusts (9,10,26).

Relationship of Mine Environment, Geology and Seam Characteristics to Dust Generation and Mobility

During the mining of a seam, dilution from the roof and floor and from partings and inclusions in the seam is a standard occurrence. In coal mining, since the roof and floor strata and inclusions and partings often have greater strength than coal, the mass of adverse dust generated can be much more than if only coal is cut, especially if quartz or other toxic material is present. The size distribution, chemical and mineralogical properties of the respirable dust can also be different from that obtained from cutting coal only. Therefore, the relationship between the coal and out-of-seam material characteristics and the characteristics of the mine respirable dust is being explored. Studies in this area have concentrated on establishment of standard procedures for characterization of coal seams for respirable dust generation potential; correlation of respirable dust characteristics of coal seams, worker locations and mining methods; and respirable dust testing procedures in metal, non-metal and metallurgical operations (6,11,17,22,23,29).

Technology Transfer

The Center conducts research in the five specified areas with primary emphasis on the engineering control of dust in mines and the interaction of dust and lungs. The unique resources of the four institutions of higher education are being brought together to address these complex problems and to also foster industrial cooperation and technology transfer. Research results are being integrated into existing mining engineering education, short courses and seminar programs.

Graduate education is an integral part of the Center's research. Each project is designed not only to attack an important problem but to train at least one graduate student. Time is projected to allow for a full development of student involvement and to ensure that students fulfill the graduate program requirements. The scope of work and the time duration of each project for the

Center have been developed taking into account the needs of the graduate research program and training.

Publication of papers in mining industry journals and reports on specific findings are presented at professional meetings. The Center sponsors conferences on respirable dust in mining. Proceedings of the first Coal Mine Dust Conference sponsored by the Generic Technology Center is available from West Virginia University. The next scheduled meeting is an International Conference titled "Respirable Dust in the Mineral Industries" to be held at Penn State on October 14-16, 1986. The major topics to be discussed at this conference include: generation, dissemination, control, measurement, characterization, legal and regulatory matters, clinical techniques and epidemiology, pathology and pathogenesis, biochemical aspects and complications.

Reference Center

The Center also serves as the reference center for publications in the respirable dust area. A computer based reference search system is in place and functioning. The Respirable Dust library is based on an IBM PC-XT system utilizing software designed to allow direct access and electronic mail services through a telephone line. Abstracts of Center generated publications are maintained in the Center. At each participating university a hard copy collection of the respirable dust research performed by that particular university's personnel is maintained, plus other relevant respirable dust publications. The Center encompasses two major medical schools and includes national and international experts in such diverse disciplines as geology, geomechanics, mining engineering, mineral processing, electrical engineering, industrial engineering, mechanical engineering, material sciences, physics, and the various fields of medicine. These authorities are constantly updating information regarding their special areas of expertise and serve as geographically dispersed resource references in the ten disciplines identified. If a more comprehensive literature search is desired, a researcher can utilize the on-line services of LIAS to search the Penn State library system.

The Reference Center also has access through the University Libraries and other institutional libraries to a large number of data bases such as MEDLINE at the National Library of Medicine, Lockhead Corporation, the energy data base of the U.S. Government, DIALOGUE Information Support System (comprised of over 100 data bases), ISI International Scientific Information System, and data bases of professional societies such as the Institute of Mining and Metallurgy (UK), and Information on Demand, Inc., a research service available to SME members and SPIRES, the Stanford University System. A one-time expenditure may be required to have a computer search performed on some of these data bases on key words such as black lung, respirable dust, silicosis, etc. Utilization can also be made of abstracting services such as Engineering Index and Coal Abstracts (EEC) as means of accessing specific information for researchers.

The most important goal of the Respirable Dust Reference Center is to identify what respirable dust related information is available at what location and provide the means of access for others to obtain the information. The second goal is to have both maximum input and retrieval capabilities to the broad team of experts in the reference center. Another goal is to ensure that the service provided to the inquiring public is complete, cost-effective, and the best professional service available.

The Center activities involve the training of engineers and scientists, graduate students and undergraduate students through their respective institutions, and the technology transfer to industry and government of scientific information regarding respirable dust.

Summary

In summary, the Center presents a comprehensive program which accelerates the attack on the fundamental understanding of the origin, generation, transport, dust-lung interaction and particle characteristics in mines. Such a program is in the spirit of the NAS study and is complementary with existing and ongoing USBM respirable dust research activities. The comprehensive research program is believed to be economically justified in view of the gigantic $1.7 billion annual cost and 500,000 person severity (miners and dependents) of the respirable dust problem. Of greater importance, the control of dust-related diseases is supreme from the humane point of view. While significant progress has been made, and the prevalence of respirable dust illness has been reduced, the problem continues to exist and needs solution. Furthermore, as the nation's demand for coal and other minerals increases, both production and number of miners employed will also increase, demanding an accelerated effort to solve the problem.

Acknowledgments

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Industrial Research Office

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The Pennsylvania State University

The research conducted in these programs is interdisciplinary and allows faculty and graduate students from diverse backgrounds to exchange knowledge, share ideas, and work together. The programs provide special facilities and support personnel, but offer no academic degrees. Annual R&D expenditures of these units range up to $7 million except for the Applied Research Laboratory which exceeds $31 million. These dollar amounts are included in Penn State's total annual research expenditures for 1986/87 of $172.7 million. Faculty participating in these research programs are interested in working with industrial companies and many are experienced in cooperative industry/university efforts. Our office is available to assist you in exploring the possibilities of working together or you can contact the program director. Write-ups on the following research programs are attached:

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- Cell and Molecular Biology Center, Hershey Medical Center
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- Center for Electronic Materials and Devices
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- Center for Locomotion Studies
- Center for Statistical Ecology and Environmental Statistics
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- Generic Mineral Technology Center for Respirable Dust
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- Institute for Policy Research and Evaluation
- Institute for Real Estate Studies
- Laboratory for Human Performance Research
- Low-Level Radiation Monitoring Laboratory
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- Materials Research Laboratory
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- Optical Measurements Facility
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August 3, 1988

GENERIC MINERAL TECHNOLOGY CENTER FOR RESPIRABLE DUST

College of Earth and Mineral Sciences
The Pennsylvania State University

The U.S. Bureau of Mines established on August 15, 1983, the Generic Mineral Technology Center for Respirable Dust within the Mining and Mineral Resources Research Institutes (MRIs) at The Pennsylvania State University and West Virginia University in association with participating MRIs at Massachusetts Institute of Technology and the University of Minnesota. The Center's research program has been developed with recognition of the stated objective of the Federal Mine Safety and Health laws which is to ". . . permit each miner the opportunity to work underground during the period of his entire adult working life without incurring any disability from pneumoconiosis or any other occupation-related disease . . . ." The Center's program is designed to permit an accelerated attack on the fundamental research problems for the control of respirable dust in mines.

The primary goal of the Center is to reduce the incidence and severity of respirable dust disease through advancing the fundamental understanding of all aspects of respirable dust associated with mining and milling and the interaction of dust and lungs. The Generic Technology Center's research program explores these concerns with the objective of refining existing strategies and developing new respirable dust control techniques that are consistent with the fundamental dust-lung interaction processes that lead to mine worker disability. The work concentrates on: (1) control of dust generation; (2) dilution, dispersion and collection in mine airways; (3) characterization of dust particles; (4) interaction of dust and lungs; and (5) relationship of mine environment, geology, and seam characteristics to dust generation and mobility. The fundamental aspects of this work are applicable to the control of respirable dust problems in both hard rock mines and coal mines and to other dusts such as diesel-generated. The Center activities involve the training of engineers and scientists, graduate students and undergraduate students through their respective institutions, and the technology transfer to the industry. The Center also serves as the reference center for publications in the respirable dust area.

The Center is composed of faculty from the four universities/institutes listed above. The personnel, facilities and equipment that are available to the Center from these entities are diverse, complementary and comprehensive. More than fifty scientists, engineers, and medical personnel in the Center are engaged in respirable dust research. Additionally, the expertise and facilities of the NIOSH—Division of Respirable Disease Studies are available as a result of the existing relationship between NIOSH and West Virginia University.

The breakdown of the dust research program into the five areas mentioned above recognizes the importance of an integrated fundamental research approach to the respirable dust problem compatible and complementary with the existing and ongoing U.S. Bureau of Mines activities. The specific projects in the research areas are a result of a careful evaluation of the past and ongoing research activities, the identification of areas where data and information are scarce, and awareness of the recommendation of the National Academy of Sciences Study on the Measurement and Control of Respirable Dust. Penn State is the administrative unit for the Center. Funding to date is nearly $6.5 million.

For more information regarding the Generic Mineral Technology Center for Respirable Dust, call or write Drs. R. V. Ramani or R. L. Frantz, Co-directors, 104 Mineral Sciences Building, University Park, PA 16802; (814)863-4487.

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RESEARCH PROGRAMS AND LABORATORIES
The Pennsylvania State University

Brief write-ups on the following research programs and laboratories at Penn State are available upon request. Please indicate with an "x" in the appropriate space which write-up(s) you would like to receive and return this form to Industrial Research Office, Penn State, 201 ABL Building, University Park, PA 16802. If you would like to request this information by phone, please call 814-865-9519.

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_____ Cell and Molecular Biology Center--College of Medicine.
_____ Center for Advanced Materials--high temperature ceramics.
_____ Center for Cell Research--a NASA Center.
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_____ Center for Dielectric Studies--ceramic capacitators.
_____ Center for Electronic Materials and Devices
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_____ Center for Issues Management Research
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_____ Consortium for the Advancement of Building Sciences
_____ Consortium on Chemically Bonded Ceramics--cements.
_____ Cooperative Program in Biotechnology
_____ Cooperative Program in Coal Research
_____ Cooperative Program in High Temperature Engineering Materials Research--ceramics.
_____ Cooperative Program in Metallurgy
_____ Diamond and Related Materials Consortium
_____ Earth System Science Affiliates Program
_____ Electronic Materials, Processing, and Devices Consortium
_____ Energy and Fuels Research Center
_____ Environmental Resources Research Institute--air; land; water.

(Continued)

RESEARCH PROGRAMS AND LABORATORIES
The Pennsylvania State University
Page 2

_____ *Escherichia coli* Reference Center and Systematics Collection

_____ Generic Mineral Technology Center for Respirable Dust

_____ Institute for Applied Psychology and Behavioral Sciences

_____ Institute for Policy Research and Evaluation

Respirable Dust Center information is supplied when this box is checked.

_____ Institute for Real Estate Studies--market research; land regulation vs. property rights.

_____ Institute for the Study of Business Markets--industrial marketing.

_____ Laboratory for Human Performance Research--exercise tolerance; energetics.

_____ Low-Level Radiation Monitoring Laboratory

_____ Manufacturing Technology Research Programs--laser articulated robotic system, intelligent robotic inspection system.

_____ Materials Research Laboratory--piezoelectric motors; sensors and transducers; ferroelectric; specialized materials.

_____ Mine Electrical Laboratory

_____ Mining & Excavation Research Institute

_____ Motor Behavior Laboratory--human movement skills.

_____ Optical Measurements Facility--electro-optics.

_____ Particle Beam Interactions with Solid Surfaces and Thin Films

_____ Penn State Rock Mechanics Laboratory

_____ Pennsylvania Transportation Institute--transp. systems; public transp.; transp. policy analysis; vehicle/surface interaction; pavement & materials; accident analysis.

_____ Project FERMI--nuclear energy.

_____ Radionuclear Applications Laboratory

_____ Research Center for the Engineering of Electronic and Acoustic Materials and Devices--wave-materials interaction; electromagnetic and optically absorbing materials; anti-reflective paints.

_____ Sensory Evaluation Laboratory

_____ Sports Research Institute--athletic surfaces and protective equipment.

_____ Standard Oil Center of Scientific Excellence in Mining Technology

_____ Please list any specific technical interest areas not listed above:

_____ I am interested in discussing our specific technical interests as they relate to industry/university interaction.

Forward the above requested write-up(s) to:

Name: Title:

Company: Subsidiary of:

Address: Telephone:

City: State: _____ Zip: _____

10/88

THE PENNSYLVANIA STATE UNIVERSITY
VICE PRESIDENT FOR RESEARCH AND DEAN OF THE GRADUATE SCHOOL
INDUSTRIAL RESEARCH OFFICE
201 ABL BUILDING
865-9519

Date: June 10, 1988

From: James W. Lundy JWL

To: Raja V. Ramani

Re: Generic Mineral Technology Center for Respirable Dust

A mailing to the Pennsylvania headquartered Fortune 500 companies offering to send brief write-ups on research centers, etc. at Penn State has recently been completed.

Responses are being received from this mailing. Copies of the reply forms which requested a write-up on your program are attached. Information on other responses will be forwarded to you as they are received.

Let's keep each other informed on the results of these contacts as we want to be able to evaluate our effort. Some of the responses should develop into further contacts/interaction and project or program support.

Please feel free to call or write these contacts. A follow-up contact soon after receipt of their initial request is the best approach in most instances. I will be calling some of the companies to determine the degree of their interest.

Attachments

cc: Peter T. Luckie
Richard L. McCarl
Forrest J. Remick
Kenneth J. Yost

cc: R. L. Frantz
Nancy Rishel

RESEARCH PROGRAMS AND LABORATORIES
The Pennsylvania State University

SEP - 8 '88

Brief write-ups on the following research programs and laboratories at Penn State are available upon request. Please indicate with an "x" in the appropriate space which write-up(s) you would like to receive and return this form to Industrial Research Office, Penn State, 201 ARL Building, University Park, PA 16802. If you would like to request this information by phone, please call 814-865-9519.

_____ Applied Research Laboratory—Navy lab; underwater acoustics; hydrodynamics.
_____ Architectural Engineering Illumination Affiliates Program
_____ Biomechanics Laboratory—exercise and sport science field.
_____ Biotechnology Institute
_____ Cell and Molecular Biology Center—College of Medicine.
_____ Center for Advanced Materials—high temperature ceramics.
_____ Center for Automation and Robotics
_____ Center for Cell Research—a NASA Center.
_____ Center for Composites—structural.
_____ Center for Dielectric Studies—ceramic capacitators.
_____ Center for Electronic Materials and Devices
_____ Center for Issues Management Research

RESEARCH PROGRAMS AND LABORATORIES
The Pennsylvania State University

✓ Generic Mineral Technology Center for Respirable Dust
_____ Institute for Applied Psychology and Behavioral Sciences
_____ Institute for Policy Research and Evaluation
_____ Institute for the Study of Business Markets—industrial marketing.
_____ Laboratory for Human Performance Research—exercise tolerance; energetics.
_____ Manufacturing Technology Research Programs—laser articulated robotic system, intelligent robotic inspection system.
_____ Materials Research Laboratory—piezoelectric; ferroelectric; specialized materials.
_____ Mine Electrical Laboratory
_____ Mining & Excavation Research Institute
_____ Motor Behavior Laboratory—human movement skills.
_____ Optical Measurements Facility—electro-optics.
_____ Particle Beam Interactions with Solid Surfaces and Thin Films
_____ Penn State Rock Mechanics Laboratory
_____ Pennsylvania Transportation Institute—transp. systems; public transp.; transp. policy analysis; vehicle/surface interaction; pavement & materials; accident analysis.
_____ Project PERMI—nuclear energy.
_____ Research Center for the Engineering of Electronic and Acoustic Materials—piezoelectric motors; sensors and transducers; actuators; capacitors.
_____ Sports Research Institute—athletic surfaces and protective equipment.
_____ Standard Oil Center of Scientific Excellence in Mining Technology

_____ Please list any specific technical interest areas not listed above: _____

Forward the above requested write-up(s) to:
Name: Carolyn C. Klett Title: Gen Mgr, Tech Svcs.
Company: Armstrong World Industries, Inc. Subsidiary of:
Address: 2500 Columbia Avenue Telephone: (717) 396-3601
City: Lancaster Pa. State: PA Zip: 17604

PENNSTATE

Industrial Research Office
Sr. Vice President for Research
and Dean of the Graduate School

(814) 865-9519
306 W. College
The Pennsylvania State University
University Park, PA 16801

September 9, 1988

Nancy
RR 9/13

Ms. Carolyn C. Kent
General Manager, Technical Services
Armstrong World Industries, Inc.
2500 Columbia Avenue
Lancaster, PA 17604

Dear Ms. Kent:

Thank you for sending us your response form requesting the write-up on Penn State's research. We have enclosed the written material which you requested, and have informed the faculty who may be sending you some additional information.

Please feel free to contact us or the respective program directors for additional information or to discuss specific technical interests. We would be willing to arrange a meeting for discussions of potential projects or possible participation in affiliate/cooperative programs. General exploratory campus visits with department heads, program directors, and research deans can also be scheduled.

Let us know if we can be of assistance.

Sincerely,

James W. Lundy
Director

Enclosure

THE PENNSYLVANIA STATE UNIVERSITY
Industrial Research Office
201 ABL Building
865-9519

SEP 1 2 1988

Date: September 9, 1988

From: J. W. Lundy

To: R. V. Ramani

( ) For your approval and forwarding

( ) For your approval and return to me

(✓) For your information — do not return
please return
please forward

Comments:

Enclosed is another response form for the Generic Mineral Technology Center for Respirable Dust.

RESPIRABLE DUST PROGRAM

RESEARCH PROGRAMS AND LABORATORIES
The Pennsylvania State University

Brief write-ups on the following research programs and laboratories at Penn State are available upon request. Please indicate with an "x" in the appropriate space which write-up(s) you would like to receive and return this form to Industrial Research Office, Penn State, 201 ABL Building, University Park, PA 16802. If you would like to request this information by phone, please call 814-865-9519.

_____ Applied Research Laboratory--Navy lab; underwater acoustics; hydrodynamics.
_____ Architectural Engineering Illumination Affiliates Program
_____ Biomechanics Laboratory--exercise and sport science field.
_____ Biotechnology Institute
_____ Cell and Molecular Biology Center--College of Medicine.
X Center for Advanced Materials--high temperature ceramics.
_____ Center for Automation and Robotics
_____ Center for Cell Research--a NASA Center.
_____ Center for Composites--structural.
_____ Center for Dielectric Studies--ceramic capacitators.
_____ Center for Electronic Materials and Devices
_____ Center for Issues Management Research

RESEARCH PROGRAMS AND LABORATORIES
The Pennsylvania State University

X Generic Mineral Technology Center for Respirable Dust
_____ Institute for Applied Psychology and Behavioral Sciences
_____ Institute for Policy Research and Evaluation
_____ Institute for the Study of Business Markets--industrial marketing.
_____ Laboratory for Human Performance Research--exercise tolerance; energetics.
_____ Manufacturing Technology Research Programs--laser articulated robotic system, intelligent robotic inspection system.
_____ Materials Research Laboratory--piezoelectric; ferroelectric; specialized materials.
_____ Mine Electrical Laboratory
_____ Mining & Excavation Research Institute
_____ Motor Behavior Laboratory--human movement skills.
X Optical Measurements Facility--electro-optics.
_____ Particle Beam Interactions with Solid Surfaces and Thin Films
_____ Penn State Rock Mechanics Laboratory
_____ Pennsylvania Transportation Institute--transp. systems; public transp.; transp. policy analysis; vehicle/surface interaction; pavement & materials; accident analysis.
_____ Project PERMA--nuclear energy.
X Research Center for the Engineering of Electronic and Acoustic Materials--piezoelectric motors; sensors and transducers; actuators; capacitors.
_____ Sports Research Institute--athletic surfaces and protective equipment.
_____ Standard Oil Center of Scientific Excellence in Mining Technology

_____ Please list any specific technical interest areas not listed above: _____

RIPS

Forward the above requested write-up(s) to:
Name: Mr. Domenic J. Tessari
Company: CertainTeed Corporation
Address: 1400 Union Meeting Road
City: Blue Bell

Title: Vice President, Research & Develop
Subsidiary of:
Telephone: (215) 341-6661
State: PA Zip: 19422

III
PERSONNEL

INTRODUCTION

The faculty, graduate students, and post-doctoral researchers are an integral part of the Generic Mineral Technology Center for Respirable Dust. More than fifty (50) scientists, engineers, and medical personnel are engaged in respirable dust research at five universities, The Pennsylvania State University, West Virginia University, Massachusetts Institute of Technology, University of Minnesota, and Michigan Technological University. The expertise, effort and contribution of these individuals has proven to be invaluable in the attack on respirable disease. Nationally and internationally recognized researchers in the areas of particle characterization, interaction of dust and lungs, dilution and dispersion, rock mechanics and continuing education lend their laboratory facilities, equipment and human resources to benefit the mining industry. The expertise and resources of the National Institute for Occupational Safety and Health--Division of Respirable Disease Studies is available through their relationship with West Virginia University.

Summary of Current Personnel

	Lead Institutions	Affiliates
1. Faculty	41	12
2. Masters Candidates	14	7
3. Doctoral Candidates	21	5
4. Post-doctoral	9	0
5. Faculty who have transferred as a result of the existence of this center	0	0

PERSONNEL CURRENTLY ACTIVE ON GTCRD PROJECTS

Penn State University - Lead Institution

USBM Account Number	GTC Number	Title	Faculty	Graduate Students		Post Doctoral
				Masters	Doctoral	
4200	PS6	Information Exchange & Dissemination	Frantz Ramani			
4201	PS1	A Fracture Mechanics Study of Crack-Propagation Mechanism in Coal Utilizing Fracture Toughness and Fracture Velocity Concepts	Bieniawski			
4202	PS2	Prediction of Ambient Dust Concentrations in Mine Atmospheres	Ramani		Shankar	
4203	PS3	Characterization of Dust Particles	Hogg Luckie	Runnaul	Dumm	
4204	PS4	Characterization of the Mechanism of Lung Injury by Coal Mine Dusts	Bartlett			
4205	PS5	Establishment of Standard Procedures for Characterization of Respirable Coal Mine Dust Potential	Mutmansky Bise	Xu Padmanabhan		
4206	PS7	Computer Modeling of Longwall Face Ventilation	Ramani		Qin	
4207	PS8	Wetting Characteristics of Dust	Aplan Chander	Alaboyun		
4208	PS9	Analysis of Coal Particles on a One-by-One Basis Using an Automated, Computer-Controlled SEM with X-ray Fluorescence Particles in Relation to Dust Abatement	Austin			

PERSONNEL CURRENTLY ACTIVE ON GTCRD PROJECTS

Penn State University - Lead Institution

USBM Account Number	GTC Number	Title	Faculty	Graduate Students		Post Doctoral
				Masters	Doctoral	
4209	PS10	Investigation of the Role of Polymorphonuclear Leukocytes (PMN's) in the Dust Lung Intertaction	Demers			
4210	PS11	Biochemical Alternations in Mammalian Respiratory Mucus by Coal Mine Dust	Bhavanandan			
4211	PS12	Interactions with Nonhuman Primate Lungs	Drozdowicz Bowman			
4221	PS13	Knowledge Based Expert System for Planning Mine Ventilation Systems	Ramani	Swaminathan	Prasad	
4222	PS14	Formulation, Evaluation and Verification of Improved Dust Sampling and Analytical Strategies for Use at Coal Mines (jt.proj.)	Mutmansky	Li		
4223	PS15	Adhesion, Agglomeration and Deposition of Respirable Dust	Chander	Polat	Ray	
			Hogg	Koban	Kumar	

PERSONNEL CURRENTLY ACTIVE ON GTCRD PROJECTS

West Virginia University - Lead Institution

USBM Account Number	GTC Number	Title	Faculty	Graduate Students		Post Doctoral
				Masters	Doctoral	
5400 5421	WV7	Information Exchange & Dissemination	Bajura			
5401	WV1	Experimental Study of the Mechanisms of Dust Generation and Entrainment	Khair Siriwardane	Sirwargane	Begley DeVilder	
5402	WV2	Experimental Studies of Dispersion and Transport of Respirable Dusts in Mine Atmospheres	Wang			
5403	WV3	Measurements and Construction of Dust Distribution Maps for Longwall Faces	Peng Chiang			*McCawley
5404	WV4	General Support Characterization	Bajura Pavlovic			*Vallyathan
5405	WV5	Pulmonary Inhalation Toxicity of Respirable Coal Mine Dusts: A Morphometric Study	Hinton		Chien	Jafari
5406	WV6	Correlations of Respirable Dust Characteristics to Coal Seams, Worker Positions and Mining Methods	Peng Stobbe Grayson	Kadrichu	Kim Zhao	*Wallace *McCawley
5407	WV8	Dust-Lung Interaction in Coal Miners	Lapp Abrons		Daniels	Kim Wells
5408	WV9	Effects of Respirable Dust on Release of Superoxide from Pulmonary Alveolar Macrophages	Cilento	Schrotriya Georgellis		
5409	WV10	Magnetic Resonance Spectroscopic Characterization of Paramagnetic Irons and Free Radicals in Coal Dust, Black Lung Tissue and Lung Tissue Under Controlled Dust Exposure	Dalal	Deloose	Shi	Suyan Rakvin Kahol *Vallyathan *Wallace

* NIOSH

PERSONNEL CURRENTLY ACTIVE ON GTCRD PROJECTS

West Virginia University - Lead Institution

USBM Account Number	GTC Number	Title	Faculty	Graduate Students		Post Doctoral
				Masters	Doctoral	
5410	WV11	Development of Mine Dust Distribution Models for Working Faces	Wang Chiang			
5411	WV12	Shape and Surface Characterization of Respirable Mine Dust Particles	Meloy		Hill	Flemmer *Vallyathan *Castranova
5412	WV13	Determination of Biologically Active Silica Using Photoacoustic Spectroscopy	Seehra			*Wallace Ragoottama
5413	WV14	Acoustic Impedance and Topographic Laser Holography for the Early Detection of Black Lung	Sneckenberger Stanley	Afshari	Whitmoyer Pathak Lu Chander	*Petsonk *Frazer
5421	WV15	Augmentation of Dust Owing to Regrinding at the Face	Khair		Xu	Reddy
5422	WV16	Dust Sampling and Analytical Strategies	Stobbe Grayson		Yuan	
5423	WV17	Platelet-Activating Factor in Etiology of Pneumoconioses	VanDyke Dalal		Kang	*Castranova *Vallyathan

*Adjunct

PERSONNEL CURRENTLY ACTIVE ON GTCRD PROJECTS

University of Minnesota - Affiliate Institution

USBM Account Number	GTC Number	Title	Faculty	Graduate Students		Post Doctoral
				Masters	Doctoral	
2701	MN1	Coal Dust Characterization	Marple Rubow Pui	Behm Olson Kinney Whitby Sunkavally	Zhang Ananth	
2702	MN2	Experimental and Theoretical Aerodynamic Diameter Analysis of Coal Dust	Marple			
2703	MN3	Determination of Silica Particle Concentrations in Respirable Size Ranges	Marple Brandom Reed Rubow		Tongen Fang	
2722	MN4	Dust Sampling and Analytical Strategies	Marple Rubow			

Massachusetts Institute of Technology - Affiliate Institution

USBM Account Number	GTC Number	Title	Faculty	Graduate Students		Post Doctoral
				Masters	Doctoral	
2501	MT1	Respirable Dust Testing in Metal, Non-Metal Mines and Metallurgical Operations	Ring			
2521	MT2	Effect of Physical Properties of Respirable Dust on their Toxicity	Elliott Bolsaitis McCarthy			

PERSONNEL CURRENTLY ACTIVE ON GTCRD PROJECTS

Michigan Technological University - Affiliate Institution

USBM Account Number	GTC Number	Title	Faculty	Graduate Students: Masters	Graduate Students: Doctoral	Post Doctoral
2601	MTU1	Quantitative Analysis of Diesel Particulate Matter in Respirable Coal Dust by Raman Spectroscopy	Johnson Cornilsen Carlson			
2651	MTU2	Monitoring and Control of Diesel Particulate in an Underground Coal Mine	Johnson Cornilsen Carlson	Renders Shan	Loyselle	

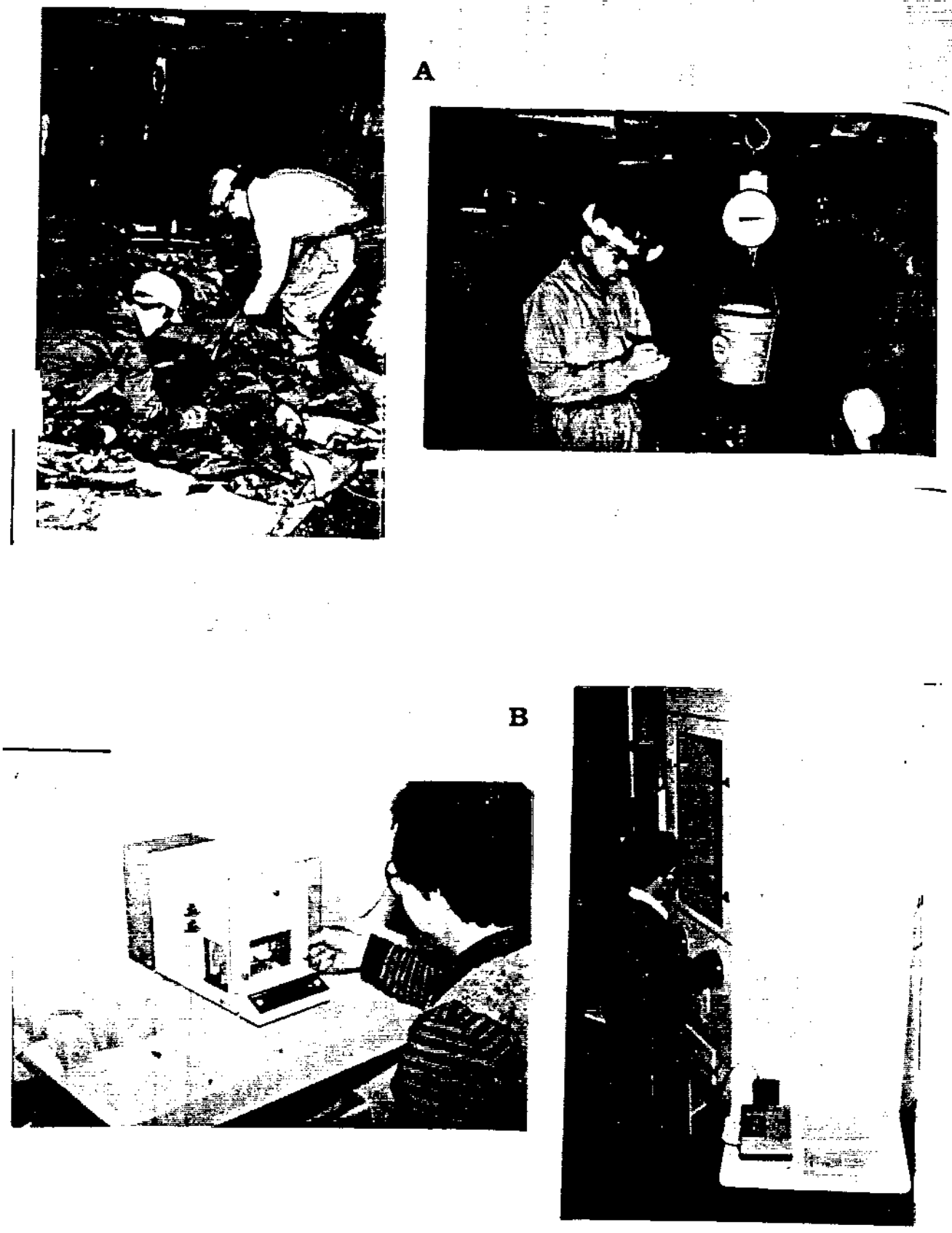


FIGURE 22 a) Dust Center personnel conducting experiments and taking measurements in an underground coal mine.
b) Dust Center personnel working in the laboratory.

IV
GRADUATE DEGREES

INTRODUCTION

Graduate education is an integral part of the Center's research program. The scope of work and the duration of each research project is calculated, in part, by taking into consideration the needs of the graduate research program and graduate training. Full development of student involvement, as demonstrated by the research practicum which is offered to qualified senior undergraduates at Penn State University and is designed to acquaint them with research methods and techniques and inform them of the opportunities available in this field, and the fulfillment of graduate program requirements are of the utmost concern. The Pennsylvania State University and West Virginia University have accredited mining engineering curricula and rank among the schools with the largest enrollment in this area in the nation. The number of undergraduate students enrolled in mining engineering at Penn State and West Virginia University account for nearly 20% of the total undergraduate enrollment in this discipline in schools across the United States. The Pennsylvania State University, West Virginia University, Massachusetts Institute of Technology, University of Minnesota, and Michigan Technological University, have granted a total of thirty-five (35) doctorate and masters degrees which can be directly attributed to research conducted in the Center. Of these graduates, fifteen(15) have found employment in the mineral sector of the economy, i.e., in private industry, with government agencies, and at various universities, worldwide. In addition, a number of those graduating with masters degrees are currently pursuing a doctorate degree.

Summary of Degrees Granted and Mineral Sector Employment

	Lead Institutions	Affiliates
1. Doctorates	10	1
2. Masters	21	2
3. Graduates who got jobs in the mineral sector of the economy	14	1

NUMBER OF GRADUATE DEGREES GRANTED
and
JOB LOCATIONS OF GRADUATES

Pennsylvania State University - Lead Institution

USBM Account Number	GTC Number	Title	Graduate Students		Mineral Industry Employment
			Masters	Doctorate	
4200	PS6	Information Exchange & Dissemination	none completed	none completed	
4201	PS1	A Fracture Mechanics Study of Crack-Propagation Mechanism in Coal Utilizing Fracture Toughness and Fracture Velocity Concepts		Zipf	USBM
4202	PS2	Prediction of Ambient Dust Concentrations in Mine Atmospheres	Bhaskar	Bhaskar	Univ. of Utah
4203	PS3	Characterization of Dust Particles	none completed	none completed	
4204	PS4	Characterization of the Mechanism of Lung Injury by Coal Mine Dusts	none completed	none completed	
4205	PS5	Establishment of Standard Procedures for Characterization of Respirable Coal Mine Dust Potential	Johnson Moore	Lee	Shell Mining Co. Central OH Mining Co. Univ. of Korea
4206	PS7	Computer Modeling of Longwall Face Ventilation	Qin		
4207	PS8	Wetting Characteristics of Dust		Mohal	SherwinWilliams Inc.
4208	PS9	Analysis of Coal Particles on a One-by-One Basis Using an Automated, Computer-Controlled SEM with X-ray Fluoreacence	Dumm		
4209	PS10	Inveatigations of the Role of Polymorphonuclear Leukocytes (PMN's) in the Dust Lung Interaction	none completed	none completed	

Pennsylvania State University - Lead Institution

USBM Account Number	GTC Number	Title	Graduate Students Masters	Graduate Students Doctorate	Mineral Industry Employment
4210	PS11	Biochemical Alterations in Mammalian Respiratory Mucus by Coal Mine Dust	none completed	none completed	
4211	PS12	Interactions with Nonhuman Primate Lungs	none completed	none completed	
4221	PS13	Knowledge Based Expert System for Planning Mine Ventilation Systems	none completed	none completed	
4222	PS14	Formulation, Evaluation and Verification of Improved Dust Sampling and Analytical Strategies for Use at Coal Mines (joint project)	none completed	none completed	
4223	PS15	Adhesion, Agglomeration and Deposition of Respirable Dust	none completed	none completed	

West Virginia University - Lead Institution

USBM Account Number	GTC Number	Title	Graduate Students Masters	Graduate Students Doctorate	Mineral Industry Employment
5400/ 5421	WV7	Information Exchange & Dissemination	none completed	none completed	
5401	WV1	Experimental Study of the Mechanisms of Dust Generation and Entrainment	Devilder Jung	Reddy Jung Quinn	Pittston Coal Co.

West Virginia University - Lead Institution

USBM Account Number	GTC Number	Title	Graduate Students		Mineral Industry Employment
			Masters	Doctorate	
5402	WV2	Experimental Studies of Dispersion and Transport of Respirable Dusts in Mine Atmospheres		Ueng	
5403	WV3	Measurements and Construction of Dust Distribution Maps for Longwall Faces	Tsang		
5404	WV4	General Support Characterization	Andre		Morgantown Energy Tech. Center
5405	WV5	Pulmonary Inhalation Toxicity of Respirable Coal Mine Dusts: A Morphometric Study	Hess Bavani Pisano Modzik		NIOSH USBM
5406	WV6	Correlations of Respirable Dust Characteristics to Coal Seams, Worker Positions and Mining Methods	Zhao		
5407	WV8	Dust-Lung Interaction in Coal Miners	none completed	none completed	
5408	WV9	Effects of Respirable Dust on Release of Superoxide from Pulmonary Alveolar Macrophages	DiGregorio	DiGregorio	Union Carbide
5409	WV10	Magnetic Resonance Spectroscopy Characterization of Paramagnetic Irons and Free Radicals in Coal Dust, Bleck Lung Tissue and Lung Tissue Under Controlled Dust Exposure	Jafari		
5410	WV11	Development of Mine Dust Distribution Models for Working Faces	none completed	none completed	

West Virginia University - Lead Institution

USBM Account Number	GTC Number	Title	Graduate Students Masters	Graduate Students Doctorate	Mineral Industry Employment
5411	WV12	Shape and Surface Characterization of Respirable Mine Dust Particles	Hurter VanEgmond		M.I.T. Stanford Univ.
5412	WV13	Determination of Biologically Active Silica Using Photoacoustic Spectroscopy	Cheng		Univ. of Hong Kong
5413	WV14	Acoustic Impedance and Topographic Laser Holography for the Early Detection of Bleck Lung	Pathak		
5421	WV15	Augmentation of Dust Owing to Regrinding at the Face	none completed	none completed	
5422	WV16	Dust Sampling and Analytical Stategies	Yuan		
5423	WV17	Platelet-Activating Factor in Etiology of Pneumoconioses	none completed	none completed	

Michigan Technological University - Affiliate Institution

USBM Account Number	GTC Number	Title	Graduate Students Masters	Graduate Students Doctorate	Mineral Industry Employment
2601	MTU1	Quantitative Analysis of Diesel Particulate Matter in Respirable Coal Dust by Raman Spectroscopy	none completed	none completed	
2602	MTU2	Monitoring and Control of Diesel Particulates in an Underground Coal Mine	none completed	none completed	

University of Minnesota - Affiliate Institution

USBM Account Number	GTC Number	Title	Graduate Students Masters	Graduate Students Doctorate	Mineral Industry Employment
2701	MN1	Coal Dust Characterization	Caldow Zhang	Fang	TSI, Inc.
2702	MN2	Experimental and Theoretical Aerodynamic Diameter Analysis of Coal Dust	none completed	none completed	
2703	MN3	Determination of Silica Particle Concentrations in Respirable Size Ranges	none completed	none completed	
2704	MN4	Dust Sampling and Analytical Strategies	none completed	none completed	

Massachusetts Institute of Technology - Affiliate Institution

USBM Account Number	GTC Number	Title	Graduate Students Masters	Graduate Students Doctorate	Mineral Industry Employment
2501	MT1	Respirable Dust Testing in Metal, Non-metal Mines and Metallurgical Operations	none completed	none completed	
2521	MT2	Effect of Physical Properties of Respirable Dust on Their Toxicity	none completed	none completed	

TITLES OF COMPLETED THESES

The Generic Mineral Technology Center for Respirable Dust

The Pennsylvania State University

4201 - PS1

A Fracture Mechanics Study of Crack-Propagation Mechanism in Coal Utilizing Fracture Toughness and Fracture Velocity Concepts
Dr. Z.T. Bieniawski

Completed Thesis: *Karl Zipf, Ph.D. (1988)*
The Mechanics of Fine Fragment Formation in Coal
Employed at the U.S. Bureau of Mines - Pittsburgh, Pa.

4202 - PS2

Prediction of Ambient Dust Concentrations in Mine Atmospheres
Dr. R.V. Ramani

Completed Thesis: *R. Bhaskar, M.S. (1984)*
A Mathmatical Model for the Prediction of Ambient Dust Concentrations in Mine Atmospheres
Completed Thesis: *R. Bhaskar, Ph.D. (1987)*
Spatial and Temporal Behavior of Dust in Mines-Theoretical and Experimental Studies
Employed as faculty member at University of Utah - Salt Lake City, Utah

4205 - PS5

Establishment of Standard Procedures for Characterization of Respirable Coal Mine Dust Potential
Dr. Jan M. Mutmansky and Dr. Christopher J. Bise

Completed Thesis: *Christopher Johnson, M.S. (1988)*
A Comparative Analysis of Mining-Generated and Laboratory -Generated Respirable Coal Dust
Employed at Shell Mining Co. - Houston, Texas
Completed Thesis: *Michael P. Moore, Ph.D. (1986)*
The Relationship Between Hardgrove Grindability Index and Respirable Dust Generation Potential
Employed at Central Ohio Coal Company - Cambridge, Ohio
Completed Thesis: *Changwoo Lee, Ph.D. (1986)*
Statistical Analysis of the Size and Elemental Composition of airborne Coal Mine Dust
Employed at the University in Seoul, Korea

4206 - PS7

Computer Modeling of Longwall Face Ventilation
Dr. R.V. Ramani

Completed Thesis: *Jianmin Qin, M.S. (1988)*
Quartz Levels in Airborne Dust in Continuous Mining Sections
Ph.D. Candidate - Penn State

4207 - PS8

Wetting Characteristics of Dust
Dr. F. F. Aplan

Completed Thesis: *Brij Raj Mohal, Ph.D. (1988)*
Enhancement of the Wettability of Coal Powders Using Surfactants
Employed at Sherwin Williams Co. - Cleveland, Ohio

4208 - PS9

Analysis of Coal Particles on a One-by-One Basis Using an Automated, Computer-Controlled SEM with X-ray Florescence Particles in Relation to Dust Abatement
Dr. L. Austin

Completed Thesis: *T. Dumm, M.S. (1986)*
An Evaluation of Techniques for Characterizing Respirable Coal Dust
Ph.D. Candidate - Penn State

West Virginia University

5401 - WV1

Experimental Study of the Mechanisms of Dust Generation and Entrainment
Dr. A. Wahab Khair

Completed Thesis: *W. M. Devilder, M.S. (1986)*
Correlation of Fragment Size Distribution and Fracture Surface in Coal Cutting Under Various Conditions
Completed Thesis: *S.S. Jung, M.S. (1984)*
Rock Behavior Under Wedge Penetration
Completed Thesis: *S.S. Jung, Ph.D. (1988)*
Energy Partition of Laterally Confined Coal Block Under Impact Indentation
Employed at Pittston Coal Company - Beckley, West Virginia
Completed Thesis: *N.P. Reddy, Ph.D. (1988)*
Characterization of Coal Breakage by Continuous Miners
Completed Thesis: *Mark Quinn, Ph.D. (1988)*
Effect of the Topography Surface Ground Movement Due to Longwall Mining
Employed by the Internal Revenue Service - Norcross, Georgia

5402 - WV2

Experimental Studies of Dispersion and Transport of Respirable Dusts in Mine Atmospheres
Dr. Y.J. Wang

Completed Thesis: *T.H. Ueng, Ph.D. (1988)*
An Experimental Study of Selected Face Ventilation Parameters and Their Effect on Respirable Coal Dust Dispersion

5403 - WV3

Measurements and Construction of Dust Distribution for Longwall Faces
Dr. H.S. Chiang

Completed Thesis: *Po Tsang, M.S. (1986)*
Study of Respirable Dust Evaluation Method
Ph.D. Candidate - West Virginia University

5404 - WV4

General Support Characterization
Dr. Richard Bajura

Completed Thesis: *R. Kannan, Ph.D. (1987)*
Antiferromagnetic System
Employed in post-doctorial position - West Virginia University
Completed Thesis: *Dick Andre, M.S. / Geology (1987)*
Geochemical Characterization of Kerogens, Shales, and Coal Refuse Associated with Allegheny Formation of Cases of Northern West Virginia
Employed at Morgantown Energy Technology Center - Morgantown, West Virginia

5405 - WV5

Pulmonary Inhalation Toxicity of Respirable Coal Mine Dusts: A Morphometric Study
Dr. C. Stanley

Completed Thesis: *John Hess, M.S. (1985)*
Heat and Mass Transfer in a Hazelton Inhalation Chamber
Employed at Naval Air Systems Command - Washington, D.C.
Completed Thesis: *Shahram Bavant, M.S. (1986)*
Particle Concentrations in a Hazelton Inhalation Chamber
Completed Thesis: *Ms. Francis Pisano, M.S. (1986)*
Maintaining Constant Mass Concentrations in an Inhalation System
Employed at NIOSH - Morgantown, West Virginia
Completed Thesis: *Andrew Modzik, M.S. (1988)*
Fresh Dust Coal Generation and Monitoring System
Employed at Boeing, U.S. Bureau of Mines - Pittsburgh, PA

5406A - WV6

Correlations of Respirable Dust Characteristics to Coal Seams, Worker Positions and Mining Methods
Dr. L. Grayson

Completed Thesis: *Lijian Zhao, M.S. (1987)*
Statistical Analysis of Respirable Coal Mine Dust Characteristics for a Longwall Panel
Ph.D. Candidate - West Virginia University

5408 - WV9

Effects of Respirable Dust on Release of Superoxide from Pulmonary Alveolar Macrophages
Dr. Eugene V. Cilento

Completed Thesis: *Kevin DiGregorio, M.S. (1985)*
Studies of the Effects of Respirable Dust on Pulmonary Alveolar Macrophages

Completed Thesis: *Kevin DiGregorio, Ph.D. (1988)*
Studies of the Effects of Respirable Dust on Pulmonary Alveolar Macrophages
Employed at Union Carbide

5409 - WV10

Magnetic Resonance Spectroscopic Characterization of Paramagnetic Irons and Free Radicals in Coal Dust, Black Lung Tissue and Lung Tissue Under Controlled Dust Exposure
Dr. Naresh Dalal

Completed Thesis: *Bardia Jafari, M.S. / Chemistry (1987)*
Electron Paramagnetic Resonance - Biochemical Studies of Free Radicals in Pneumoconiosis
Employed at the Environmental Protection Agency - Wheeling, West Virginia

5411 - WV12

Shape and Surface Characterization of Respirable Mine Dust Particles
Dr. T. Meloy

Completed Thesis: *Patricia Hurter, M.S. (1987)*
An Investigation of the Electrical Phenomenon in Hemolysis of Quartz
Employed at Massachusetts Institute of Technology on the respirable dust project
Completed Thesis: *Jan VanEgmond, M.S. (1988)*
Electrical Effect in Hemolysis by Quartz / Part 1 - The Energetics Erythrocyte Quartz Particle Interaction
Employed at Stanford University

5412 - WV13

Determination of Biologically Active Silica Using Photoacoustic Spectroscopy
Dr. M.S. Seehra

Completed Thesis: *L.H. Cheng, M.S. (1987)*
Theory of Photoacoustic Spectroscopy and Spectra of Quartz
Returned to Hong Kong to teach at the University

5413B - WV14

Topographical Laser Holography As a Method to Infer Pulmonary Function
Dr. Charles F. Stanley

Completed Thesis: *Manish Pathak, M.S. (1988)*
Holographic Interferometry to Detect Surface Vibrations of Excised Rat Lungs

5422 - WV16

Dust Sampling and Analytical Strategies
Dr. L. Grayson

Completed Thesis: *Shiquan Yuan, M.S. (1988)*
Formulation of Improved Coal Mine Dust Sampling Strategies
Ph.D. Candidate - West Virginia University

University of Minnesota

2701 - MN1

Coal Mine Dust Characterization
Dr. Virgil A. Marple

Completed Thesis: *Robert Caldow, M.S. (1988)*
Performance of the High Yield Technology PM-100-Particle Flux Monitor
Employed at TSI, Inc. in the fine particle equipment division - St. Paul, Minnesota
Completed Thesis: *Zinqin Zhang, M.S. (1988)*
The Finite Element Analysis for Large Strains of Incompressable Materials
Completed Thesis: *Ching-Ping Fang, Ph.D. (1988)*
A Fundamental Study of Multi-Nozzle Mult-Orifice Impactors

V

INDUSTRIAL INTERACTION

LEGEND

	Lead Institutions	Affiliates
1. Experimental project, all measurements industrial/ mining site	L-1	A-1
2. Experimental project, some measurements at industrial/ mining site; most experiment at University	L-2	A-2
3. Experimental project, industry provided samples or equipment; all data taken at University	L-3	A-3
4. Experimental project; industrial involvement limited to advice or information	L-4	A-4
5. Experimental project; no direct industrial interaction	L-5	A-5
6. Non-experimental project; library or computer studies only	L-6	A-6

INTRODUCTION

While control of dust-related diseases, the objective of the Generic Mineral Technology Center for Respirable Dust, is of prime importance from the human standpoint it is also essential to the economic well-being of the mining industry (FIGURE 23). Although significant progress has been made, the problem continues to be a major concern to the mining community. An increasing global demand for coal and other minerals means that production and the number of miners employed is on the rise. Therefore, the importance of this research to the mining industry cannot be overemphasized.

The five areas of dust research are 1) control of dust generation, 2) dilution, dispersion and collection of dust in mine airways, 3) characterization of dust particles, 4) interaction of dust and lungs, 5) relationship of mine environment, geology, and seam characteristics to dust generation and mobility. Some experimental projects where the research is conducted almost exclusively in the laboratory may still rely on industry for imput. No industrial resources are necessary to the research of the non-experimental projects, for example computer modeling .

The remaining research is classified as experimental and these projects do require interaction with industry in varying degrees. Periodic trips to mining sites in Western Pennsylvania, Southern Ohio, and West Virginia are necessary to record measurements or collect samples. Or companies may provide needed samples or equipment to the university for use in the laboratory. On several projects interaction is limited to advice or information supplied to the researcher by industry personnel.

Summary of Industrial Interactions

	Lead Institutions	Affiliates
1. Experimental project, all measurements industrial/ mining site	8	0
2. Experimental project, some measurements at industrial/ mining site; most experiment at University	2	3
3. Experimental project, industry provided samples or equipment; all data taken at University	6	2
4. Experimental project; industrial involvement limited to advice or information	4	1
5. Experimental project; no direct industrial interaction	13	2
6. Non-experimental project; library or computer studies only	2	0

Additionally, the Generic Center maintains a Reference Center that serves as a clearinghouse for technical information for the generic area and supplies reports on Generic Center accomplishments and research in-progress. Anyone desiring information may contact Nancy Rishel, 111 Mineral Sciences Building, The Pennsylvania State University, University Park, PA, 16802.

In addition to the direct interaction with industry, additional inputs and support are received from governmental agencies (USBM, MSHA, NIOSH) through their interaction with industry. The research structure of the Respirable Dust Center showing these relationships has been diagramed in FIGURE 23.

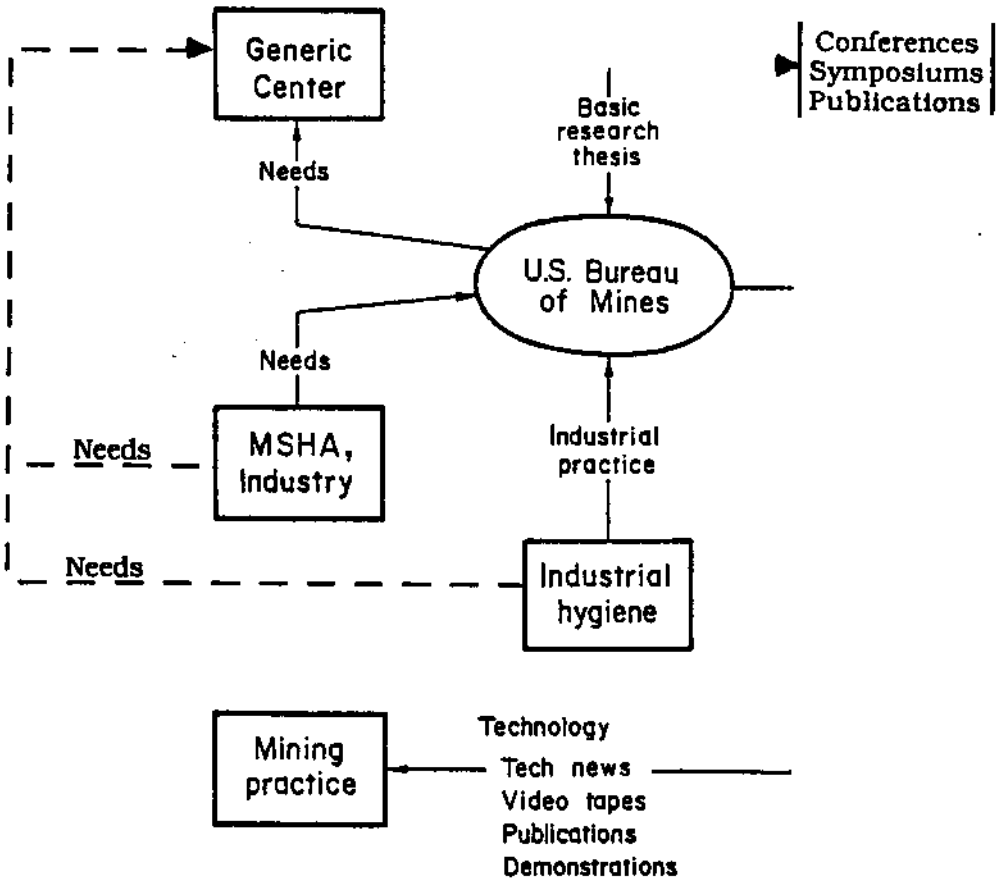


FIGURE 23 Center's respirable dust research structure.

RESEARCH PROJECTS
WITH
INDICATED DEGREE OF INDUSTRIAL INTERACTION

Penn State University Projects

USBM Account Number	GTC Number	Title	PI	Type of Industrial Interaction
4200	PS6	Information Exchange & Dissemination Indirect Rate of Subgrants	Frantz/Ramani	L-6
4201	PS1	A Fracture Mechanics Study of Crack-Propagation Mechanism in Coal Utilizing Fracture Toughness and Fracture Velocity Concepts	Bieniawski	L-3
4202	PS2	Prediction of Ambient Dust Concentrations in Mine Atmospheres	Ramani	L-1
4203	PS3	Characterization of Dust Particles	Hogg/Luckie	L-3
4204	PS4	Characterization of the Mechanism of Lung Injury by Coal Mine Dusts	Bartlett	L-5
4205	PS5	Establishment of Standard Procedures for Characterization of Respirable Coal Mine Dust Potential	Mutmansky/ Bise	L-1
4206	PS7	Computer Modeling of Longwall Face Ventiliation	Ramani	L-2
4207	PS8	Wetting Characteristics of Dust	Aplan/Chander	L-3
4208	PS9	Analysis of Coal Particles on a One-to-One Basis Using an Automated, Computer-Controlled SEM with X-ray Fluorescence Particles in Relation to Dust Abatement	Austin	L-5
4209	PS10	Investigation of the Role of Polymorphoneclear Leukocytes (PMN's) in the Dust Lung Interaction	Demers	L-5
4210	PS11	Biochemical Alternations in Mammalian Respiratory Mucus by Coal Mine Dust	Bhavanadan	L-5
4211	PS12	Interactions with Nonhuman Primate Lungs	White	L-5
4212	PS13	Knowledge Based Expert System for Planning Mine Ventilation Systems	Ramani	L-4
4213	PS14	Formulation, Evaluation and Verification of Improved Dust Sampling and Analytical Stratagies for Use at Coal Mines (joint project)	Mutmansky	L-4
4223	PS15	Adhesion, Agglomeration and Deposition of Respirable Dust	Chander/Hogg	L-5

West Virginia University Projects

USBM Account Number	GTC Number	Title	PI	Type of Industrial Interaction
5400/ 5421	WV7	Information Exchange & Dissemination	Bajura	L-6
5401	WV1	Experimental Study of the Mechanisms of Dust Generation and Entrainment	Khair	L-3
5402	WV2	Experimental Studies of Dispersion and Transport of Respirable Dusts in Mine Atmospheres	Wang	L-4
5403	WV3	Measurements and Construction of Dust Distribution Maps for Longwall Faces	Peng	L-1
5404	WV4	General Support Characterization	Bajura	L-5
5405	WV5	Pulmonary Inhalation Toxicity of Respirable Coal Mine Dusts: A Morphometric Study	Hinton	L-3
5406	WV6	Correlations of Respirable Dust Characteristics to Coal Seams, Worker Positions and Mining Methods	Peng/ Stobbe	L-1
5407	WV8	Dust-Lung Interaction in Coal Miners	Lapp	L-2
5408	WV9	Effects of Respirable Dust on Release of Superoxide from Pulmonary Alveolar Macrophages	Cliento	L-5
5409	WV10	Magnetic Resonance Spectroscopic Characterization of Paramagnetic Irons and Free Radicals in Coal Dust, Black Lung Tissue and Lung Tissue Under Controlled Dust Exposure	Dalal	L-5
5410	WV11	Development of Mine Dust Distribution Models for Working Faces	Wang/Peng/ Chiang	L-1
5411	WV12	Shape and Surface Characterization of Respirable Mine Dust Particles	Meloy	L-5
5412	WV13	Determination of Biologically Active Silica Using Photoacoustic Spectroscopy	Seehra	L-5
5413	WV14	Acoustic Impedance and Topographic Laser Holography for the Early Detection of Black Lung	Sneckenberger	L-5
5421	WV15	Augmentation of Dust Owing to Regrinding at the Face	Khair	L-3
5422	WV16	Dust Sampling and Analytical Strategies	Stobbe	L-4
5423	WV17	Platelet-Activating Factor in Etiology of Pneumoconioses	VanDyke	L-5

University of Minnesota Projects

USBM Account Number	GTC Number	Title	PI	Type of Industrial Interaction
2701	MN1	Coal Dust Characterization	Marple	A-2
2702	MN2	Experimental and Theoretical Aerodynamic Diameter Analysis of Coal Dust	Marple	A-5
2703	MN3	Determination of Silica Particle Concentrations in Respirable Size Ranges	Marple	A-3
2722	MN4	Dust Sampling and Analytical Strategies	Marple	A-4

Massachusetts Institute of Technology Projects

USBM Account Number	GTC Number	Title	PI	Type of Industrial Interaction
2501	MT1	Respirable Dust Testing in Metal, Non-Metal and Metallurgical Operations	Ring	A-3
2521	MT2	Effect of Physical Properties of Respirable Dust on Their Toxicity	Elliott	A-5

Michigan Technological University Projects

USBM Account Number	GTC Number	Title	PI	Type of Industrial Interaction
2601	MTU1	Quantitative Analysis of Diesel Particulate Matter in Respirable Coal Dust by Raman Spectroscopy	Johnson	A-2
2651	MTU2	Monitoring and Control of Diesel Particulate in an Underground Coal Mine	Johnson	A-2

VI
PUBLICATIONS

LEGEND

	Leading Institutions	Affiliates
1. In refereed professional journals	L-1	A-1
2. In non-refereed periodicals	L-2	A-2
3. Presentations at technical meetings but not otherwise published	L-3	A-3
4. Presentations at last annual GMTC seminar only	L-4	A-4

PUBLICATIONS

Chapter 6

INTRODUCTION

Contained in this chapter is a listing of the publications and reference books which have come about as a result of respirable dust research performed by faculty, staff and graduate students in the Generic Mineral Technology Center for Respirable Dust at The Pennsylvania State University, West Virginia University, University of Minnesota, Massachusetts Institute of Technology, and Michigan Technological University. These publications have appeared in scientific journals, proceedings of the national and international symposiums, and professional meetings. Complete citations of the publications can be found in Volumes 3 through 6 and Volume 8 of this series. The agenda of the last annual GMTC seminar, held at West Virginia University on February 1 - 2, 1988, follows. The project presentations are organized under the five research areas. All projects currently active were presented to the Advisory Committee. New project submissions were not. The authors were allotted thirteen (13) minutes for their presentations; the remainder of the twenty (20) minutes allotted for each project was used for introductions, transitions, and questioning by the Advisory Committee. Each author used a standard format for presentation of his/her materials for review; handout materials were distributed to the Advisory Committee for reference. Opening remarks were made by Dr. Richard Bajura of West Virginia University and Dean Robert L. Frantz and Dr. Raja V. Ramani of The Pennsylvania State University.

The Generic Mineral Technology Center for Respirable Dust is funded by the U.S. Bureau of Mines through the Mining and Mineral Resources Research Institute Program. The opinions and conclusions expressed in these papers are those of the authors alone and do not represent the opinions of the Generic Mineral Technology

Summary of Publications

	Lead Institutions	Affiliates
1. In refereed professional journals	13	4
2. In non-referred periodicals	58	6
3. Presentations at technical meetings but not otherwise published	7	5
4. Presentations at last annual GMTC seminar only	28	6

Center for Respirable Dust, the Mining and Mineral Resources Research Institute Program or the U.S. Bureau of Mines. Citations of manufacturers' names in the papers were made for general information purposes and do no imply endorsement of the products by the authors.

All of the publications and projects listed in this chapter are on research that is supported by the Department of the Interior's Mineral Institute program, administered by the Bureau of Mines through the Generic Mineral Technology Center for Respirable Dust under allotment grant number G1135142 or G1175142.

Reference Books

published by

The Generic Mineral Technology Center for Respirable Dust

1. Report to the Committee on Mining and Mineral Resources, Volume 1, edited by *Robert L. Frantz and Raja V. Ramani*, The Pennsylvania State University, University Park, PA, 1988, pp. 438.

2. Status Report, 1984-1988, Volume 2, edited by *Robert L. Frantz and Raja V. Ramani*, The Pennsylvania State University, University Park, PA, 1988, pp. 129.

3. Publications - 1984, Volume 3, edited by *Robert L. Frantz and Raja V. Ramani*, The Pennsylvania State University, University Park, PA, 1988, pp. 100.

4. Publications - 1985, Volume 4, edited by *Robert L. Frantz and Raja V. Ramani*, The Pennsylvania State University, University Park, PA, 1988, pp. 176.

5. Publications - 1986, Volume 5, edited by *Robert L. Frantz and Raja V. Ramani*, The Pennsylvania State University, University Park, PA, 1998, pp. 374.

6. Publications - 1987, Volume 6, edited by *Robert L. Frantz and Raja V. Ramani*, The Pennsylvania State University, University Park, PA, 1988, pp. 202.

7. Review of the Generic Mineral Technology Center for Respirable Dust, Volume 7, edited *Robert L. Frantz and Raja V. Ramani*, The Pennsylvania State University, University Park, PA, 1989, pp. 204.

8. Publications - 1988, Volume 8, edited by *Robert L. Frantz and Raja V. Ramani*, The Pennsylvania State University, University Park, PA, 1989, pp. 282.

Conference Proceedings

published by

The Generic Mineral Technology Center for Respirable Dust

1. Coal Mine Dust Conference, edited by *Sid S. Peng*, University of West Virginia, Morgantown, WV, 1987, pp. 267.

2. Respirable Dust in the Mineral Industries: Health Effects, Characterization and Control, edited by *Robert L. Frantz and Raja V. Ramani*, The Pennsylvania State University, University Park, PA, 1986, pp. 378.

PUBLICATIONS

Resulting from research sponsored by

The Generic Mineral Technology Center for Respirable Dust

LISTED BY YEAR AND AREA OF INVESTIGATION

1984

I. Control of Dust and Particulate Matter Generation

1. Design and Fabrication of a Rotary Cutting Simulator **L-2**

A. Wahab Khair, Department of Mining Engineering, College of Mineral and Energy Resources, West Virginia University, Morgantown, WV 26506. *S. Peng*, Ed., Proc. Coal Mine Dust Conference, Morgantown, WV, October 8-10, 1984, pp. 190-197. (WV-1)

2. Study of Fracture Mechanisms in Coal Subjected to Various Types of Surface Tractions Using Holographic Interferometry **L-2**

A. Wahab Khair, Department of Mining Engineering, College of Mineral and Energy Resources, West Virginia University, Morgantown, WV 26506. Presented at the 25th U.S. Symposium on Rock Mechanics, Northwestern University, Evanston, IL, June 25-27, 1984, pp. 1-12. (WV-2)

II. Dilution, Dispersion and Collection of Dust

3. **Dust Transport In Mine Airways** **L-2**

R. V. Ramani and R. Bhaskar, Department of Mineral Engineering, The Pennsylvania State University, University Park, PA 16802. *S. Peng,* Ed., Proc. Coal Mine Dust Conference, Morgantown, WV, October 8-10, 1984, pp. 198-204. (PS-2)

4. **Some Factors Influencing the Airborne Dust Distribution in Longwall Face Area** **L-2**

H. S. Chiang, S. S. Peng, G. C. Sun, and Y. F. Zhao, Department of Mining Engineering, College of Mineral and Energy Resources, West Virginia University, Morgantown, WV 26506. *S. Peng,* Ed., Proc. Coal Mine Dust Conference, Morgantown, WV, October 8-10, 1984, pp. 206-213. (WV-3)

5. **Analysis of an Airborne Dust Study Made for a Southwestern Pennsylvania Underground Bituminous Coal Mine** **L-2**

Robert L. Grayson and Syd S. Peng, Department of Mining Engineering, College of Mineral and Energy Resources, West Virginia University, Morgantown, WV 26506. *S. Peng,* Ed., Proc. Coal Mine Dust Conference, Morgantown, WV, October 8-10, 1984, pp. 13-15. (WV-6A)

III. Dust Characterization

6. **Instrumentation for the Measurement of Respirable Coal Mine Dust** **A-2**

Virgil A. Marple and Kenneth L. Rubow, Department of Mechanical Engineering, University of Minnesota, Minneapolis, MN 55455. *S. Peng,* Ed., Proc. Coal Mine Dust Conference, Morgantown, WV, October 8-10, 1984, pp. 214-221. (MN-1)

7. **Pulmonary Surfactant Interaction with Respirable Dust** **L-2**

W. E. Wallace, Jr., M. J. Keane, V. Vallyathan, T. M. Ong, V. Castranova, National Institute for Occupational Safety and Health, 944 Chestnut Ridge Road, Morgantown, WV 26506. *S. Peng,* Ed., Proc. Coal Mine Dust Conference, Morgantown, WV, October 8-10, 1984, pp. 180-187. National Technical Information Service Report PB86 169380/AS, Springfield, VA: NTIS. (WV-12)

IV. Dust Lung Interaction

8. **The Development of an Electro-Optical Technique to Measure Superoxide Release from Pulmonary Alveolar Macrophages Exposed to Coal Dusts** L-2

Kevin A. DiGregorio, Eugene V. Cilento, and R. Clark Lantz, Departments of Chemical Engineering and Anatomy, West Virginia University, Morgantown, WV 26506. *S. Peng,* Ed., Proc. Coal Mine Dust Conference, Morgantown, WV, 1984, pp. 222-226. (WV-9)

V. Relationship of Mine Environment, Geology and Seam Characteristics to Dust Generation and Mobility

9. **An Analysis of Coal and Geologic Variables Related to Coal Workers' Pneumoconiosis** L-2

Jan M. Mutmansky and Changwoo Lee, Department of Mineral Engineering, The Pennsylvania State University, University Park, PA 16802. *S. Peng,* Ed., Proc. Coal Mine Dust Conference, Morgantown, WV, October 8-10, 1984, pp. 236-249. (PS-5)

10. **The Relationship Between the Hardgrove Grindability Index and the Potential for Respirable Dust Generation** L-2

Michael P. Moore and Christopher J. Bise, Department of Mineral Engineering, The Pennsylvania State University, University Park, PA 16802. *S. Peng,* Ed., Proc., Coal Mine Dust Conference, Morgantown, WV, October 8-10, 1984, pp. 250-255. (PS-5)

11. **Correlation of Respirable Dust Mass Concentration with Worker Positions** L-2

R. L. Grayson and S. S. Peng, Department of Mining Engineering, College of Mineral and Energy Resources, West Virginia University, Morgantown, WV 26506. *S. Peng,* Ed., Proc. Coal Mine Dust Conference, Morgantown, WV, October 8-10, 1984, pp. 256-260. (WV-6A)

1985

I. Control of Dust and Particulate Matter Generation

1. **Characterizing Fracture Types of Rock/Coal Subjected to Quasi-Static Indention Using Acoustic Emission Technique** L-2

A. Wahab Khair, Department of Mining Engineering, College of Mineral and Energy Resources, West Virginia University, Morgantown, WV 26506. Presented at the Second International Conference on Acoustic Emission, Morgantown, WV, 1985, pp. 1-6. (WV-1)

2. **Correlation of Fragment Size Distribution and Fracture Surface in Coal Cutting Under Various Conditions** **L-3**

A. Wahab Khair and W. M. DeVilder, Department of Mining Engineering, West Virginia University, Morgantown, WV 26506, pp. 1-47. (WV-1)

3. **Coal Fracture Analysis Using Two Simultaneous Wedge Indicators and Laser Holographic Interferometry** **L-2**

Richard D. Begley, Fairmont State College, Division of Technology, Fairmont, WV 26554, and *A. Wahab Khair,* Department of Mining Engineering, College of Mineral and Energy Resources, West Virginia University, Morgantown, WV 26506. Presented at the 4th International Congress on Applications of Lasers and Electro Optics, San Francisco, CA, November 10-14, 1985, pp. 10-18. Sponsored by the Laser Institute of America. (WV-1)

4. **The Effect of In-Situ and Operating Parameters on Fragmentation of Coal** **L-2**

A. Wahab Khair and Nagendra P. Reddy, Department of Mining Engineering, College of Mineral and Energy Resources, West Virginia University, Morgantown, WV 26506. Presented at the 26th U.S. Symposium on Rock Mechanics, South Dakota School of Mines and Technology, Rapid City, SD, June 26-28, 1985, pp. 1-27. (WV-1)

5. **Mechanisms of Respirable Dust Generation by Continuous Miner** **L-3**

A. Wahab Khair and M. K. Quinn, Department of Mining Engineering, College of Mineral and Energy Resources, West Virginia Univeristy, Morgantown, WV 26506. Presented at the SME-AIME Fall Meeting, Alburquerque, New Mexico, October 16-18, 1985, pp. 1-14. (WV-1)

II. Dilution, Dispersion and Collection of Dust

6. **Behavior of Dust Clouds in Mine Airways** **L-1**

R. Bhaskar and R. V. Ramani, Department of Mineral Engineering, The Pennsylvania State University, University Park, PA 16802. Presented at the SME-AIME Annual Meeting, New York, NY, February 24-28, 1985, pp. 1-10. Accepted for SME-AIME Transactions. (PS-2)

III. Dust Characterization

7. **Suppression of Inhaled Particle Cytotoxicity by Pulmonary Surfactants and Re-Toxification by Phospholipase– Distinguishing Properties of Quartz and Kaolin** **L-2**

W. E. Wallace, Engineering Sciences, West Virginia University, Morgantown, WV 26506 and *M. J. Keane, V. Vallyathan, P. Hathaway, E. D. Regad, V. Castranova, and F. H. Y. Greene,* Appalachian Laboratory of Occupational Safety and Health Division of Respirable Disease Studies, National Institute for Occupational Safety and Health, Inhaled Particles VI - Proc. of an International Symposium organized by the British Occupational Hygiene Society, Cambridge, England, September 1985, pp. 1-19. (WV-12)

8. **In Vitro Biologic Toxicity of Native and Surface-Modified Silica and Kaolin** L-1

W. E. Wallace, Jr., V. Vallyathan, M. J. Keane, and V. Robinson, National Institute for Occupational Safety and Health, Morgantown, WV 26506. Journal of Toxicology and Environmental Health, 16: 415-424, 1985, Hemisphere Publishing Corporation. (WV-12)

IV. Dust Lung Interaction

9. **Evaluation of the Size Distribution of Large Aerosols in an Animal Exposure Chamber** L-3

F. Pisano, M. McCawley, D. Hinton, C. Stanley, and R. C. Lantz, West Virginia University, Morgantown, WV 26506. (WV-5)

V. Relationship of Mine Environment, Geology and Seam Characteristics to Dust Generation and Mobility

10. **Coal Mine Respirable Dust** L-2

Christopher J. Bise and Jan M. Mutmansky, Department of Mineral Engineering, The Pennsylvania State University, University Park, PA 16802. Published in Earth and Mineral Sciences, Volume 54, No. 4, Summer 1985, pp. 43-45. (PS-5)

1986

I. Control of Dust and Particulate Matter Generation

1. **Mixed Mode Testing for Fracture Toughness of Coal Based on Critical-Energy-Density** L-2

R. Karl Zipf, Jr. and Z. T. Bieniawski, Department of Mineral Engineering, The Pennsylvania State University, University Park, PA 16802. Presented at the 27th U.S. Symposium on Rock Mechanics, The University of Alabama, June 23-25, 1986, pp. 1-8. (PS-1)

2. **Fracture Mode and Loading Rate Influences on the Formulation of Respirable Size Fragments on New Fracture Surfaces** L-2

R. Karl Zipf, Jr. and Z. T. Bieniawski, Departmen of Mineral Engineering, The Pennsylvania State University, Univeristy Park, PA 16802. Presented at the International Symposium on Respirable Dust, The Pennsylvania State University, October 14-16, 1986, pp. 1-14. (PS-1)

3. **An Analysis of Respirable Dust Generation by Continuous Miner** **L-2**

A. Wahab Khair and Nagendra P. Reddy, Department of Mining Engineering, West Virginia University, Morgantown, WV 26506. Presented at the Engineering Health and Safety in Coal Mining SME Annual Meeting Symposium, New Orleans, LA, March 2-6, 1986, pp. 75-94. (WV-1)

4. **Characterization of Coal Breakage as A Function of Operating Parameters** **L-2**

A. Wahab Khair and Nagendra P. Reddy, Department of Mining Engineering, West Virginia University, Morgantown, WV 26506. Proc. of the International Symposium on Applications of Rock Characterization Techniques in Mine Design, Annual Meeting, SME-AIME, New Orleans, LA, March 1986, l8: 170-180. (WV-1)

II. Dilution, Dispersion, and Collection of Dust

5. **Experimental Studies and Dust Dispersion in Mine Airways** **L-1**

R. Bhaskar and R. V. Ramani, The Pennsylvania State University, University Park, PA 16802 and *R. A. Jankowski,* U.S. Bureau of Mines, Pittsburgh, PA 15236. Presented at the SME-AIME Annual Meeting, New Orleans, Louisiana, March 2-6, 1986, pp. 1-16. Accepted for SME-AIME Transactions. (PS-2)

6. **Theoretical and Experimental Studies on Dust Transport in Mine Airways: A Comparative Analysis** **L-2**

R. V. Ramani and R. Bhaskar, The Pennsylvania State University, University Park, PA 16802. Presented at the International Symposium on Respirable Dust, The Pennsylvania State University, University Park, PA, October 14-16, 1986, pp. 1-37. (PS-2)

7. **Air Velocity Distribution Measurements on Four Mechanized Longwall Coal Faces** **L-1**

S. S. Peng and H. S. Chiang, Department of Mining Engineering, West Virginia University, Morgantown, WV 26506. International Journal of Mining and Geological Engineering, Vol. 4, pp. 235-246. (WV-3)

8. **Simulations on Dust Dispersion for a Coal Mine Face Using a Scale Model** **L-2**

T. H. Ueng, S. D. Thompson and Y. J. Wang, Department of Mining Engineering, West Virginia University, Morgantown, WV 26506. Proc. International Symposium on Respirable Dust, The Pennsylvania State University, University Park, PA, October 14-16, 1986, pp. 1-18. (WV-2)

9. **Size Distribution of the Airborne Dust in Longwall Coal Faces** **L-2**

H. S. Chiang, S. S. Peng and Y. Luo, Department of Mining Engineering, West Virginia University, Morgantown, WV 26506. Proc. International Symposium on Respirable Dust, The Pennsylvania State University, University Park, PA, October 14-16, 1986, pp. 1-21. (WV-11)

10. **Application of a Particle Dispersion System for Obtaining the Size Distribution of Particles Collected on Filter Samples** **A-1**

K. L. Rubow and V. A. Marple, Particle Technology Laboratory, Mechanical Engineering Department, University of Minnesota, Minneapolis, MN 55455. Proc. 2nd International Aerosol Conference, Berlin, September 22-26, 1986. Pergamon Journals Ltd. Printed in Great Britain, pp. 1-4. (MN-1)

11. **Numerical Technique for Calculating the Equivalent Aerodynamic Diameter of Particles** **A-2**

V. A. Marple, Z. Zhiqun and B. Y. H. Liu, Particle Technology Laboratory, Mechanical Engineering Department, University of Minnesota, Minneapolis, MN 55455. Presented at the International Symposium on Respirable Dust, The Pennsylvania State University, University Park, PA 16802, October 14-16, 1986, pp. 1-21. (MN-1)

III. Dust Characterization

12. **Wetting Behavior of Coal in the Presence of Some Nonionic Surfactants** **L-1**

S. Chander, B. R. Mohal and F. F. Aplan, Mineral Processing Section, Department of Mineral Engineering, The Pennsylvania State University, University Park, PA 16802. Presented at the 191st National Meeting of the American Chemical Society, New York, April 13-18, 1986. Accepted for publication in Colloids and Surfaces (in press), pp. 1-25. (PS-8)

13. **Wetting Characteristics of Particles and Their Significance In Dust Abatement** **L-2**

S. Chander, B. R. Mohal and F. F. Aplan, Mineral Processing Section, Department of Mineral Engineering, The Pennsylvania State University, University Park, PA 16802. Presented at the International Symposium on Respirable Dust in the Mineral Industries, The Pennsylvania State University, University Park, PA 16802, October 14-16, 1986, pp. 1-16. (PS-8)

14. **A New Technique to Determine Wettability of Powders-Imbibition Time Measurements** **L-1**

B. R. Mohal and S. Chander, Mineral Processing Section, Department of Mineral Engineering, The Pennsylvania State University, University Park, PA 16802. Printed in the Colloids and Surfaces, 21 (1986), Elsevier Science Publishers, B. V., Amsterdam - Printed in The Netherlands, pp. 193-203. (PS-8)

15. **A Procedure for Extensive Characterization of Coal Mine Dust Collected Using a Modified Personal Sampler** **L-2**

T. F. Dumm and R. Hogg, Mineral Processing Section, Department of Mineral Engineering, The Pennsylvania State University, University Park, PA 16802. Presented at the International Symposium on Respirable Dust, The Pennsylvania State University, University Park, PA 16802, October 14-16, 1986, pp. 1-19. (PS-3)

16. **Estimation of Particle Size Distributions Using Pipet-Withdrawal Centrifuges** **L-1**

T. F. Dumm and R. Hogg, Mineral Processing Section, Department of Mineral Engineering, The Pennsylvania State University, University Park, PA 16802. Printed in Particle Characterization.3 (1986), pp. 122-128. (PS-3)

17. **Standard Respirable Dusts** **L-2**

T. F. Dumm and R. Hogg, Mineral Processing Section, Department of Mineral Engineering, The Pennsylvania State University, University Park, PA 16802. Presented at the International Symposium on Respirable Dust, The Pennsylvania State University, University Park, PA 16802, October 14-16, 1986, pp. 1-44. (PS-3)

18. **Detection of Organic Free Radicals in Coal-Dust Exposure Lung Tissue and Correlations with Their Histopathological Parameters** **L-2**

B. Jafari and N. S. Dalal, Chemistry Department, West Virginia University, Morgantown, WV 26506. *V. Vallyathan and F. Y. H. Green,* National Institute of Occupational Safety and Health, Morgantown, WV 26505. Presented at the International Symposium on Respirable Dust, The Pennsylvania State University, University Park, PA 16802, October 14-16, 1986, pp. 1-8. (WV-10)

19. **Electron Spin Resonance Detection of Reactive Free Radicals in Fresh Coal Dust and Quartz Dust and Its Implications to Pneumoconiosis and Silicosis** **L-2**

N. S. Dalal, M. M. Suryan, B. Jafari and X. Shi, Chemistry Department, West Virginia University, Morgantown, WV 26506 and *V. Vallyathan and F. H. Y. Green,* National Institute of Occupational Safety and Health, Morgantown, WV 26506. Presented at the International Symposium on Respirable Dust, The Pennsylvania State University, Univeristy Park, PA 16802, October 14-16, 1986, pp. 1-15. (WV-10)

20. **Cascade Impactor Sampling and Data Analysis Chapter (4) Theory and Design Guidelines** **A-1**

Virgil A. Marple and Kenneth L. Rubow, Mechanical Engineering Department, University of Minnesota, Minneapolis, MN 55455. Copyright - American Industrial Hygiene Association 475 Wolf Ledges Parkway, Akron, OH, pp. 79-101. (MN-2)

21. **Cascade Impactor Sampling and Data Analysis Chapter (5) Low-Pressure and Micro-Orifice Impactors** A-1

Susanne V. Hering, Department of Chemical Engineering, University of California, Los Angeles, CA 90024 and *Virgil A. Marple*, Mechanical Engineering Department, University of Minnesota, Minneapolis, MN 55455. Copyright - American Industrial Hygiene Association, 475 Wolf Ledges Parkway, Akron, OH, pp. 103-127. (MN-2)

22. **Micro-Orifice Uniform Deposit Impactor** A-1

Virgil A. Marple, Kenneth L. Rubow, G. Ananth, University of Minnesota, Minneapolis, MN 55455. *H. J. Fissan*, University of Duisburg, D 4100 Duisburg, F.R.G. Printed in Journal of Aerosol Science, Vol. I7, No. 3, pp. 489-494. (MN-2)

23. **The Effect of Lecithin Surfactant and Phospholipase Enzyme Treatment on Some Cytotoxic Properties of Respirable Quartz and Kaolin Dusts** L-2

W. E. Wallace, M. J. Krane, C. A. Hill, V. Vallyathan, F. Saus, V. Castranova and D. Bates, Division of Respiratory Disease Studies, National Institute for Occupational Safety and Health, West Virginia University, Morgantown, WV 26506. Presented at the International Symposium on Respirable Dust in Mineral Industries, The Pennsylvania State University, University Park, PA, October 14-16, 1986, pp. 1-26. (WV-2)

IV. Dust Lung Interaction

24. **Superoxide Release from Single Pulmonary Alveolar Macrophages** L-2

K. A. DiGregorio, E. V. Ciento and R. C. Lantz, Departments of Chemical Engineering and Anatomy, West Virginia University, Morgantown, WV 26506. Presented at the International Symposium on Respirable Dust in Mineral Industries, The Pennsylvania State University, University Park, PA, October 14-16, 1986, pp. 1-27. (WV-9)

25. **Effects of Coal Dusts and Alveolar Macrophages on Growth of Lung Fibroblasts** L-2

G. L. Bartlett and Ann B. Pedersen, Department of Pathology, The Milton S. Hershey Medical Center, The Pennsylvania State University, Hershey, PA 17033. Presented at the International Symposium on Respirable Dust in Mineral Industries, The Pennsylvania State University, University Park, PA, October 14-16, 1986, pp. 1-12. (PS-4)

26. **The Metabolism of Arachidonic Acid by Pulmonary Alveolar Macrophages Exposed to Coal Mine Dust** L-2

Lawrence M. Demers, Richard A. Edelson, Matthew P. Rose, David T. Superdock, Department of Pathology, The Milton S. Hershey Medical Center, The Pennsylvania State University, Hershey, PA 17033. Presented at the International Symposium of Respirable Dust in Mineral Industries, The Pennsylvania State University, University Park, PA, October 14-16, 1986, pp. 1-18. (PS-9)

V. Relationship of Mine Environment, Geology and Seam Characteristics to Dust Generation and Mobility

27. **Engineering Health and Safety in Coal Mining** L-2

Changwoo Lee and Jan M. Mutmansky, Department of Mineral Engineering, The Pennsylvania State University, University Park, PA 16802. Proceedings of the Symposium held at the SME Annual Meeting, New Orleans, Louisiana, March 2-6, 1986, pp. 1-14. (PS-5)

28. **Statistical Analysis of the Elemental Characteristics of Airborne Coal Mine Dust** L-2

Changwoo Lee and Jan M. Mutmansky, Department of Mineral Engineering, The Pennsylvania State University, University Park, PA 16802. Presented at the International Symposium on Respirable Dust, The Pennsylvania State University, University Park, PA, October 14-16, 1986, pp. 1-23. (PS-5)

29. **Variation in Mineral and Elemental Composition of Respirable Coal Mine Dusts by Worker Location and Coal Seams** L-2

R. A. Andre, T. Simonyi, R. L. Grayson, West Virginia University, Morgantown, WV 26506. Presented at the International Symposium on Respirable Dust, The Pennsylvania State University, University Park, PA, October 14-16, 1986, pp. 1-18. (WV-6A)

30. **Characterization of Respirable Dust on a Longwall Panel– A Case Study** L-2

R. L. Grayson and S. S. Peng, Department of Mining Engineering, College of Mineral and Energy Resources, West Virginia University, Morgantown, WV 26506. Presented at the SME Annual Meeting Symposium, New Orleans, LA, March 2-6, 1986, pp. 95-117. (WV-6A)

31. **A Methodology for Determining the Mineral Content and Particle Size Distribution of Airborne Coal Mine Dust** L-1

Terrence J. Stobbe, Ralph W. Plummer, Hyunwook Kim, and William G. Jones, Department of Industrial Engineering, West Virginia University and Division of Respiratory Disease Studies, National Institute for Occupational Safety and Health, Morgantown, WV 26506. Printed in Appl. Ind. Hyg. Vol. 1, No. 2, July 1986, pp. 95-100. (WV-6A)

32. **Characterization of Coal Mine Dust** L-1

Terrence J. Stobbe, Ralph W. Plummer, Hyunwook Kim, and John M. Dower, Department of Industrial Engineering, West Virginia University, Morgantown, WV 26506. Printed in Ann. Am. Conf. Gov. Ind. Hyg. Vol. 14, 1986, pp. 689-696. (WV-6B)

VI. Coordination

33. **A Review of the Programs and Activities of the Generic Mineral Technology Center for Respirable Dust** L-3

Robert L. Frantz and Raja V. Ramani, Co-Directors of the Generic Technology Center for Respirable Dust, The Pennsylvania State University, University Park, PA 16802. Presented at the SME-AIME Annual Meeting, New Orleans, LA, March 2-6, 1986, pp. 1-4. (PS-6)

1987

I. Control of Dust and Particulate Matter Generation

1. **Development of a Mixed Mode Testing System for Geologic Materials** L-2

R. K. Zipf, Jr. and Z. T. Bieniawski, Department of Mineral Engineering, The Pennsylvania State University Park, PA 16802. Presented at the International Conference on Fracture of Concrete and Rock, Houston, TX, June 17-19, 1987, pp. 1-15. (PS-1)

2. **Identification of Fracture in Coal by AE in Dynamic Test** L-2

A. Wahab Khair and S. Jung, Department of Mining Engineering, College of Mineral and Energy Resources, West Virginia University, Morgantown, WV 26506. Presented at the Fourth Conference on Acoustic Emission, The Pennsylvania State University, University Park, PA, October 22, 1987, pp. 1-15. (WV-1)

II. Dilution, Dispersion and Collection of Dust

3. **A Comparison of the Performance of Impactors and Gravimetric Dust Samplers in Mine Airflow Conditions** L-2

R. Bhaskar and R. V. Ramani, Department of Mineral Engineering, The Pennsylvania State University, University Park, PA 16802. Presented at the Third Mine Ventilation Symposium, The Pennsylvania State University, October 12-14, 1987, pp. 1-6. (PS-2)

III. Dust Characterization

4. **Surfactant Adsorption and Wetting Behavior of Freshly Ground and Aged Coal** **L-2**

B. R. Mohal and S. Chander, Mineral Processing Section, Department of Mineral Engineering, The Pennsylvania State University, University Park, PA 16802. Submitted for publication in Proc. Symp. Interfacial Phenomena in Biotechnology and Materials Processing. Eds., *Y. A. Attia, B. M. Moudgil and S. Chander,* Elsevier, N.Y. in preparation. Paper presented at the Symposium on Interfacial Phenonmena in Material Processing, The Final Particle Society, August 3-7, 1987, pp. 1-23. (PS-3)

5. **Distribution of Sulfur and Ash in Ultrafine Coal** **L-2**

T. E. Dumm and R. Hogg, Mineral Processing Section, Department of Mineral Engineering, The Pennsylvania State University, University Park, PA 16802. Presented at the Proc. 2nd International Conference on Processing and Utilization of High Sulfur Coal II, *T. P. Chugh and R. D. Caudle,* Eds., pp. 23-32, Elsevier, N.Y., 1987. (PS-7)

6. **Washability of Ultrafine Coal** **L-3**

T. F. Dumm and R. Hogg, Mineral Processing Section, Department of Mineral Engineering, The Pennsylvania State University, University Park, PA 16802. SME Preprint 87-136, SME-AIME Annual Meeting, Denver, CO, February 1987, pp. 1-8. (PS-7)

7. **Particle Size Distribution of Airborne Dust in Coal Mines** **L-2**

T. F. Dumm and R. Hogg, Mineral Processing Section, Department of Mineral Engineering, The Pennsylvania State University, University Park, PA 16802. Presented at the Third Mine Ventilation Symposium, The Pennsylvania State University, University Park, PA, October 12-14, 1987. (PS-7)

8. **Mutagenicity of Diesel Exhaust Particles and Oil Shale Particles Dispersed in Lecithin Surfactant** **L-1**

William E. Wallace, Michael J. Keane and Tong-Man Ong, National Institute for Occupational Safety and Health, Division of Respiratory Disease Studies, Morgantown, WV 26506, *Jing Xu,* Shanxi Medical College, Taiyuan, Shanxi, China. Printed in the Journal of Toxicology and Environmental Health, 21, pp. 165-174, 1987. (WV-12)

IV. Dust Lung Interaction

V. Relationship of Mine Environment, Geology and Seam Characteristics to Dust Generation and Mobility

9. **Application of the Size and Elemental Characteristics of Airborne Coal Mine Dust and Dust Source Identification** L-2

Changwoo Lee, Dong-A University, Pusan, Korea, and *Jan M. Mutmansky,* Department of Mineral Engineering, The Pennsylvania State University, University Park, PA 16802. Presented at the International Symposium on Coal Mining and Safety, April 22-24, Seoul, Korea, 1987, pp. 1-10. (WV-5)

10. **World Wide Coal Mine Dust Research--Where Are We Going?** L-2

Jan M. Mutmansky, Department of Mineral Engineering, The Pennsylvania State University, University Park, PA 16802. Presented at the International Symposium on Coal Mining and Safety, April 22-24, 1987, Seoul, Korea, pp. 1-9. (PS-5)

1988

I. Control of Dust and Particulate Matter Generation

1. **Alteration of Respirable Quartz Particle Cytotoxicity by Thermal Treatment in Aqueous Media** L-2

W. E. Wallace, C. A. Hill, M. J. Deane, S. J. Page, P. Bolsaitis, and B. L. Razzaboni, West Virginia University, U.S. National Institute for Occupational Safety and Health, Division of Respiratory Disease Studies, U.S. Department of Interior, Bureau of Mines, Energy Laboratory, Massachusetts Institute of Technology. Presented at the VIIth International Pneumoconioses Conference, August 23-26, 1988, Pittsburgh, PA

2. **Cytotoxicity and Spectroscopic Investigations of Organic Free Radicals in Fresh and Stale Coal Dusts** L-2

N. S. Dalal and B. Jafari, Department of Chemistry, West Virginia University, Morgantown, WV 26505, *V. Vallyathan,* National Institute for Occupational Safety and Health, Morgantown, WV 26506. Presented at the VIIth International Pneumoconiosis Conference, Pittsburgh, PA, August 23-26, 1988.

3. **Do Silicon-Based Radicals Play a Role in Quartz-Induced Hemolysis and Fibrogenicity?** L-2

N. S. Dalal and Xianglin Shi, Department of Chemistry, West Virginia University, Morgantown, WV 26506, *V. Vallyathan,* National Institute for Occupational Safety and Health, Morgantown, WV 26506. Presented at the VIIth International Pneumoconiosis Conference, Pittsburgh, PA, August 23-26, 1988.

4. **Suppression of Quartz Cytotoxicity by Pulmonary Surfactant-Electrical Effects** L-2

T. P. Meloy , J. W. Van Egmond, and J. M. Cox-Ganser, Particle Analysis Center, West Virginia University, Morgantown, WV 26506.

II. Dilution, Dispersion, and Collection of Dust

5. **Dust Flows in Mine Airways: A Comparison of Experimental Results and Mathematical Predictions** L-1

R. Bhaskar and R. V. Ramani, Department of Mineral Engineering, The Pennsylvania State University, University Park, PA 16802. Prepared for presentation at the SME-AIME Annual Meeting, Phoenix, Arizona, January 25-28, 1988. Accepted for SME-AIME Transactions.

6. **Experimental and Theoretical Measurement of the Aerodynamic Diameter of Irregular Shaped Particles** A-2

V. Marple, K. Rubow, and Z. Zhiqun, Particle Technology Laboratory, University of Minnesota, Minneapolis, MN. Presented at the VIIth International Pneumoconioses Conference, Pittsburgh, PA, August 23-26, 1988.

7. **Measurement of Coal Dust and Diesel Exhaust Aerosols in Underground Mines** A-2

K. L. Rubow and V. A. Marple, University of Minnesota, Minneapolis, MN and *B. D. Cantrell,* U.S. Bureau of Mines, Minnepolis, MN. Presented at the VIIth International Pneumoconioses Conference, Pittsburgh, PA, August 23-26, 1988.

8. **On the Transport of Airborne Dust in Mine Airways** L-2

R. V. Ramani and R. Bhaskar, Department of Mineral Engineering, The Pennsylvania State University, University Park, PA 16802. Presented at the VIIth International Pneumoconioses Conference, Pittsburgh, PA, August 23-26, 1988.

9. **Photoacoustic Spectroscopy of Quartz: Chopping Frequency Dependence Saturation Phenomenon and Quantitative Analysis** L-1

Mohindar S. Seehra, P. S. Raghoottama, and L. Cheng, West Virginia University, Morgantown, WV 26506. Accepted for publication in "Applied Spectroscopy", 1988.

10. **Respirable Particulate Surface Interactions with the Lecithin Component of Pulmonary Surfactant** L-2

M. J. Keane, W. E. Wallace, M. S. Seehra, and C. A. Hill, West Virginia University, Morgantown, WV 26506. Presented at the VIIth International Pneumoconioses Conference, Pittsburgh, PA, August 23-26, 1988

III. Dust Characterization

IV. Dust Lung Interaction

11. **A Kinetic Model of Superoxide Production from Single Pulmonary Alveolar Macrophages** L-3

K. A. DiGregorio, E. V. Cilento, and R. C. Lantz, West Virginia University, Morgantown, WV 26506. Prepared for presentation at FASEB Meetings, December 1987.

12. **Acoustic Impedance Method for Detecting Lung Dysfunction** L-2

John Sneckenberger and Timothy Whitmoyer, West Virginia University, Morgantown, WV and *David Frazer,* NIOSH, Morgantown, WV 26506. Presented at the VIIth International Pneumoconioses Conference, Pittsburgh, PA, August 23-26, 1988.

13. **Effects of Platelet Activating Factor on Various Physiological Parameters of Neutrophils, Alveolar Macrophages, and Alveolar Type II Cells** L-2

K. VanDyke, J. Rabovsky, D. J. Judy, W. H. Palles, M. McPeek, and V. Castranova, West Virginia University, Morgantown, WV 26506. Presented at the VII International Pneumoconioses Conference, August 23-26, 1988, Pittsburgh, PA.

14. **Effects of Serum on Superoxide Release from Single Pulmonary Alveolar Macrophages** L-3

K. A. DiGregorio, E. V. Cilento, and R. C. Lantz, West Virginia University, Morgantown, WV 26506. Prepared for presentation at Microcirculatory Society Meetings, December, 1987.

15. **Effect of Coal Dust on Mucin Production by the Rat Trachea** L-2

V. P. Bhavanandan, Department of Biological Chemistry, The M. S. Hershey Medical Center, The Pennsylvania State University, Hershey, PA 17033. Presented at the VIIth International Pneumoconioses Conference, August 23-26, 1988.

16. **Factors That May Influence Interactions Between Mineral Dusts and Lung Cells** L-2

G. L. Bartlett, and J. D. Barry, The Hershey Medical Center, The Pennsylvania State University, Hershey, PA 17033. Presented at the VIIth International Pneumoconioses Conference, Pittsburgh, PA, August 23-26, 1988.

17. **Use of a Sensitive Electro-Optical Method to Quantify Superoxide Release from Single PAM Exposed to Dusts In Vitro or In Vivo: Some Current Experimental and Model Results** L-2

E. V. Cilento, K. A. DiGregorio, and R. C. Lantz, Departments of Chemical Engineering and Anatomy, West Virginia University, Morgantown, WV. Presented at the VIIth International Pneumoconioses Conference, Pittsburgh, PA, August 23-26, 1988.

V. Relationship of Mine Environment, Geology and Seam Characteristics to Dust Generation and Mobility

18. **An Analysis of the Mass-Size Distribution of Airborne Coal Mine Dust In Continuous Miner Sections** L-1

Changwoo Lee, Journal of Korean Institute of Mineral and Mining Engineers, Vol. 25, No. 2, 1988, pp. 109-117.

19. **A Comparative Analysis of the Elemental Composition of Mining-Generated and Laboratory-Generated Coal Mine Dust** L-2

Christopher J. Johnson and Christopher J. Bise, Department of Mineral Engineering, The Pennsylvania State University, University Park, PA 16802. Presented at the VIIth International Pneumoconioses Conference, Pittsburgh, PA, August 23-26, 1988.

20. **Effect of Thermal Treatment on the Surface Characteristics and Hemolytic Activity of Respirable Size Silica Particles** A-2

P. Boisaitis, B. L. Razzaboni, W. E. Wallace, and M. J. Keane, Energy Laboratory, Massachusetts Institute of Technology, U.S. National Institute. Presented at the VIIth International Pneumoconioses Conference, Pittsburgh, PA, August 23-26, 1988.

21. **Measurement of Airborne Diesel Particulate in a Coal Mine Laser Raman Spectroscopy** **A-2**

B. C. Comilsen, J. H. Johnson, P. L. Loyselle, and D. H. Carlson, Michigan Technological University, Houghton, MI. Presented at the VIIth International Pneumoconioses Conference, Pittsburgh, PA, August 23-26, 1988.

22. **Mineral Content Variability of Coal Mine Dust by Coal Seam, Sampling Location, and Particle Size** **L-2**

T. J. Stobbe, H. Kim, and R. W. Plummer, Department of Industrial Engineering, West Virginia University, Morgantown, WV 26506. Presented at the VIIth International Pneumoconioses Conference, Pittsburgh, PA, August 23-26, 1988.

23. **Seeking the "Rank Factor" in CWP Incidence: The Potential Role of Respirable Dust Particle Purity** **L-2**

R. L. Grayson, R. Andre, and T. Simonyi, West Virginia University, Morgantown, WV 26506. Presented at the VIIth International Pneumoconioses Conference, Pittsburgh, PA, August 23-26, 1988.

PRESENTATIONS AT THE LAST ANNUAL GMTC SEMINAR

Generic Mineral Technology Center for Respirable Dust

The Pennsylvania State University
West Virginia University
University of Minnesota
Massachusetts Institute of Technology
Michigan Technological University

February 1 - 2, 1988
Mountainlair Student Center
West Virginia University

Session A 7:45 AM Monday, February 1

OPENING REMARKS

Time	Authors	Project Title	Ref. Nos.
7:45 AM	Bajura/WVU	Welcome and Introductions (coffee and donuts)	n/a
8:00 AM	Frantz/Ramani	Opening Remarks and Purpose of of Technical Program	n/a

Session B 8:15 AM Monday. February 1

RELATIONSHIP OF MINE ENVIRONMENT, GEOLOGY, AND SEAM CHARACTERISTICS TO DUST GENERATION AND MOBILITY

Time	Authors	Project Title	Ref. Nos.	
8:15 AM	Mutmansky	Establishment of Standard Proc. for Char. of Respirable Coal Mine Dust Potential	PS05/4205	L-4
8:35 AM	Grayson	Correlations of Resp. Dust Char. to Coal Seams, Worker Positions, and Mining Methods [Task A - Longwall Mining]	WV06/5406	L-4
8:55 AM	Stobbe	[Task B - Continuous Mining]	WV06/5406	L-4
9:15 AM	Mutmansky et. al.	Formulation, Evaluation and Verification of Improved Dust Sampling and Analytical Strategies for Use at Coal Mines (jt. proj.)	4222/5422 2722	L-4
9:35 AM	Johnson	Quantitative Analysis of Diesel Particulate Matter in Resp. Coal Dust by Raman Spectroscopy	MI01/2601	A-4
9:55 AM	Johnson	Improved Methods for Monitoring and Control of Diesel Particulate in an Underground Coal Mine	MI02/2621	A-4
10:15 AM	N/A	BREAK	N/A	

Session C 10:35 AM Monday. February 1

DUST CHARACTERIZATION

Time	Authors	Project Title	Ref. Nos.	
10:35 AM	Hogg	Characterization of Dust Particles	PS03/4203	L-4
10:55 AM	Austin	Analysis of Coal Particles on a One-by-One Basis Using an Automated, Computer-Controlled SEM with X-ray Fluorescence	PS09/4208	L-4
11:15 AM	Marple	Coal Mine Dust Characterization	MN01/2701	A-4
11:35 AM	Marple/Rubow	The Determination of Silica Particle Concentrations in the Respirable Size Range	MN03/2703	A-4

11:55 AM	Seehra	Determination of Biologically Active Silica in Coal Mine Dust Using Photoacoustic Spectroscopy	WV13/5412	L-4
12:15 PM	N/A	LUNCH IN MOUNTAINLAIR	N/A	
1:15 PM	Chander/Aplan	Wetting Characteristics of Dust Particles in Relation to Dust Abatement	PS08/4207	L-4
1:35 PM	Chander/Hogg	Adhesion, Agglomeration, and Deposition of Respirable Dust	/4223	L-4
1:55 PM	Dalal/Vallyathan	Magnetic Resonance Spectroscopy of Coal Dust, Black Lung Tissue, and Lung Tissue under Controlled Exposure	WV10/5409	L-4
2:15 PM	Meloy/Wallace	Shape and Surface Characterization of Resp. Mine Dust Particles	WV12/5411	L-4
2:35 PM	Elliott	Effect of Physical Properties of Resp. Dust on Their Toxicity	MT02/2521	A-4
2:55 PM	N/A	BREAK	N/A	

Session D 3:10 PM Monday, February 1

DILUTION, DISPERSION, AND COLLECTION OF DUST

Time	Authors	Project Title	Ref. Nos.	
3:10 PM	Ramani	Prediction of Ambient Dust Concentrations in Mine Atmospheres	PS02/4202	L-4
3:30 PM	Ramani	Computer Modeling of Longwall Face Ventilation	PS07/4206	L-4
3:50 PM	Wang	Development of Mine Dust Distribution Models for Working Faces	WV11/5410	L-4
4:10 PM	Ramani	Knowledge Based Expert System for Planning Mine Ventilation Systems	/4221	L-4
4:30 PM	Marple	Experimental and Theoretical Aerodynamic Diameter Analysis of Coal Dust	MN02/2701	A-4
4:50 PM	N/A	BREAK	N/A	

Session D 5:00 PM Monday. Februarv 1

CONTROL OF DUST GENERATION

Time	Authors	Project Title	Ref. Nos.	
5:00 PM	Khair	Correlation of Dust Due to Regrinding at the Face	/5421	L-4
5:20 PM	Bieniawski	Fracture Mechanics of Fine Coal-Fragment Formation	PS01/4201	L-4

Session E 5:40 PM Mondav. Februarv 1

PROGRAM ADMINISTRATION

Time	Authors	Project Title	Ref. Nos.	
5:40 PM	Frantz/Bajura	Administration/Reference Center/ Technology Transfer	4200/4220 5400/5420 WV04/5404	L-4
6:00 PM	N/A	DINNER AND EVENING PROGRAMS	N/A	

Session F 7:45 AM Tuesdav. February 2

DUST - LUNG INTERACTION

Time	Authors	Project Title	Ref. Nos.	
7:45 AM	N/A	COFFEE AND DONUTS	N/A	
8:00 AM	Bartlett	Mechanism of Lung Injury by Coal Mine Dusts	PS04/4204	L-4
8:20 AM	Van Dyke	Role of Platelet-Activating Factor in the Etiology of Coal or Silica-Induced Pneumoconiosis	/5423	L-4
8:40 AM	White	Interaction of Coal Mine Dusts and Nonhuman Primate Lungs	PS12/4211	L-4
9:00 AM	Abrons/Petsonk	Airway Reactivity in Coal Miners	WV08/5407	L-4
9:20 AM	Cilento/Lantz	Effects of Resp. Dust on the Release of Superoxide From Alveolar Macrophages	WV09/5408	L-4

9:45 AM	Demers	Alveolar Macrophage and Polymorphonuclear Leukocytes in Dust-Lung Interactions	PS10/4209	L-4
10:00 AM	N/A	BREAK	N/A	
10:20 AM	Stanley, et. al.	Pulmonary Inhalation Toxicity of Resp. Coal Mine Dusts: A Morphometric Study	WV05/5405	L-4
10:40 AM	Bhavanandan	Biochemical Alterations in Mammalian Respiratory Tract Mucus	PS11/4210	L-4
11:00 AM	Sneckenberger	Development of New Early Detection Methods for Black Lung: Task A - Tracheal Acoustic Impedance of Lung Air Passages	WV14/5413	L-4
11:20 AM	Stanley	Task B - Topographical Laser Holography as a Method to Infer Pulmonary Function	WV14/5413	L-4

Session F 11:40 AM Tuesday, February 2

PROGRAM ADMINISTRATION, CONCLUDING REMARKS AND SCHEDULE INFORMATION

Time	Authors	Project Title	Ref. Nos.
11:40 AM	Frantz	Open Discussion	N/A
12:00 PM	N/A	LUNCH IN MOUNTAINLAIR	N/A
1:00 PM	Munson	Advisory Committee Meeting (NIOSH)	N/A
	N/A	Departure	N/A

VII
RESEARCH EFFORT

Chapter 7

INTRODUCTION

A coordinated, integrated research effort aimed at studying the scientific, engineering and medical aspects of the respirable dust problem is underway in the areas of dust generation, dust dispersion and dilution, dust characterization, interaction of dust and lungs, and relationship of seam characteristics to dust generation and mobility. (FIGURE 24) The Center's research program explores these concerns with the objective of refining existing strategies and developing new respirable dust control techniques that are consistent with the dust-lung interaction processes that lead to mine worker disability. The fundamental aspects of this work are applicable to the control of respirable dust problems in both hard rock mines and coal mines and to other dusts such as diesel-generated.

Research projects in the Generic Mineral Technology Center for Respirable Dust have effected several improved methods for the preparation and characterization of the dusts needed by these projects. Superior procedures for generating "standard" dust samples have been developed and are in regular use in the laboratory. Questions raised

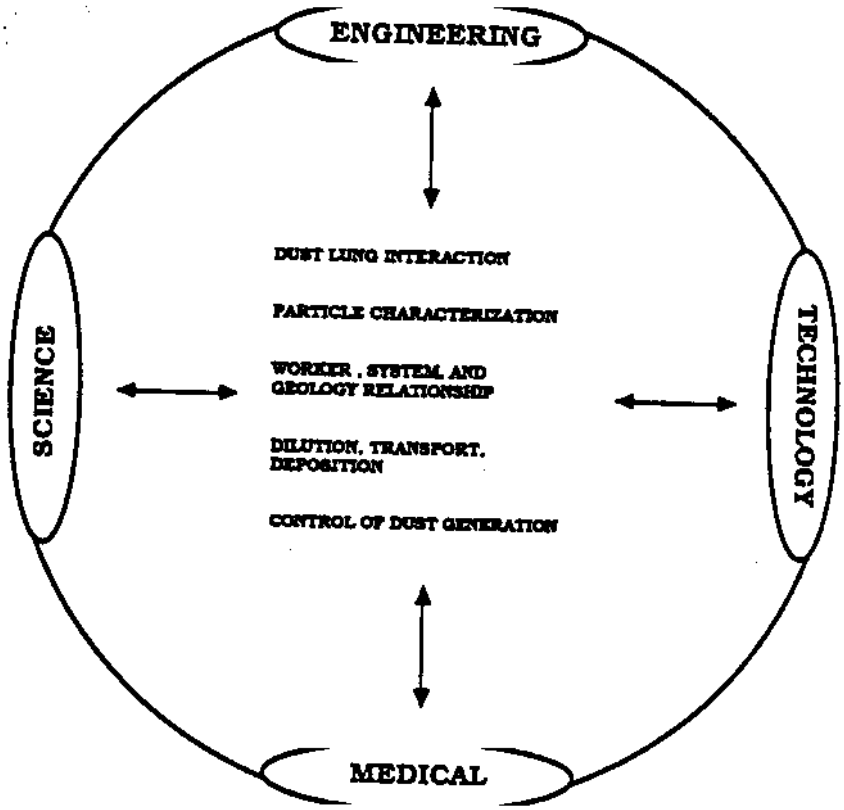


FIGURE 24 Standardized protocals for Respirable Dust Research in scientific, engineering, and medical areas.

during the course of some projects regarding "stale" versus "fresh" dust have led to the development of sampling techniques where the dust is directly collected in a surfactant. MSHA and CANMET have requested and received information on Center generated software. An equipment manufacturer, TSI, Inc., requesting input on modifying the inlet of an aerosol sampler has been assisted as a result of research that was conducted at the University of Minnesota.

The objectives, scope and progress of all the research projects in the Center, in the form of abstracts and reports, have been detailed in Volume 1 of this series. Research papers written by the principle investigators and resulting from the findings of projects (FIGURE 25) and which are funded by U.S. Bureau of Mines grant number G1135142 have been published in Volumes 3 through 6 and Volume 8 of this series. Volume 2 relates the cooperation and interaction of the U.S. Bureau of Mines and the Generic Mineral Technology Center for Respirable Dust in research on the problem of respirable dust in the mineral industries.

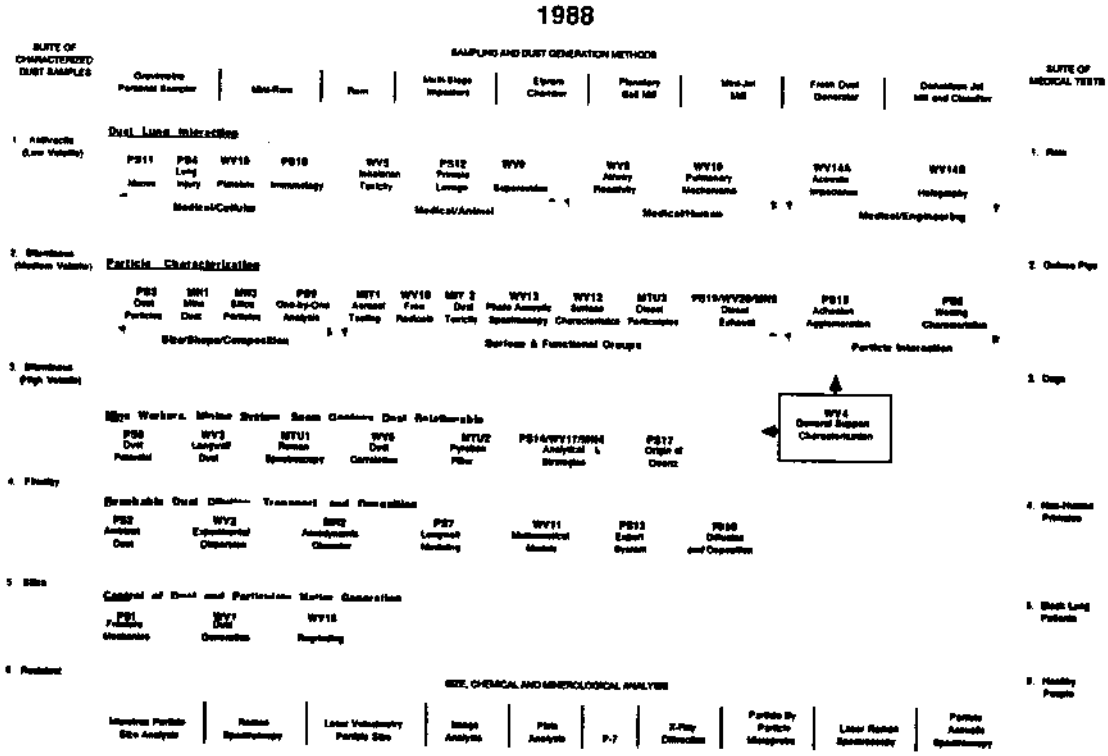
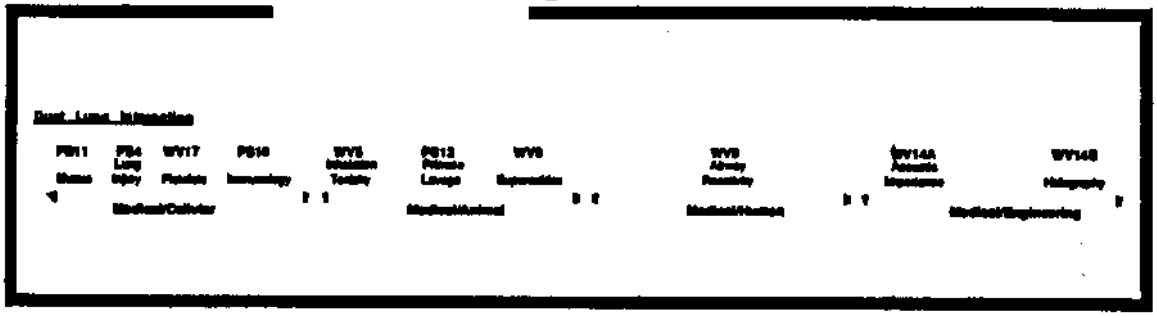


FIGURE 25 The integration of scientific, engineering, and medical research findings into on-going projects.

Dust Lung Interaction



Mechanism of Lung Injury
(PS4/USBM 4204) *Bartlett*

Alveolar Macrophage and Polymorphonuclear Leukocytes
(PS10/USBM 4209) *Demers*

Biochemical Alterations in Respiratory Tract Mucus
(PS11/USBM 4210) *Bhavanandan*

Interaction of Dust and Nonhuman Primate Lungs
(PS12/USBM 4211) *White/Drozdowicz/Bowman*

Pulmonary Inhalation Toxicity of Respirable Dust
(WV5/USBM 5405) *Lantz/Stanley/Dalal*

Airway Reactivity in Coal Miners
(WV8/USBM 5407) *Abrons/Petsonk*

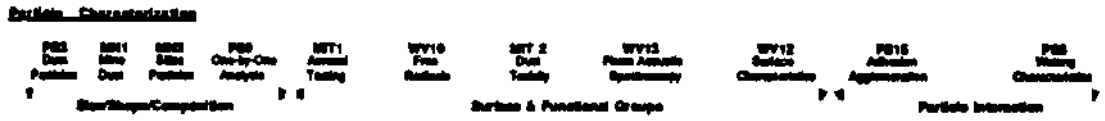
Effects of Dust on Release of Superoxide
(WV9/USBM 5408) *Cilento/Lantz*

Tracheal Acoustic Impedance of Air Passage
(WV14A/USBM 5413) *Sneckenberger*

Topographical Laser Holography for Detection of Black Lung
(WV14B/USBM 5413) *Stanley*

The Role of Platelet Activating Factor in Pneumoconioses
(WV17/USBM 5423) *VanDyke/Castronova*

Particle Characterization



Characterization of Dust Particles
(PS3/USBM 4203) *Hogg/Luckie*

Wetting Characteristics in Relation to Dust Abatement
(PS8/USBM 4207) *Chander/Aplan*

Analysis of Coal Dust Particles Using an SEM
(PS9/USBM 4208) *Hogg/Austin*

Adhesion, Aglomeration and Deposition of Dust
(PS15/USBM 4223) *Chander/Hogg*

Magnetic Resonance of Paramagnetic Ions and Free Radicals
(WV10/USBM 5409) *Dalal/Vallyathan*

Shape and Surface Characterization of Dust Particles
(WV12/USBM 5411) *Meloy/Vallyathan/Wallace*

Dust Testing in Mines and Metallurgical Operations
(MIT1/USBM 4202) *Ring*

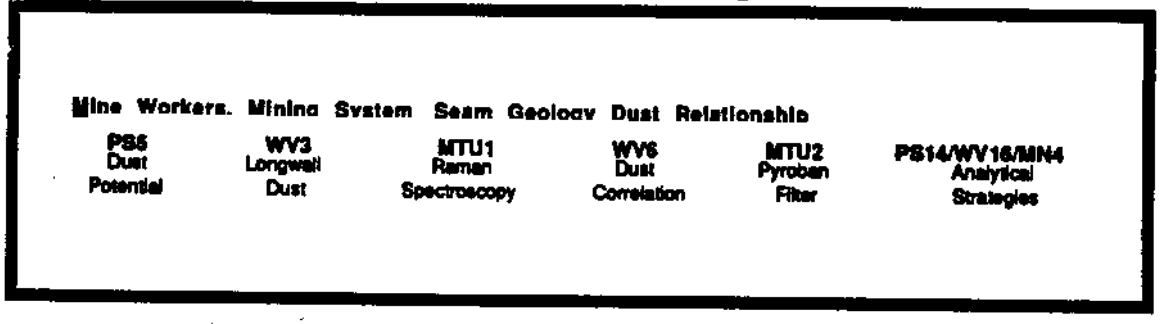
Effect of Physical Properties of Dusts on Toxicity
(MIT2/USBM 2521) *Elliott/Bolsaitis*

Coal Mine Dust Characterization
(MN1/USBM 2701) *Marple/Rubow*

Determination of Silica Particle Concentration
(MN3/USBM 2703) *Marple/Rubow*

Determination of Active Silica Using PA Spectroscopy
(WV13/USBM 5412) *Seehra/Wallace*

Mine Workers, Mining Systems, Seam Geology Dust Relationship Area.



Standard Procedures for Characterization of Dust Potential
(PS5/USBM 4205) *Mutmansky/Bise/Frantz*

Improved Dust Sampling/Analytical Strategies for Mine Use
(PS14/USBM 4222/5422/2722) *Mutmansky*

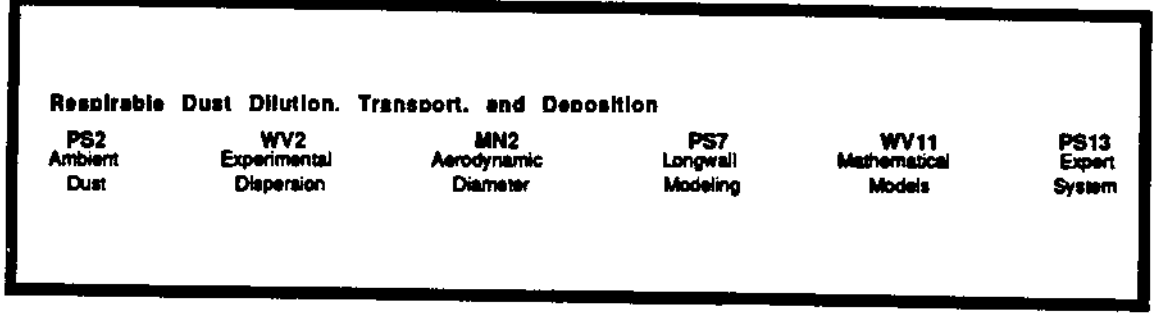
Longwall Dust
(WV3/USBM) *Peng*

Correlations of Respirable Dust Characteristics
(WV6/USBM 5406) *Stobbe/Grayson*

Analysis of Diesel Particulate by Raman Spectroscopy
(MTU1/USBM 2601) *Johnson/Cornilsen*

Monitoring and Control of Diesel Particulate in a Mine
(MTU2/USBM 2621) *Johnson/Cornilsen*

Dust Dilution, Transport, and Deposition Area.



Prediction of Ambient Dust Concentration in Mines
(PS2/USBM 4202) *Ramani*

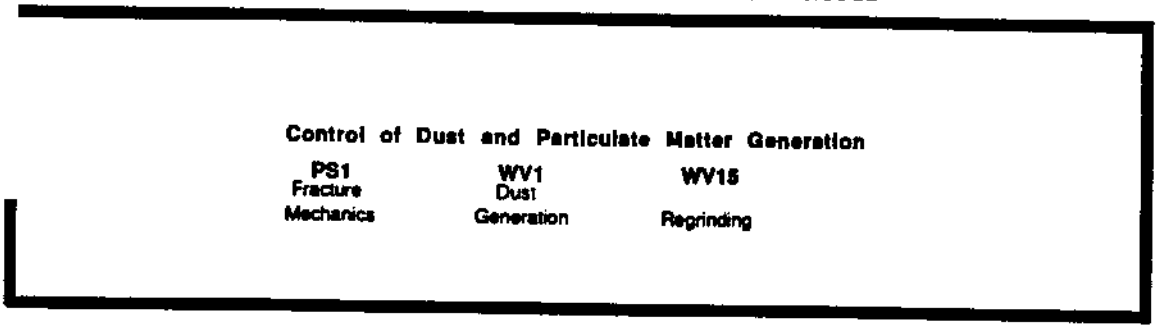
Computer Modeling of Longwall Face Ventilation
(PS7/USBM 4206) *Ramani*

An Expert System for Planning Mine Ventilation Systems
(PS13/USBM 4221) *Ramani*

Development of Mine Dust Distribution Models
(WV11/USBM 5410) *Wang/Chiang*

Aerodynamic Diameter Analysis of Coal Dust
(MN2/USBM 2702) *Marple/Rubow*

Control of Dust and Particluate Matter



Fracture Mechanics Study of Crack Propagation in Coal
(PS1/USBM 4201) *Bieniawski*

Mechanisms of Dust Generation and Entrainment
(WV1/USBM 5401) *Khair*

Correlation of Dust Due to Regrinding at the Face
(WV15/USBM 5421) *Khair*

VIII
TECHNOLOGY TRANSFER

Chapter 8

INTRODUCTION

Research on the control of exposure to respirable contaminants in mine atmospheres is conducted in five areas: 1) control of dust generation, 2) dilution, dispersion and collection of dust in mine airways, 3) characterization of dust particles, 4) interaction of dust and lungs, 5) relationship of mine environment, geology, and seam characteristics to dust generation and mobility. The distribution of research findings to the mining industry, to government agencies, and to scientists at other universities is accomplished in several ways.

A data bank of respirable dust samples displaying a wide range of characteristics (low volatile, medium volatile, high volatile, silica fireclay, rockdust) has been established by the Center. This data bank is being utilized by Center researchers in a suite of medical, scientific, and engineering tests (FIGURE 26).

The Center has honored requests for educational and informational materials from several sources, including MSHA and CANMET who received information on Center generated software and used the Center's expertise in developing a computer program for particle distribution model (DISFIT).

The Generic Mineral Technology Center for Respirable Dust has organized two dust conferences on respirable dust, the Coal Mine Dust Conference, held at West Virginia

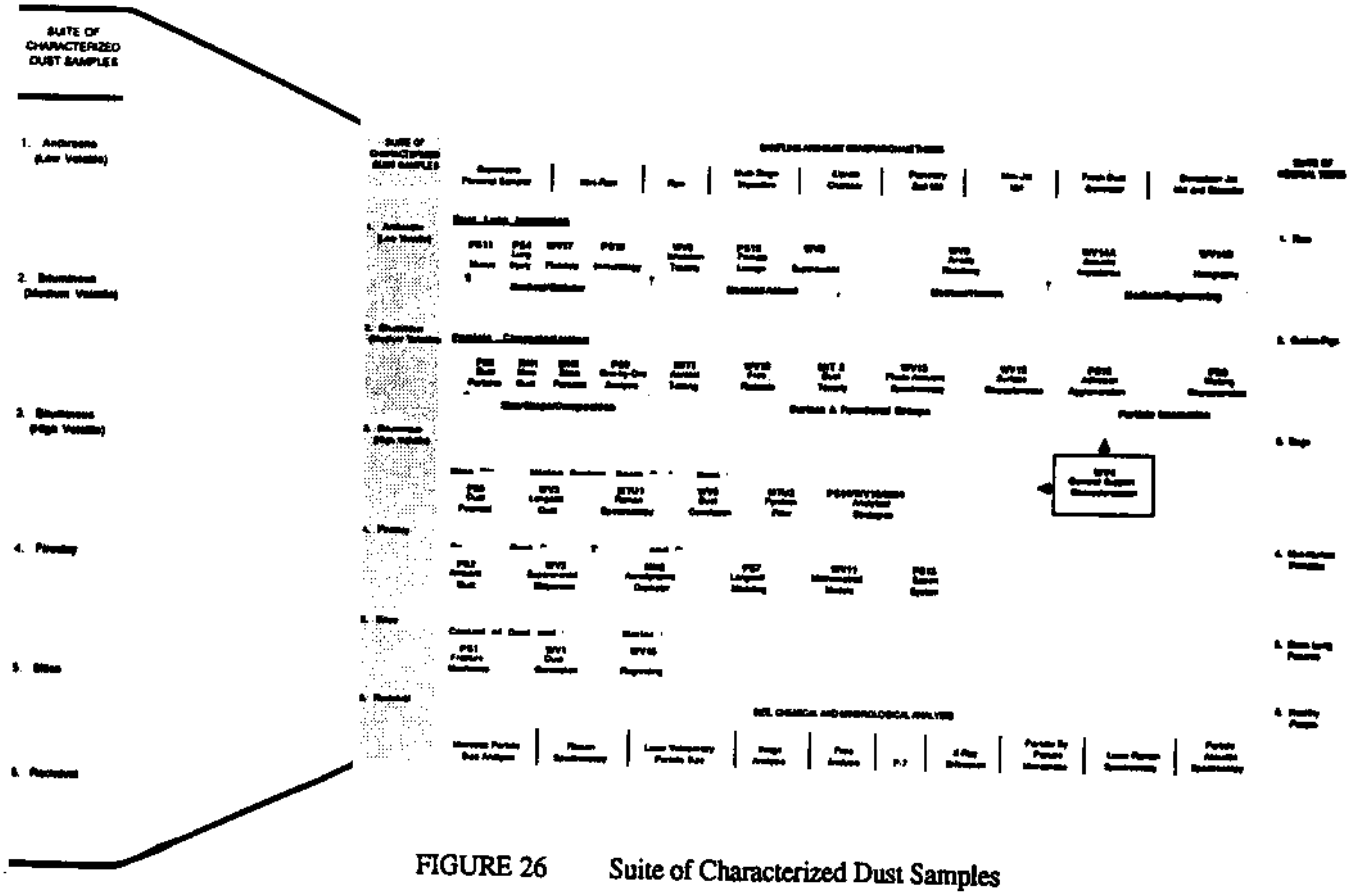


FIGURE 26 Suite of Characterized Dust Samples

University, Morgantown, West Virginia from October 8-10, 1984 and Respirable Dust in the Mineral Industries: Health Effects, Characterization and Control, an international symposium on Respirable Dust in the Mineral Industries held at The Pennsylvania State University, University Park, Pennsylvania from October 14-16, 1986. These conferences were co-sponsored by the U.S. Bureau of Mines, Mine Safety and Health Administration, National Institute for Occupational Safety and Health (NIOSH), and the American Conference of Governmental Industrial Hygienists (ACGIH). On August 23-26, 1988, the VIIth International Pnuemoconioses Conference was held in Pittsburgh, Pennsylvania. While not a sponsor of this conference, researchers in the Generic Mineral Technology Center for Respirable Dust had significant participation with sixteen (16) papers presented (see Volume 8 of this series for abstracts and papers). These conferences provided a significant forum for the exchange of ideas on dust research and the interchange of research findings. The proceedings from these conferences are available from NTIS and ACGIH.

In sum, significant benefits to mine worker health have resulted and should continue to result from the synergistic scientific, engineering, and medical research in respirable dust (FIGURE 27). As always, an important objective is the rapid dissemination of the results of this research to industry. Video tapes and the Bureau's Technology News series have been a very effective means of USBM technology transfer. Individual no-cost subscriptions to the Technology News series are available from the U. S. Bureau of Mines, Branch of Technology Transfer, 2401 E Street, N.W., Washington, DC, 20241.

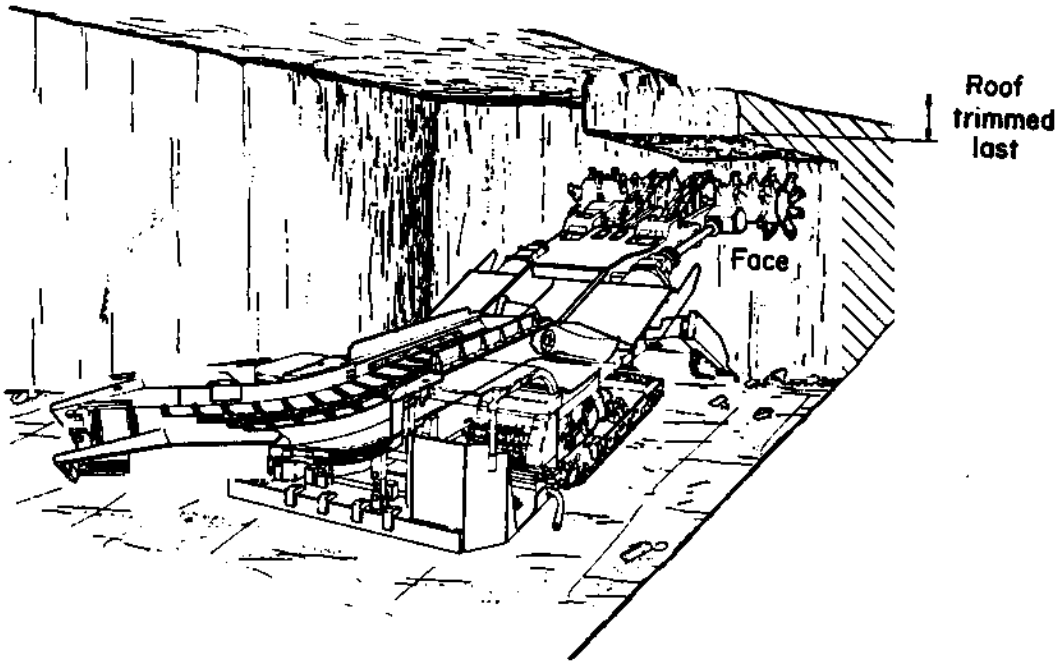


FIGURE 27 Modified cutting sequence reduces quartz dust generation when cutting roof rock.

COAL MINE DUST CONFERENCE
PROCEEDINGS

edited by
SYD S. PENG
Professor and Chairman
Department of Mining Engineering
College of Mineral and Energy Resources
West Virginia University
Morgantown, WV 26506

CHARACTERIZATION AND SAMPLING

Session Chairman: V. A. Marple, University of Minnesota
Session Co-chairman: M. Jacobson, MSHA

GENERAL DUST CONTROL

Session Chairman: F. N. Kissell, USBM
Session Co-chairman: Stewart Deck, Pittston Coal Group

7. RESEARCH ON REDUCING GENERATION OF PRIMARY RESPIRABLE DUST IN CUTTING COAL, W. W. Roepke, C. F. Wingquist, B. D. Hanson, and L. S. Sundae, USBM Twin Cities Research Center

8. WET DRUMS FOR CONTROLLING FRICTIONAL IGNITION AND DUST: A STATUS REPORT, R. F. J. Adam, Kelron, Inc. and J. Tisdale, Pennsylvania Mines Corp.

9. CONTROL OF RESPIRABLE COAL DUST IN CONVENTIONAL COAL MINING OPERATIONS, S. J. Rodgers, MSA Research Corp. and N. Jayaraman, USBM-PRC

10. LONGWALL DUST CONTROL--RESPIRATORS, D. E. Cole, Kitt Energy Corp.

DISCUSSION

11. DUST CONTROL IN SURFACE COAL MINING OPERATIONS (Abstract), G. Sutton, MSHA-Denver

12. TECHNIQUES FOR THE APPLICATION OF A PROPRIETARY REFINED WOOD BASED ADHESIVE POLYMER FOR RESPIRATORY FUGITIVE DUST CONTROL IN UNDERGROUND AND OPEN PIT COAL MINES, K. J. Charlton, Special Mining Services Pty., Ltd., New South Wales, Australia

LONGWALL DUST CONTROL

Session Chairman: J. Girod, US Steel Mining Co.
Session Co-chairman: P. C. Thakur, CONOCO Inc.

13. LONGWALL DUST CONTROL--ENFORCEMENT ACTION, J. M. Krese, MSHA

14. THE EFFECTIVENESS OF WATER INFUSION ON RESPIRABLE DUST CONTROL--A CASE STUDY, R. S. Ondrey, Pittsburgh Health Technology Center, MSHA

DISCUSSION

15. DUST CONTROL ON CONSOL'S LONGWALL FACES, J. B. Riester, L. D. Taylor, and P. C. Thakur, CONOCO, Inc.

DISCUSSION

16. EVALUATION OF HOMOTROPOL VENTILATION FOR LONGWALL DUST CONTROL, J. S. Kelly, Foster-Miller, Inc. and R. A. Jankowski, USBM-PRC

DISCUSSION

17. FIELD TESTS OF A FOAM-DUST SUPPRESSION SYSTEM WITH LONGWALL SHEARERS, M. M. Singh and A. W. Laurito, Engineers International, Inc.

DISCUSSION

18. EFFECTS OF WATER-THROUGH-BIT IN UNDERGROUND MINING OPERATIONS, R. Morris and R. O. Agbede, ACCO Mining Sales, and J. D. Thorpe, Padley & Venables, Ltd.

DISCUSSION

MEASUREMENT AND CONTROL OF QUARTZ DUST

Session Chairman: T. F. Tomb, MSHA
Session Co-chairman: J. Kost, BCR National Laboratory

19. EVALUATION OF RESPIRABLE QUARTZ IN CONTINUOUS MINER SECTIONS, L. D. Taylor, J. B. Riester, and P. C. Thakur, CONOCO, Inc.

20. CONCEPTS FOR CONTROLLING QUARTZ DUST EXPOSURE OF COAL MINE WORKERS, R. A. Jankowski, USBM-PRC, R. E. Nesbit, MSHA, and F. N. Kissell, USBM-PRC

21. MAINTENANCE OF A ROOF BOLTER DUST COLLECTOR AS A MEANS TO CONTROL QUARTZ, R. A. Thaxton, MSHA

    DISCUSSION

22. COMPARISON OF ALPHA QUARTZ MATERIALS USED AS CALIBRATION STANDARDS, P. M. Kacsmar and T. F. Tomb, Pittsburgh Health Technology Center, MSHA

    DISCUSSION

HEALTH EFFECTS

Session Chairman: N. F. Rodman, West Virginia University
Session Co-chairman: M. D. Attfield, NIOSH

23. THE NATIONAL COAL WORKERS' HEALTH SURVEILLANCE PROGRAM: 1970-1980, R. Althouse, NIOSH

24. RECENT RESULTS AND FORTHCOMING STUDIES IN THE EPIDEMIOLOGY OF COAL WORKERS' PNEUMOCONIOSIS IN UNDERGROUND MINERS, M. D. Attfield, NIOSH

25. DUST CONCENTRATIONS AND PREVALENCE OF PNEUMOCONIOSIS IN THE UNITED STATES AND GREAT BRITAIN: A RE-EXAMINATION AND COMPARISON OF DATA PRIOR TO 1970, K. Morring and M. D. Attfield, NIOSH

26. RESPIRATORY STATUS OF SURFACE COAL MINERS, H. E. Amandus, NIOSH

27. THE NATIONAL COAL WORKERS' AUTOPSY STUDY, F. H. Y. Green, R. Althouse, V. Vallyathan, NIOSH, and J. A. Merchant, University of Iowa

28. LUNG CANCER IN COAL MINERS--RECENT RESULTS (Abstract), V. Vallyathan, R. Althouse, F. H. Y. Green, NIOSH, and C. Boyd and N. F. Rodman, West Virginia University

29. PULMONARY SURFACTANT INTERACTION WITH RESPIRABLE DUST, W. E. Wallace, Jr., M. J. Keane, V. Vallyathan, T. M. Ong, and V. Castranova, NIOSH

30. THE PARENCHYMAL LESION OF COAL WORKERS PNEUMOCONIOSIS (Abstract), N. F. Rodman, West Virginia University

GENERIC TECHNOLOGY CENTER FOR RESPIRABLE DUST

Session Chairman: R. L. Frantz, Pennsylvania State University
Session Co-chairman: R. Bajura, West Virginia University

DUST GENERATION AND CONTROL

31. DESIGN AND FABRICATION OF A ROTARY COAL CUTTING SIMULATOR, A. W. Khair, West Virginia University

DUST DILUTION, DISPERSION AND COLLECTION

32. DUST TRANSPORT IN MINE AIRWAYS, R. V. Ramani and R. Bhaskar, Pennsylvania State University

    DISCUSSION

33. SOME FACTORS INFLUENCING THE AIRBORNE DUST DISTRIBUTION IN LONG WALL FACE AREA, H. S. Chiang, S. S. Peng, G. C. Sun, and Y. F. Zhao, West Virginia University

34. INSTRUMENTATION FOR THE MEASUREMENT OF RESPIRABLE COAL MINING DUST, V. A. Marple and K. L. Rubow, University of Minnesota

INTERACTION OF DUST AND LUNG

35. THE DEVELOPMENT OF AN ELECTRO-OPTICAL TECHNIQUE TO MEASURE SUPEROXIDE RELEASE FROM PULMONARY ALVEOLAR MACROPHAGES EXPOSED TO COAL DUSTS, K. A. DiGregorio, E. V. Cilento, and R. C. Lantz, West Virginia University

    DISCUSSION

36. EVALUATION OF THE SIZE DISTRIBUTION OF LARGE AEROSOLS IN AN ANIMAL EXPOSURE CHAMBER, F. Pisano, M. McCawley, D. Hinton, C. Stanley, and R. C. Lantz, West Virginia University

RELATIONSHIP OF MINE ENVIRONMENT, GEOLOGY AND SEAM CHARACTERISTICS TO DUST GENERATION AND MOBILITY

37. AN ANALYSIS OF COAL AND GEOLOGIC VARIABLES RELATED TO COAL WORKERS' PNEUMOCONIOSIS, J. M. Mutmansky and C. Lee, Pennsylvania State University

38. THE RELATIONSHIP BETWEEN THE HARDGROVE GRINDABILITY INDEX AND THE POTENTIAL FOR RESPIRABLE DUST GENERATION, M. P. Moore and C. J. Bise, Pennsylvania State University

39. CORRELATION AND DUST CONCENTRATION WITH WORKER POSITIONS, R. L. Grayson and S. S. Peng, West Virginia University

RESPIRABLE DUST IN THE MINERAL INDUSTRIES: HEALTH EFFECTS, CHARACTERIZATION AND CONTROL

edited by
Robert L. Frantz
and
Raja V. Ramani

The Pennsylvania State University
University Park, PA

MEASUREMENT

GENERIZATION & CHARACTERIZATION I

HEALTH EFFECTS – CELLULAR RESPONSES

HEALTH EFFECTS – INHALATION STUDIES

Effects of Silica Inhalation on Pulmonary Alveolar Macrophages (PMA) and Microsomal Cytochrome P450 Activities
W. Pailes, J. Rabovsky, D. Judy, J. Tucker, V. Castranova and R.C. Lantz

Development of Alterations in the Lung Induced by Inhaled Silica: A Morphometric Study
R. Clark Lantz, Charles Stanley and David E. Hinton

Noninvasive Magnetopneumographic Studies of Lung Dust Retention and Clearance in Coal Miners
Allan P. Freedman and Stephen E. Robinson

Pulmonary Injury in Laboratory Animals Induced by Huai-Nan Coal Mine Respiratory Dust
B.H. Chen, Z.H. Men, Y Huang, H.Q. Mao and S.Y. Wang

CHARACTERIZATION I

Standard Respirable Dusts
T.F. Dumm and R. Hogg

Detection of Organic Free Radicals in Coal Dust-Exposed Lung Tissue and Correlations with Their Histopathological Parameters
B. Jafari, N.S. Dalal, A.V. Vallyathan and F.Y.H. Green

Mineral Fiber Toxicity: Further Evidences for an Involvement of the Surface Chemistry
Denis Nadeau, Louise Fouquette-Couture, Jaleh Khorami and Daniel Paradis

A Hypothesis on the Possible Contribution of Coal Cleats to CWP
Thomas P. Meloy

GENERIZATION & CHARACTERIZATION II

Reducing Employee Silica Dust Exposures – A Case Study
William J. Francart, Joseph M. Denka and W. Carol Ensminger

Investigation of Cuartz Dust Sources and Control Mechanisms on Surface Coal Mine Operations
Robert A. Zimmer, Stan R. Luecka and Stephen J. Page

Assessment of Respirable Dust Control for Rotary Blasthole Drills at Surface Coal Mines
Raymond Gadomski and Debora L. Chiz

Dust Sampling Roof Bolting Operations
Robert Ondrey, Richard Stoltz, David Atchison and Everett Gerbec

CHARACTERIZATION II

Size Distribution of the Airborne Dust in Longwall Coal Faces
H.S. Chiang, S.S. Peng and Y. Luo

Longwall Respirable Dust Simulator
Robert A. Haney

A Procedure for Extensive Characterization of Coal Mine Dust Collected Using a Modified Personal Sampler
T.F. Dumm and R. Hogg

Deposition of Respirable Dust in an Airway
Welby G. Courtney, Lung Cheng and Edward F. Divers

CONTROL I

The Campbell Flooded Bed Scrubber System, a Quiet Revolution
John A.L. Campbell

Evaluation of a New Half-curtain Technique for Continuous Miner Faces
Natesa I. Jayaraman, Edward F. Divers, R. Link Derick and Charles Babbitt

Dust Control for Personnel Downwind of the Miner
Charles A. Babbitt and Natesa I. Jayaraman

Remote Brattice Face Ventilation Systems
John E. Urosek, Charles S. Battistoni and George G. Hazuza

CONTROL II

Adhesive Foam Dust Control for Mine Production Face and Materials Handling
Kenneth J. Charlton

Dust Control on Longwall Shearers Using Water-Jet-Assisted Cutting
C.D. Taylor, P.D. Kovscek and E.D Thimons

The Relationship Between Respirable Dust and Ventilation In Underground Auger Mining
Dale D. Durrett and Natesa I. Jayaraman

Get Away from the Dust with Clean Air from an Overhead Air Supply Island (OASIS)
Jon C. Volkwein, Mark R. Engel and Thomas D. Raether

Simulations of Dust Dispersion for a Coal Mine Face Using a Scale Model
T.H. Ueng, S.D. Thompson and Y.J. Wang

VIIth International Pneumoconioses Conference

Program

Sponsored by
NIOSH-ILO-BOM-MSHA-OSHA

Pittsburgh, Pennsylvania
August 23-26, 1988

Opening Ceremony

Tuesday, August 23, 1988
Allegheny Grand Ballroom
Vista International Hotel

8:30 a.m.

Welcome
Edward L. Baker, M.D.

Timothy Uhrich
Assistant Executive Secretary to the Mayor of Pittsburgh

8:45 a.m.

Keynote Speakers

John Pendergrass
Assistant Secretary General of Labor, OSHA
Washington, DC, USA

David Taylor
Deputy Director General, International Labour Office
Geneva, Switzerland

Overview Speakers

Bruce Karrh, M.D.
Vice President Safety, Health, and Environmental Affairs
E.I. Dupont de Nemours Company, USA

Lynn Williams
International President, United Steel Workers of America
Pittsburgh, PA, USA

J. Donald Millar, M.D., D.T.P.H. (Lond)
Assistant Surgeon General, Director, NIOSH
Atlanta, GA, USA

SCIENTIFIC PROGRAM

A. Oral Communications

Opening General Session
Tuesday, August 23rd, from 8:30 a.m. to 12:30 noon

Technical Sessions
Tuesday, August 23rd, 2:00 p.m. to 5:30 p.m.
Wednesday, August 24th, 8:30 a.m. to 12:00 noon and 1:30 p.m. to 5:30 p.m
Thursday, August 25th, 8:30 a.m. to 12:00 noon and 1:30 p.m. to 5:00 p.m.
Friday, August 26th, 8:30 a.m. to 12:00 noon.

B. Poster Communications

Wednesday, August 24th and Thursday, August 25th, from 9:30 a.m.to 11:00 a.m.and 2:30 p.m. to 4:00 p.m. in the David L. Lawrence Convention Center

C. Work Groups

Tuesday, August 23rd, from 2:00 p.m. to 5:00 p.m.
Wednesday, August 24th, from 8:00 a.m. to 5:00 p.m.
Thursday, August 25th, from 8:00 a.m. to 11:30 a.m.

D. Technical Visits

Wednesday, August 24th, from 1:00 p.m. to 5:00 p.m.

Scientific Program

Technical Sessions

Technical Sessions have been arranged according to the following categories:

- Animal models of pneumoconioses
- Surveillance/Screening/Health Reviews
- Silica, Coal, and Asbestos: Epidemiology
- Dust Measurements, Sampling Strategies and Controls
- Radiological Methods
- Clinical and Hazard Evaluation Studies of Dust Induced Lung Diseases
- Treatment of Lung Diseases
- Case Studies: Dust Induced Lung Diseases
- Medical Methods in the Evaluation of Occupational Lung Disease
- Lung Fiber Burden and Cytotoxicity
- Teaching Demonstrations - ILO International Classification of Radiographs of Pneumoconioses, 1980
- Scientific Poster Sessions

10:15 a.m. **Break**

10:45 a.m. **Addresses, Representatives: International Organizations**

Rolf Hopf
International Social Security Association

Premsyl Pelnar, M.D.
International Commission of Occupational Health

Mrs. Bernice Goelzer
Office of Occupational Health, World Health Organization

11:00 a.m. **Conference Theme Presentations**

- **Evaluation of Respiratory Hazards in the Working Environment Through Environmental, Epidemiological and Medical Surveys**
  Margaret Becklake, M.D.
  McGill University
  Montreal, Canada

- **Progress in Etiopathogenesis of Respiratory Disorders Due to Occupational Exposures to Mineral and Organic Dust**
  J.C. Wagner, M.D.
  MRC Pneumoconiosis Unit
  Penarth, Glamorgan, S. Wales, UK

- **Progress in Prevention, Early Diagnosis, and Medical Control of Occupational Lung Disease**
  Wolfgang T. Ulmer, M.D.
  Pneumoconiosis Research Institute
  Bochum, Federal Republic of Germany

- **Progress in Dust Control and Dust Suppression Technologies for Mining and Industry**
  Morton Corn, Ph.D.
  The Johns Hopkins University
  Baltimore, Maryland, USA

12:20 noon **Break**

12:30 p.m. **Luncheon**
The Three Rivers Complex Room & The Pittsburgh Room
Westin William Penn Hotel

Poster Sessions - Commercial Exhibits

Wednesday, August 24 and Thursday, August 25, 8:30 a.m. to 4:30 p.m.

Poster Sessions, together with **Commercial Exhibits**, will be located in the David L. Lawrence Convention Center, which is connected by walkway to the Vista International Hotel.

The Poster and Exhibit areas will be open, Wednesday and Thursday, to all registered attendees, exhibitors, and their designated representatives. Dates, times, and specific information about individual Exhibits and Poster Sessions will be available at the registration area.

Working Groups

Working Groups will be convened in selected subjects to supplement the above themes.

- ILO International Classification of Radiographs of Pneumoconioses, 1980
- Pathology Standards for the Pneumoconioses
- Occupational Exposure to Airborne Particulate Matter and Respiratory Carcinogenesis: Risk Assessment at Low Exposure Levels
- Non-malignant Respiratory Disorders Due to Exposure to Asbestos, Asbestos Substitutes, and Man-made Fibers
- Standardization of Methods of Monitoring Environmental Exposure to Airborne Particulate Matter
- Properties of Mineral Dusts Influencing Biological Outcome

Technical Site Visits

Wednesday, August 24, 1:00 - 4:00 p.m.

Arrangements have been made for visits to occupational health and industrial research facilities in and around Pittsburgh. Buses will leave from the lobby of the Vista International Hotel at 1:00 p.m. Site visits are:.

Consolidation Coal Company
Analytical laboratory, metallurgical coal and coke combustion, fluid gas emissions, synthetic fuels, coal preparation and slurry transport, and general earth/science technology.

U.S. Department of the Interior
Bureau of Mines
Bruceton Research Facility
Dust control and ventilation demonstration laboratory, safety research, coal mine water-jet assisted cutting.

Mine Safety Appliances Company
Research and production of instruments and personal protection products.

U.S. Department of Labor
Mine Safety and Health Administration
The Respirable Dust Measurement and Assessment Laboratory and The Physical Agents and Toxic Materials Laboratory.

University of Pittsburgh - Graduate School of Public Health
Aerosol sampling systems, aerosol generation system for inhalation, pulmonary testing of small animals, ventilation system design occupational health programs.

United States Steel Clairton Works
Coke oven, by-products areas, and the occupational health clinic.

IX
REFERENCE CENTER

Chapter 9

INTRODUCTION

The combined library facilities of the five universities in the Generic Technology Center for Respirable Dust, The Pennsylvania State University, West Virginia University, University of Minnesota, Massachusetts Institute of Technology, and Michigan Technological University, represent one of the most extensive and comprehensive collections of information on respirable dust research which is available in the United States. The Center encompasses two major medical schools, the Milton S. Hershey Medical Center at The Pennsylvania State University and West Virginia University Hospital at West Virginia University, and includes national and international experts from such diverse disciplines as geology, geomechanics, mining engineering, mineral processing, electrical engineering, industrial engineering, mechanical engineering, material science, physics and several areas of medicine. In order to maximize achievements in research and facilitate early results application in the private industry, university, government and public sectors, a geographically dispersed Reference Center on Respirable Dust has been established at each of the affiliated universities. This network serves to encourage unity between the universities in the Center and coordination and communication with other entities who benefit from their research.

Description of the Reference Center

In this light, the goal of the Reference Center network is to identify at what location information is available and to provide a means for others to access this information. It is especially necessary to have both ease of input and maximum retrieval capabilities available to all the research personnel in the Reference Center. At the same time, the service provided to the inquiring public must be complete and cost-effective. The Center's approach to realizing this goal incorporates advances in computerized and electronic searching of individual library holdings and the networking of major library and commercial search systems.

The Reference Center uses the following means to achieve this goal. At each participating university, a hard copy collection is maintained of the current respirable dust research in progress by that institution's personnel. Also, available at each university is a review of their past and present research on respirable dust. At each participating university a hard copy collection of annual status reports and of all publications produced by Center personnel for symposiums, national and international conferences is maintained. A key word computer search capability is available to participating universities. This computer search, by title, author and location, allows researchers to determine at which facility information is available, thus avoiding the tremendous expense and effort of housing all the information on respirable dust research under one roof. The Reference Center has access, through The Pennsylvania State University Libraries system and the libraries of other institutions, to a large number of data bases such as MEDLINE at the National Library of Medicine,

Lockhead Corporation, the energy data base of the U.S. Government, DIALOGUE Information Support System (comprised of over 100 data bases), ISI International Scientific Information System, and data bases of professional societies such as the Institute of Mining and Metallurgy (UK), and Information on Demand, Inc., a research service available to SME members. A magazine article explaining this service appears in this chapter.

Researchers are asked at regular intervals to update the system with their most recent publications (FIGURE 28). This, in effect, requires a current technical publications review by each researcher in the Respirable Dust Center. Towards this end, each principal investigator (PI) is required to submit a copy of all annual and final reports plus bibliography references and abstracts for each project to the Center. Each PI has been invited to submit to the Reference Center at his/her university a bibliography reference, abstract and key reference words for any prior respirable dust research.

the scientific, engineering and medical information on respirable dust under one roof, it also utilizes the existing library holdings, library personnel and other associated library access facilities to the best advantage of the GTCRD reference center. For instance, **LIAS**, the **L**ibrary **I**nformation **A**ccess **S**ystem developed by Penn State, is an online, electronic catalog that replaces the traditional card catalog. LIAS provides access to materials owned by the University and available at the main campus and all branch and Commonwealth campus locations in the system. The Earth and Mineral Sciences Library, located in 105 Deike Building, University Park Campus and adjacent to the Generic Mineral Technology Center for Respirable Dust, maintains collections in most relevant areas including geoscience, materials sciences and mineral engineering. Strong emphasis is placed on coal resources and research. All College of Earth and Mineral Sciences theses and dissertations are located here. Twenty-five major indexing and abstracting periodicals service the periodical and serial collections. In addition, an indexed collection of geologic, stratigraphic , and tectonic maps are housed here. Reference materials in the science and technology libraries include encyclopedias, specialized dictionaries, directories of scientific organizations and research facilities, technical handbooks, and catalogs of special collections such as the Engineering Societies Library. Computerized literature searches are available through the library on a cost- recovery basis.

You can access LIAS three ways: via terminals conveniently located in all University Libraries; via a modem and a microcomputer or terminal; and via terminals hardwired to the University Computation Center. LIAS is a "user friendly " interactive system. A pocket guide and online HELP is available if needed. The system tells you not only whether the library has a particular book, but also where it is located and if it is available for you to use. Therefore, it is possible to browse the Libraries' holdings without going to the shelves. A Remote Access Guide is provided in FIGURE 29 to illustrate the ease with which LIAS may be used by outside parties. A detailed, computerized list of some of the journal holdings available through The Pennsylvania State University Libraries is included as an example of the ease with which a bibliographic file may be constructed or a computer search conducted. A similar, partial list of government publications which are available is also included as an

example. A collection of more than two million government publications is currently available. U.S. government documents comprise the largest part of this collection. These include technical reports, patents, statistics, and reports of governmental agencies. The Documents Section of the library also receives publications from most of the major international governmental organizations, such as the U.N., the World Bank, and OPEC. The publications of the Pennsylvania State government are housed here as well. This computer search capability has been developed to provide bibliographic references for all books and technical publications on respirable dust related topics which are available through The Pennsylvania State University Library system. An example of a bibliographic file on diesel equipment in mines using the available facilities at Penn State has been included to illustrate the comprehensive nature of the system.

The Generic Mineral Technology Center for Respirable Dust has sponsored two conferences on respirable dust research. In each case there was significant participation by Center researchers. The agenda from these conferences has been included in this chapter on the reference center to illustrate the scope of research being conducted on respirable dust wordwide. Individual research presentations are marked as being either a reference center author or an outside reference center author.

REFERENCE CENTER PUBLICATIONS

The Generic Mineral Technology Center for Respirable Dust has published a series of reference books that describe the Center and present the collected research papers of Center personnel. These research papers have resulted from respirable dust research at The Pennsylvania State University, West Virginia University, University of Minnesota, Michigan Technological University, and Massachusetts Institute of Technology and form the nucleus of the Reference Center, representing years of scientific study in this field.

VOLUME 1	Status Report, 1984-1988
VOLUME 2	Report to the Committee on Mining andMineral Resources Research,1987
VOLUME 3	Publications, 1984
VOLUME 4	Publications, 1985
VOLUME 5	Publications, 1986
VOLUME 6	Publications, 1987
VOLUME 7	Respirable Dust Center Research Program Review
VOLUME 8	Publications, 1988

FIGURE 28 Reference Center Publications

LIAS: REMOTE ACCESS GUIDE

LIAS (the Library Information Access System) is available not only in the library, but also from remote terminals and microcomputers.
You do not have to open an account with the University Libraries to use LIAS. The only charge is for telecommunications; this means that users dialing into LIAS with a local phone call have no charge at all. Access to LIAS is available via University Park or via any of the nineteen campus locations.

DIRECT DIAL ACCESS

Necessary Hardware:

- Asynchronous terminal or microcomputer
- One of three modems:
  a. Bell 103 compatible (300 baud)
  b. Bell 212 compatible (1200 baud)
  c. Vadic 34XX compatible (1200 baud)

Instructions for Use:

STEP 1: Communication settings are FULL DUPLEX, NO PARITY, 8 BITS, 1 STOP BIT.

STEP 2: Dial (814) 865-LIAS or 865-5427.

STEP 3: Press [RETURN] once.

STEP 4: At SELECTION prompt, press [RETURN] once.

STEP 5: You are now connected to the system switch at Pattee Library.

If LIAS is available, the system responds with: WE ARE P.S.U. (beep)
Go to Step 6.

If LIAS is busy, the system responds with: BUSY, WAIT?
If you wish to wait, press [y] and [RETURN]. LIAS will respond with the number of users waiting. If you do not wish to wait, disconnect and hang up.

STEP 6: Press [RETURN] twice.

STEP 7: LIAS will respond: WELCOME ... >>>

STEP 8: Make terminal adjustments. See flip side of this sheet for instructions or type: [HELP TERMINAL] [RETURN]

STEP 9: Begin searching.

STEP 10: To exit from LIAS, disconnect modem communication. There is no exit command for LIAS.

PSU NETWORK ACCESS

Necessary Hardware:

- Terminal hardwired to the asynchronous PSU network.

Instructions for Use:

STEP 1: Set terminal to FULL DUPLEX, NO PARITY, AND 300, 1200, 2400, 4800, or 9600 BAUD. Follow usual procedures for connecting to the network.

STEP 2: At the REQUEST prompt, enter: LIAS

STEP 3: System reponds with a CONNECTION message. Press [RETURN] once.

STEP 4: At SELECTION? prompt, press [RETURN] once.

STEP 5: You are now connected to the system at Pattee Library.

If LIAS is available, the system responds with: WE ARE P.S.U. (beep).
Go to Step 6.

If LIAS is busy, the system responds with: BUSY, WAIT? If you wish to wait, press [y] and [RETURN]. LIAS will respond with the number of users waiting. If you do not wish to wait, disconnect and hang up.

STEP 6: Press [RETURN] twice.

STEP 7: LIAS will respond: WELCOME ... >>>

STEP 8: Make terminal adjustments. See flip side for instructions, or type [HELP TERMINAL] [RETURN].

STEP 9: Begin searching.

STEP 10: Follow usual disconnect procedures from the PSU Network. There is no exit command for LIAS.

TERMINAL ADJUSTMENT:

LIAS assumes you are using a standard hard copy terminal, with a display that is 80 characters wide and 24 lines long. If you are not using a hard copy device, you can improve the readability of the screen display and enhance the functional characteristics of your terminal by specifying the type of terminal you are using. Owners of microcomputers should consult their microcomputer manuals to identify the terminals emulated by their computer.

INPUT: **terminal model number**

EXAMPLE: terminal dec vt100

Not all terminals are supported by LIAS. For a list of supported terminals and more information:

INPUT: **help terminal type**

To modify the width and length of display:

INPUT: **terminal w=xx** (where xx = no. of characters on lines)
terminal l=xx

For more instructions on changing the width and length of display:

INPUT: **help terminal width**
help terminal length

LIBRARY OPTION:

The library you are searching is indicated by **lib** followed by a two-letter code, e.g., **lib up**.

To change the library(ies) being searched:

INPUT: **lib xx** or **lib xx, yy** (where xx and yy = library codes)

For a list of library codes:

INPUT: **help library codes**

AVAILABILITY:

- LIAS is currently available:

  Monday - Saturday, 8 a.m. - midnight
  Sunday, noon - midnight

COST:

- The only charge incurred by the user is the communications charge or the cost of the telephone call.
- There is no need to open an account with the library to use LIAS.

ASSISTANCE:

- Use the online HELP.
- Consult *LIAS, an Introductory Guide to Searching the Online Catalog*, available at any PSU Library.
- For assistance call (814) 865-2112 during the following hours:

  Monday - Thursday, 9 a.m. - 10 p.m.
  Friday & Saturday, 9 a.m. - 9 p.m.
  Sunday, noon - 10 p.m.

- Leave a message via PSU electronic mail: **swk@psulias**
- If you can communicate via BITNET: **swk@psulias.bitnet**

<< LIAS WILL AUTOMATICALLY DISCONNECT YOU AFTER 10 MINUTES OF INACTIVITY! >>

February 1989

FIGURE 29 LIAS (the Library Information Access System) developed by Penn State and accessible from remote terminals and microcomputers.

EXAMPLE

COMPUTER SEARCH BY KEY-WORD
Penn State Libraries

```
(1)  Lungs - Dust diseases
(2)  Lungs - Dust diseases - Bibliography
(3)  Lungs - Dust diseases - Congresses
(4)  Lungs - Dust diseases - Etiology - Congresses
(5)  Lungs - Evolution
(6)  Lungs - Fungi
(7)  Lungs - Growth
(8)  The lungs in systemic diseases
(9)  Lungs - Radiography
(10) Lungwitz, Anton, 1845-
 To see more entries, press [NEXT] or [PREV].
>>> 1

 Lungs - Dust diseases  (18 citations)
[1]  Asbestos. / National Research Council. Committee on Biologic Effects of
          Atmospheric Pollutants. 1971.
[2]  Byssinosis. 1982.
[3]  The chemistry and therapy of industrial pulmonary diseases. / Browne,
          Richard Charles. [1966].
[4]  Dust in steel foundries. / Great Britain. Committee on Dust in Steel
          Foundries. 1st-. 1944-.
[5]  The economic impact of public policy on the Appalachian coal industry and
          the regional economy. / Charles River Associates. 1973.
[6]  Experimental pneumoconiosis. / Zaidi, S. H. [1969].
[7]  Industrial dust. / Drinker, Philip. 2d ed. 1954.
[8]  Industrial dust. / Drinker, Philip. 1st ed. 1936.
[9]  Lung function in coalworkers' pneumoconiosis. / Gilson, John Carv. 1955.
[10] Mineral resources and the environment, supplementary report. / National
          Research Council. Committee on Mineral Resources and the Environment.

          1976.
[11] Occupational lung diseases. / Morgan, William Keith C. 1975.
[12] Occupational lung diseases. / Morgan, William Keith C. 1975.
[13] Pneumoconiosis among mica and pegmatite workers ... / United States.
 To see more citations, press [NEXT].
>>> Next

 Lungs - Dust diseases (18 citations)
[13] Pneumoconiosis among mica and pegmatite workers ... / United States.
          Public health service. 1940.
[14] Proceedings. / Pennsylvania Governor's Conference on Pneumoconiosis
          (Anthraco-Silicosis). [196-].
[15] Pulmonary reactions to coal dust. 1971.
[16] Silicosis, pneumokoniosis and dust suppression in mines. 1947.
[17] Symposium, mineral dust in industry [held] at the British Ceramic
          Research Association, December 19-21, 1961. / Symposium on Mineral
          Dust in Industry. 1963.
[18] Tuberculosis in industry. / Trudeau school of tuberculosis. Saranac Lake,
          N.Y. [1942].
>>> BACK


>1<  Lungs - Dust diseases
```

```
(2)  Lungs - Dust diseases - Bibliography
(3)  Lungs - Dust diseases - Congresses
(4)  Lungs - Dust diseases - Etiology - Congresses
(5)  Lungs - Evolution
(6)  Lungs - Fungi
(7)  Lungs - Growth
(8)  The lungs in systemic diseases
(9)  Lungs - Radiography
(10) Lungwitz, Anton, 1845-
 To see more entries, press [NEXT] or [PREV].
>>> 2

 Lungs - Dust diseases - Bibliography
Davis, George Gilbert, 1879-.
    The pneumonokonioses (silicosis), bibliography and laws. / by George G.
  Davis ... Ella M. Salmonsen ... [and] Joseph L. Earlywine ... with a
  foreword by E.R. Le Count ... Chicago, Industrial medicine, inc., 1934-.
    v. 24 cm.
    [Vol.1] section I, Bibliography, covers the period 1556-1933.
    1. Lungs -- Dust diseases -- Bibliography. 2. Occupational diseases --
  Bibliography. 3. Occupations -- Diseases and hygiene -- Bibliography. 4.
  Factory laws and legislation -- United States. 5. Labor laws and legislation
  -- United States. 6. Employer's liability -- United States.
 Call#: 016.613d3D29p        Earth & Min Sci Library
>>> BACK

(1)  Lungs - Dust diseases
>2<  Lungs - Dust diseases - Bibliography
(3)  Lungs - Dust diseases - Congresses
 4)  Lungs - Dust diseases - Etiology - Congresses
(5)  Lungs - Evolution
(6)  Lungs - Fungi
(7)  Lungs - Growth
(8)  The lungs in systemic diseases
(9)  Lungs - Radiography
(10) Lungwitz, Anton, 1845-
 To see more entries, press [NEXT] or [PREV].
>>> 3

 Lungs - Dust diseases - Congresses (5 citations)
[1]  Dusts and disease. / Conference on Occupational Exposures to Fibrous and
          Particulate Dust and Their Extension into the Environment. 1979.
[2]  Inhaled particles and vapours. / British Occupational Hygiene Society.
          1961-[1967].
[3]  Inhaled particles IV. 1st ed. 1977.
[4]  Occupational pulmonary disease. / International Symposium on Grain Dust
          and Health. 1980.
[5]  Papers and proceedings. / National Conference on Medicine and the Federal
          Coal Mine Health and Safety Act of 1969. 1970].
>>> BACK

(1)  Lungs - Dust diseases
(2)  Lungs - Dust diseases - Bibliography
>3<  Lungs - Dust diseases - Congresses
(4)  Lungs - Dust diseases - Etiology - Congresses
(5)  Lungs - Evolution
(6)  Lungs - Fungi
(7)  Lungs - Growth
(8)  The lungs in systemic diseases
(9)  Lungs - Radiography
(10) Lungwitz, Anton, 1845-
 To see more entries, press [NEXT] or [PREV].
>>> 4
```

Lungs - Dust diseases - Etiology - Congresses
Inhaled particles IV, proceedings of an international symposium organized by the British Occupational Hygiene Society, Edinburgh, 22-26 September 1975. / edited by W. H. Walton ; assisted by Brenda McGovern. 1st ed. Oxford; New York, Pergamon Press, 1977.
2 v. (xii, 838 p.). ill. 26 cm.
Includes bibliographies and indexes.
1. Lungs -- Dust diseases -- Etiology -- Congresses. 2. Dust -- Physiological effect -- Congresses. 3. Lungs -- Dust diseases -- Congresses. 4. Coal-miners -- Diseases and hygiene -- Congresses. 5. Aerosols -- Physiological effect -- Congresses.
Call#: RC773.I55 1977
McKeesport Campus
>>> BACK

(1) Lungs - Dust diseases
(2) Lungs - Dust diseases - Bibliography
(3) Lungs - Dust diseases - Congresses
>4< Lungs - Dust diseases - Etiology - Congresses
(5) Lungs - Evolution
(6) Lungs - Fungi
(7) Lungs - Growth
(8) The lungs in systemic diseases
(9) Lungs - Radiography
(10) Lungwitz, Anton, 1845-
To see more entries, press [NEXT] or [PREV].

EXAMPLE

COMPUTER SEARCH BY CALL NUMBER
Penn State Libraries

```
      CALL RC756

An exact call number match was not found - closest one used

[1] RC756.A9
     The lung circulation. / Aviado, Domingo M. [1st ed]. [1963].
[2] RC756.B37
     Textbook of pulmonary diseases. / Baum, Gerald L. [1st ed.]. [1965].
[3] RC756.B37 1974
     Textbook of pulmonary diseases. / Baum, Gerald L. 2d ed. 1974.
[4] RC756.C8
     Form and function in the human lung. 1968.
[5] RC756.C8 1968a
     Form and function in the human lung. 1968.
>>> CALL RC757

An exact call number match was not found - closest one used

[1] RC768.7.S23A43
     Saccharin. / American Council on Science and Health. 1979].
[2] RC768.7.S23S2
     The Saccharin ban. c1977.
[3] RC773.B75
     The chemistry and therapy of industrial pulmonary diseases. / Browne.
         Richard Charles. [1966].
[4] RC773.C63 1977
     Dusts and disease. / Conference on Occupational Exposures to Fibrous and
         Particulate Dust and Their Extension into the Environment. 1979.
[5] RC773.B5
     Lung function in coalworkers' pneumoconiosis. / Gilson, John Cary. 1955.

>>> CALL RC774

An exact call number match was not found - closest one used

[1] RC774.H6
     Control of silicosis in Vermont granite industry. / Hosey, Andrew D.
         [1958].
[2] RC774.M67
     Occupational lung diseases. / Morgan, William Keith C. 1975.
[3] RC774.M67
     Occupational lung diseases. / Morgan, William Keith C. 1975.
[4] RC774.S5
     Silicosis. pneumokoniosis and dust suppression in mines. 1947.
[5] RC775.A8B56
     Biological effects of asbestos. 1973.

>>> CALL RC776

An exact call number match was not found - closest one used
```

>>> CALL HD7264

An exact call number match was not found - closest one used

[1] HD7264.A1S7 Staub. Bd. 1- ; Apr. 1936 -.
[2] HD7264.B38 1954
Dust is dangerous. / Davies, Charles Norman. [1954].
[3] HD7264.D75 1954
Industrial dust. / Drinker, Philip. 2d ed. 1954.
[4] HD7264.G65
Methods for the detection of toxic substances in industry. / Great Britain. Factory Inspectorate. Booklet no. 1- ; 1937-. 1937-.
[5] HD7264.N3
Combustible solids. / National Fire Protection Association. rev. to July 30, 1959. 1959.

>>> CALL TN279

An exact call number match was not found - closest one used

[1] TN279.A5
Rock blasting. / Andre, George Guillaume. 1878.
[2] TN279.B58
Bohren, Sprengen, Rauben. 1.- Jahrg.; Sept. 1952-.
[3] TN279.C9
Selected translations on explosives. / Cybulski, Wacilaw B. 1965.
[4] TN279.D72 Q
A treatise on explosive compounds, machine rock drills and blasting. / Drinker, Henry Sturgis. 1883.
[5] TN279.D75
Blasters' handbook. / Du Pont de Nemours (E. I.) and Company, Wilmington, Del. ?- ed. 19__-.

>>> CALL TN313

An exact call number match was not found - closest one used

[1] TN313.H8
Historical summary of coal-mine explosions in the United States, 1810-1958. / Humphrey, Hiram Brown. 1960.
[2] TN313.M45 1946
Colliery explosions and recovery work. / Whitaker, John Wilfrid. 2d ed. 1946.
[3] TN313.W5
Preventing fatal explosions in coal mines. / Mieck, Edward A. 1942.
[4] TN315.B54
Three mine fire control projects in northeastern Pennsylania. / Bierks, Henry A. 1971.
[5] TN315.D67
Control of mine fires. / Dougherty, John J. [c1969].

>>> CALL TN301

An exact call number match was not found - closest one used

[1] TN301.B32 1920
Mine gases and ventilation. / Beard, James Thom. 2d ed., rev. and enl. 1920.
[2] TN301.F5
Methane control by isolation of a major coal panel. / Findlay, Charles. [1973].
[3] TN301.H17
Airflow in mines. / Hall, Christopher J. [1967].

EXAMPLE

JOURNAL HOLDINGS RELATED TO MINING AND MINERAL PROCESSING

Penn State Libraries

CALL TN1.A1S45

An exact call number match was not found - closest one used

[1] TN1.A1S45 1969
Proceedings. / Seminar on Mining Legislation and Administration. [1970].
[2] TN1.A2I45
Proceedings. / Illinois Mining Institute.
[3] TN1.A2I68
In situ. v.1- 1977-.
[4] TN1.A2P5
Pit and quarry. v.1- 1916-.
[5] TN1.A2U5
Mineral perspectives. MP-1- ; May 1977 -.
>>> NEXT

[1] TN1.A25
Acta metallurgica. v. 1- Jan. 1953-.
[2] TN1.A5
Transactions. / American Institute of Mining, Metallurgical and Petroleum Engineers. v.1- May 1871-.
[3] TN1.A5 Index
General and analytical index [to] publications of the American Institute of Mining and Metallurgical Engineers. / American Institute of Mining, Metallurgical, and Petroleum Engineers. 1871-1904 - 1926-1935.
Continued in part by: Its. / Cumulative index of mining publications of SME/AIME.
[4] TN1.A502 1936-1968
Cumulative index of mining publications of SME/AIME, 1936-1969. / American Institute of Mining, Metallurgical, and Petroleum Engineers. 1972.
[5] TN1.A51
CRM. / Centre de Recherches Metallurgiques. no. 1- Oct. 1964-.
>>> NEXT

[1] TN1.A513
Journal of metals. v.1- Jan. 1949-.
Absorbed: Mining and metallurgy.
Absorbed: Metals technology.
[2] TN1.A515
Mining and metallurgy. No. 1-29, Jan. 1905 - 1948.
Merged with Metals technology and Journal of petroleum technology and Petroleum technology and Mining engineering and Coal technology and Mining technology to form Journal of metals.
[3] TN1.A5255
Metals technology (ferrous, nonferrous). v.1-15 Jan. 1934-Dec. 1948.

[1] TN1.A527
Symposium series. / American Institute of Mining and Metallurgical Engineers. Institute of Metals Division. v.[1]-. 194e-.
[2] TN1.A56
ASM news. / American Society for Metals. v.1- Jan. 1970-.
Continues: ASM news quarterly.
[3] TN1.A58
A. S. M. review of metal literature. / American society for metals. v.1. 1944-. c1945-.
Merged with Metallurgical Abstracts to form Metals Abstracts. 1967.
[4] TN1.A7
Mining technology. v.51- May 1969-.
Continues: Mining electrical & mechanical engineer.
[5] TN1.A89
The Aus. I.M.M. bulletin. [19__]-.
Continues: Bulletin (Australasian Institute of Mining and Metallurgy).
>>> NEXT

[1] TN1.A892
Proceedings. / Australasian Institute of Mining and Metallurgy. 18__-.
[2] TN1.A934
Journal of the Australasian Institute of Metals. / Australasian Institute of Metals. v. 1-22 May 1956 - 1977.
Continued by: Metals forum.
[3] TN1.A935
Metals forum. v. 1- March 1978-.
Continues: Australasian Institute of Metals. / Journal of the Australasian Institute of Metals.
[4] TN1.C23
CAB.no. 1- Jan. 7, 1977 -.
Continues in part: Review of ceramic technology.
Continues in part: Battelle Memorial Institute. Columbus. Ohio. Metals and Ceramics Information Center. / Newsletter.
Continues in part: Review of metals technology.
[5] TN1.C27
Canadian metallurgical quarterly. v. 1- July/Sept. 1962-.
>>> NEXT

[1] TN1.C3
The Canadian mining journal. 1879-.
Absorbed: Mining in Canada (1964). Nov. 1970.
[2] TN1.C34
Cast metals research journal. v. 1-11 ; June 1965 - 1975.
Continued by: American Foundrymen's Society. / AFS international cast metals journal.
[3] TN1.C35
Special volume. / Canadian Institute of Mining and Metallurgy. 1- 19__.
[4] TN1.C53
Journal. / South African Institute of Mining and Metallurgy. v. 1- ; Feb. 1898 -.
[5] TN1.C6
Coal mining & processing. v.1- Jan. 1964-.
>>> Next

[1] TN1.C63
Coal age. v. 1- ; Oct. 14, 1911-. 1911-.
Absorbed: Colliery engineer. Nov. 1915.

[2] TN1.C69
Coal quarterly. v.1-3, no.1; spring 1962-spring 1966.
[3] TN1.C715
The Coal industry. 19__.
[4] TN1.C717
Earth moving and construction. v. 1- Aug. 1924-.
Merger of Coal industry and Mine electrician.
[5] TN1.C75
Coal and coal trade journal. v.1-68, no.16; Apr. 1869-Sept. 9, 1937.
Absorbed: Coal from the mine to the furnace. May 1926.
>>> Next

[1] TN1.C753
Coal technology. v. 1-3; Feb. 1946-Nov. 1948.
Absorbed by: Mining engineering.
[2] TN1.C76
The Colliery engineer ... 18__-1888.
Absorbed by: Coal age.
[3] TN1.C765
Colliery engineering. v. 1- Mar. 1924-.
Continued by: Mining & minerals engineering.
[4] TN1.C791
The Mines magazine. v. 1- Oct. 1910 -. [1910-33.
Continues: Bulletin of the Technical and Engineering Society of the Colorado School of Mines, published 1900-1910.
[5] TN1.C793
The Compass of Sigma gamma epsilon. 19__.
>>> Next

[1] TN1.C85
Crerar metals abstracts. v. 1- Aug. 1952 -.
[2] TN1.F6
Foote prints. v. 1- 1928 -.
Continues: Mineral Foote-notes.
[3] TN1.H6
Oklahoma geology notes. v. 1- July 1941 -.
[4] TN1.I43
Journal of mines, metals & fuels. Vol. 7, no. 2 (Feb. 1959) -. 1959-].
Absorbed: Indian mining journal.
[5] TN1.I54
Industrial minerals. no. 1- Oct. 1967-.
>>> Next

[1] TN1.I59
Metallurgical abstracts (general and non-ferrous). series 2, v.1-ser.3, v.2. 1934-1967.
[2] TN1.I6
Transactions. / Institution of Mining and Metallurgy, London. 1- 1892-.
[3] TN1.I62
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BIBLIOGRAPHIC FILE

A Partial Bibliography on Diesel Literature

EVALUATION OF DIESEL EQUIPMENT DEPLOYMENT IN UNDERGOUND COAL MINES

Volume II

Diesel Bibliography

Prepared for

The United States Department of the Interior

Bureau of Mines

by

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College of Earth and Mineral Sciences
The Pennsylvania State University

FINAL REPORT

on

USBM Grant No. G0166052

DISCLAIMER NOTICE

The views and conclusions contained in this document are those of the authors and should not be interpreted as necessarily representing the official policies or recommendations of the Interior Department's Bureau of Mines or of the U.S. Government.

I. INTRODUCTION

The industrial hygiene and safety aspects with internal combustion engines in mining systems is truly interdisciplinary and encompasses many fields such as mine ventilation, exhaust gas and particulate analyses, mine atmospheric environment monitoring, mathematical modeling of generation, dilution and dispersion of pollutants in ventilation systems, and engine testing and approval. This bibliography, therefore, is a compilation of references from interdisciplinary sources pertaining to diesels and related areas. Related areas are defined as those concerned with: (i) mine ventilation system design and operation; (ii) description, measurement, modeling and monitoring of mine atmosphere contaminants, and (iii) tests, standards, selection procedures, and operational practices for internal combustion engines in underground mines.

SOURCES OF REFERENCES

Sources of references for this bibliography include reports, papers, technical journals, proceedings of meetings, professional and technical magazines, manufacturers' literature, and monographs. Subjective criteria governed the definition and selection of relevant references to be included. Hence, the bibliography is neither all-inclusive nor does it purport to be an exhaustive search of all sources.

References cited from source materials span the years 1900 to early 1977. Major sources of information were:

Bulletin--The Canadian Institute of Mining and Metallurgy

Environmental Protection Agency (EPA)

Information Circulars--U.S. Bureau of Mines

Journal--Air-Pollution Control Association

Journal--Mine Ventilation Society of South Africa

Journal--South African Institute of Mining and Metallurgy

The Mining Engineer--The Institution of Mining Engineers (London)

National Technical Information Service (NTIS)

Reports of Investigation--U.S. Bureau of Mines

Society of Automotive Engineers (SAE)

Soviet Mining Science (Sov Min Sci)

Transactions--The Society of Mining Engineers of AIME

BIBLIOGRAPHY STRUCTURE

The bibliography is divided into three sections:

A. List of References

B. Author list

C. List of title key-words

References are arranged in an alphabetical order according to senior author's last name. Each reference is assigned a number which is subsequently used to identify a specific reference in the author and key-word lists.

The author list is arranged alphabetically. It includes all authors of a reference, and lists, in ascending order, the number(s) of the reference(s) in which the author name appears.

The key-word from title list is an alphabetically arranged list of selected words, or synonyms of words, from each reference title. Each occurrence of a word or defined synonym in a title is specified by its reference number in ascending numerical order following the key-word. The word list is unique in that the computer program initially compares

each word in a title to a primary list of user-defined stopwords (trivial or frequently appearing words) and then to a user-defined synonym list. The stopword list is restricted to words or character strings less than 12 characters long.

Broad semantical interpretations of words in the list should be applied when searching for references.

FUTURE WORK

This bibliography is the first stage in the production of an information source for diesels in mining. Areas for future work include: (i) modification of data base to include a reference descriptor word list based upon reference major/minor topics rather than title key-word list, (ii) inclusion of reference abstracts or summaries, and (iii) periodic up-dating of data base.

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EXAMPLE

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In the non-technical arena, the *Commerce Business Daily* has daily updates of federal procurement information. The *Federal Register* is abstracted on-line in a data base, and ABI/Inform is a data base full of marketing and management information for all industries. IOD offers a free pamphlet listing these and other data bases.

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documents, whether or not they are from an IOD literature search.

Background

These powerful resources are available to SME members as a result of the recommendation of Working Party #60 (WP #60), John F. Havard, chairman, and Emmett J. Murphy and Robert C. Schenk, members. Charge to the working party was to develop "a long-range SME information system (I/S) plan."

There were two prime recommendations of Working Party #60. First, to provide a total information system to SME members by contracting with Information on Demand, which would provide this service under the name of the Society of Mining Engineers. This program would initiate a useful service without capital investment or financial risk to the society. Second, to investigate and, if practical, start creating a broad base for all SME technical papers.

The working party began its deliberations with an awareness that there was an increasing penetration of electronic data processing (EDP) and information systems into all aspects of the mining industry. A question to be answered was to what extent should SME-AIME become involved, both in conducting its business and in serving its members.

WP #60 obtained and exchanged general information concerning electronic data processing and information systems. Each member discussed these subjects with specialists in his company and with representatives of computer service companies.

The current "electronic information revolution" was given careful consideration. At the time (1981) there were about one million home computers in use, with a forecast of eight million by 1990. Computer searching of "yellow pages" type directories for a specific item appeared to have great potential, with use of computers in the education process being another area of great potential. Although EDP appeared to be the information "revolution" for the 1980s and 1990s, WP #60 concluded that books and publications, the traditional concepts, would survive. Most individuals go to a library to copy something or use reference books. The computer assists this process by finding the reference source, after which a hard copy is used.

The increasing use of home microcomputers, particularly among professional people, was one of the reasons for investigating the possibilities of electronic information. Substantial information retrieval systems do exist and can be immediately used. WP #60 believed that by contracting with IOD it had found a means of providing SME-AIME members with access to hundreds of sophisticated data bases, supplemented by data research.

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To use the service, call the SME-AIME hot line — 415-549-3259 — which will be answered in SME-AIME's name. IOD personnel will interview you to find out exactly what information is needed. They will ask for key words or, if the question is technical, they may ask for some background and explanation to help them put the question in context. You will be asked if you wish to see foreign language materials, the dates that should be covered, and whether a brief or exhaustive literature search is required. A mutually agreeable budget for the project is established and any deadlines are determined. Usual turnaround is between one and two weeks, although special arrangements can be made for faster delivery.

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Advantages

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COAL MINE DUST CONFERENCE
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Morgantown, WV 26506

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RESPIRABLE DUST IN THE MINERAL INDUSTRIES: HEALTH EFFECTS, CHARACTERIZATION AND CONTROL

edited by

Robert L. Frantz
and
Raja V. Ramani

The Pennsylvania State University
University Park, PA

KEYNOTE

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GENERIZATION & CHARACTERIZATION I

HEALTH EFFECTS – CELLULAR RESPONSES

HEALTH EFFECTS — INHALATION STUDIES

CHARACTERIZATION I

GENERIZATION & CHARACTERIZATION II

CHARACTERIZATION II

CONTROL I

CONTROL II

Dissertations

Theses on Research Supported by The Generic Mineral Technology Center for Respirable Dust

Twenty-three (23) M.S. degrees and eleven (11) Ph. D. degrees have been granted as a result of support from the Generic Mineral Technology Center for Respirable Dust. They are listed here under the university where they were earned, The Pennsylvania State University, West Virginia University, and the University of Minnesota. These dissertations contain a wealth of data and represent years of research on respirable dust projects.

As an example of the exacting manner in which these theses have been prepared several excerpts from a doctoral thesis have been included. The literature review chapter and a representative portion of the bibliography illustrate the completeness of the author's investigation.

THE PENNSYLVANIA STATE UNIVERSITY

BHASKAR, R.	M.S. - 1984 - "A Mathematical Model for the Prediction of Ambient Dust Concentrations in Mine Atmospheres"
DUMM, T.	M.S. - 1986 - "An Evaluation of Techniques for Characterizing Respirable Coal Dust"
LEE, C.	Ph.D. - 1986 - "Statistical Analysis of the Size and Elemental Composition of Airborne Coal Mine Dust"
MOORE, M.	M.S. - 1986 - "The Relationship Between Hardgrove Grindability Index and Respirable Dust Generation Potential"
BHASKAR, R.	Ph.D. - 1987 - "Spatial and Temporal Behavior of Dust in Mines -- Theoretical and Experimental Studies"
JOHNSON, C.	M.S. - 1988 - "A Comparative Analysis of Mining - Generated and Laboratory-Generated Respirable Coal Dust"
MOHAL, B.	Ph.D. - 1988 - "Enhancement of the Wettability of Coal Powders Using Surfactants"
QIN, J.	M.S. - 1988 - "Quartz Levels in Airborne Dust in Continuous Mining Sections"
ZIPF, K.	Ph.D. - 1988 - "The Mechanics of Fine Fragment Formation"

WEST VIRGINIA UNIVERSITY

JUNG, S.S.	M.S. - 1984 - "Rock Behavior Under Wedge Penetration"
DIGREGORIO, K.	M.S. - 1985 - "Studies of the Effects of Respirable Dust on Pulmonary Alveolar Macrophages"
HESS, J.	M.S. - 1985 - "Heat and Mass Transfer in a Hazelton Inhalation Chamber"
BAVANI, S.	M.S. - 1986 - "Particle Concentrations in a Hazelton Inhalation Chamber"
DEVILDER, W.	M.S. - 1986 - "Correlation of Fragment Size Distribution and Fracture Surface in Coal Cutting Under Various Conditions"
PISANO, F.	M.S. - 1986 - "Maintaining Constant Mass Concentrations in an Inhalation System"
TSANG, P.	M.S. - 1986 - "Study of Respirable Dust Evaluation Method"
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HURTER, P.	M.S. - 1987 - "An Investigation of the Electrical Phenomenon in Hemolysis of Quartz"
JAFARI, B.	M.S. - 1987 - "Electron Paramagnetic Resonance-Biochemical Studies of Free Radicals in Pneumoconiosis"
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YUAN, S.	M.S. - 1988 "Formulation of Improved Coal Mine Dust Sampling Strategies"

UNIVERSITY OF MINNESOTA

CALDOW, R.	M.S. - 1988 "Performance of the High Yield Technology PM - 100 - Particle Flux Monitor" - Working at T.S.I. St. Paul, Minnesota.
ZHANG, Z.	M.S. - 1988 "The Finite Element Analysis for Large Strains of Incompressable Materials"
FANG, C.P.	Ph.D. - 1988 - "A Fundamental Study of Multi-Nozzle Multi-Orifice Impactors"

LITERATURE ABSTRACTED

An Abstract, Literature Review Chapter and Partial Bibliography

The Pennsylvania State University

The Graduate School

Department of Mineral Engineering

SPATIAL AND TEMPORAL BEHAVIOR OF DUST IN MINES– THEORETICAL AND EXPERIMENTAL STUDIES

A Thesis in

Mining Engineering

by

Ragula Bhaskar

Submitted in Partial Fulfillment
of the Requirements
for the Degree of

Doctor of Philosophy

December 1987

ABSTRACT

The objective of this research was to provide a better understanding of airborne dust flow in mine airways through (1) a review of literature and of a specific mathematical model for predicting dust cloud behavior in mine airways; (2) an in-mine experimental study under controlled and mine operating conditions for generating spatial and temporal data on airborne concentration and deposition of dust in the total and respirable size ranges; and (3) a comparative analysis of model prediction and experimental results for similar conditions.

The mathematical model is a convection-diffusion model incorporating various size-dependent deposition and coagulation mechanisms. The model is solved using a finite-difference scheme.

The experimental studies involved preliminary experiments aimed at development of experimental design, controlled environment studies and experiments conducted under mine operating conditions. The results of the controlled experiments were used to perform a comparative analysis with the prediction of the mathematical model for similar operating conditions. Model assumptions were also evaluated.

The study shows that maximum decrease in dust concentration occurs within a few hundred feet of the source after which the dust concentration assumes an asymptotic form. The experimental data show that the deposition rate per unit concentration increases with increase in airborne concentration. Comparative analysis between the experimental data and mathematical model predictions indicate that deposition is well modeled, and the respirable portion of the model needs additional modeling. The model tends to predict better at lower velocities than at higher velocities. Total size dust is better predicted than respirable dust.

LITERATURE REVIEW

Dust flow in mines has been the subject of research since the recognition of respirable dust as a major health hazard affecting mine workers. The need to develop dust control devices to reduce worker exposure at the face spawned research on dust transport and deposition in the early fifties. The studies were mostly experimental in nature and attempted to use ventilation as the primary dust reduction method. Later studies attempted to determine the role of various mechanisms in determining the ambient dust concentrations. This was followed by empirical studies which attempted to explain the effect of the mechanisms on the basis of experimental results. With the advances in aerosol sciences and the availability of computers, the mechanisms that affect dust flow have been integrated in mathematical models to predict dust concentrations in mine airways.

Studies relating to dust flow in mines can be divided into (a) theoretical studies that attempt to explain the behavior of dust clouds in mine atmospheres, (b) experimental studies which are aimed at developing and testing engineering solutions to dust control problems in mines and (c) experimental studies whose objectives are to understand the role of various mechanisms in dust transport and deposition.

2.1 Theoretical Studies

The number of theoretical studies pertaining to dust flows in mines is rather small. The studies have largely tended to include certain basic relations from aerosol sciences and several empirical relationships to explain mining specific phenomena. A detailed review

of the literature pertaining to the effect of various physical mechanisms on dust flow has been presented in recent publications by the author (Bhaskar and Ramani, 1986; Bhaskar, 1984) and therefore will not be repeated here. Important conclusions from this review are as follows.

1. Considerable theoretical research has been performed in the aerosol sciences while few theoretical studies have been performed in the mining field.
2. Some statistical models, based on data obtained from mines, have been developed for predicting dust concentrations in mines. The models, however, do not have general applicability.
3. There is a need to develop and validate models, based on principles of fine particle behavior under mine airflow conditions for wider applicability.

2.2 Engineering Studies

A number of experimental studies for developing and testing engineering solutions to dust control problems in underground coal mines have been performed in the U.S., especially after the passage of the Coal Mine Health and Safety Act of 1969. The U.S. Bureau of Mines, during the last 18 years has funded several projects in the area of engineering control. Much of the work has been in the following areas: water spray design and location, dust collectors, face ventilation techniques, water infusion, deep cutting techniques, and dust sampling and measurement. The Bureau's research program addressed three areas, 1) control of dust formation, 2) control of airborne dust, and 3) dust measurement. In the area of dust formation, the Bureau's studies showed

the relationship between specific energy needed to cut coal and the quantity of dust produced. It also showed that deep and slow cutting led to lower dust levels, leading to a constant-depth linear cutting miner head, to reduce the amount of coal cut. In the area of control of airborne dust, major efforts centered on the development of high-efficiency mechanical and water-powered dust collectors and improved water spray systems. The impact has been maximum in continuous miner faces with spray fans and the longwall face with the shearer-clearer system. Both these advances considerably reduce operator exposure to dust. The Bureau's efforts to improve dust monitoring instrumentation led to the development of real-time aerosol monitors which are useful in identifying dust sources and in evaluating the effectiveness of dust controls. Recent dust control research in the Bureau is directed towards the quartz content in the respirable dust including the identification of the sources of quartz and its control in airborne dust. An excellent summary of this work has been presented in Breslin and Niewiadomski (1982). Since 1983, work of the Bureau has been concentrated on studies of silica in respirable dust (Jankowski et al., 1986; Kok et al., 1985; Colinet et al., 1985; and Taylor et al., 1986) and dust reduction in longwall faces and to some extent dust deposition. The NAS Committee in its report concluded that the research by the Bureau of Mines to reduce concentrations of respirable coal dust has been effective. The Committee also noted that adoption of existing technology to control dust in mines, while having resulted in good solutions so far, is likely to yield diminishing returns in the future. The Committee reviewed the work of the U.S. Bureau of Mines and its contractors and concluded as follows for future work:

1. Because current sampling technology is adequate for measuring concentrations of respirable coal mine dust for compliance purposes, further research in this area need not be pressed.
2. Variations in the composition and other characteristics of respirable dust from different coal seams should be studied, because it has been demonstrated that factors other than concentration significantly affect the incidence of coal mine workers' pneumoconiosis.
3. Samples of respirable coal mine dust large enough to be characterized chemically, morphologically, and physically should be collected, and some of them stored cryogenically for future reference.
4. Research is needed on the fundamental mechanisms by which fragments are produced in coal mining; how some of these fragments in the respirable size range become airborne; and the spatial and temporal characteristics of respirable coal mine dust atmospheres. The mechanism of fragmentation needs to be understood so that machines can be designed to produce the least amount of coal mine dust in the respirable size range. Entrainment needs to be understood so as to minimize the proportion of the dust that is entrained. The spatial and the temporal characteristics need to be understood so that the exposure of workers to the dust can be controlled.
5. Development of techniques for suppressing respirable coal mine dust near its source and for collecting it in high concentration should be expanded vigorously, particularly in view of the high dust concentrations associated with high production cutting and longwall shearing machines.

6. Many more data relating to noncoal mine respirable dust must be collected and studied before meaningful progress can be made in defining the extent of the health hazard and controlling it in the noncoal sector of the industry.

2.3 Experimental Studies on Airborne Dust Cloud Behavior

The scope of work of this thesis is closely related to the second category of experimental studies (i.e., fundamental experimental studies). The literature reviewed here deals only with studies where some attempt has been made to understand the fundamental mechanisms influencing dust transport and deposition under simulated or actual mine airflow conditions. Hall (1955) has provided a summary of the studies conducted prior to 1954 in this area.

A number of studies have been conducted since the early fifties for determining flow velocities to optimally balance the dilution and the reentrainment effects of increased airflow. Two major efforts are those by Hall (1955) and Hodkinson (1960). Experimental studies by Hall (1955) were directed to evaluate the effect of velocity on dust concentrations with the objective of determining optimal velocities for meeting airborne dust standards. The tests were carried out in special underground tunnels and in several working faces. Tests were also conducted in a drift connecting two shafts. The respirable dust concentrations (particles per cubic centimeter) were determined using thermal precipitators. The dust levels were determined to be minimum in the 1.02 m/s to 1.524 m/s (200-300 fpm) range (Figure 1). Above 1.524 m/s, the results were very erratic and in the higher ranges, the diluting effect of the quantity of air was usually exceeded by the

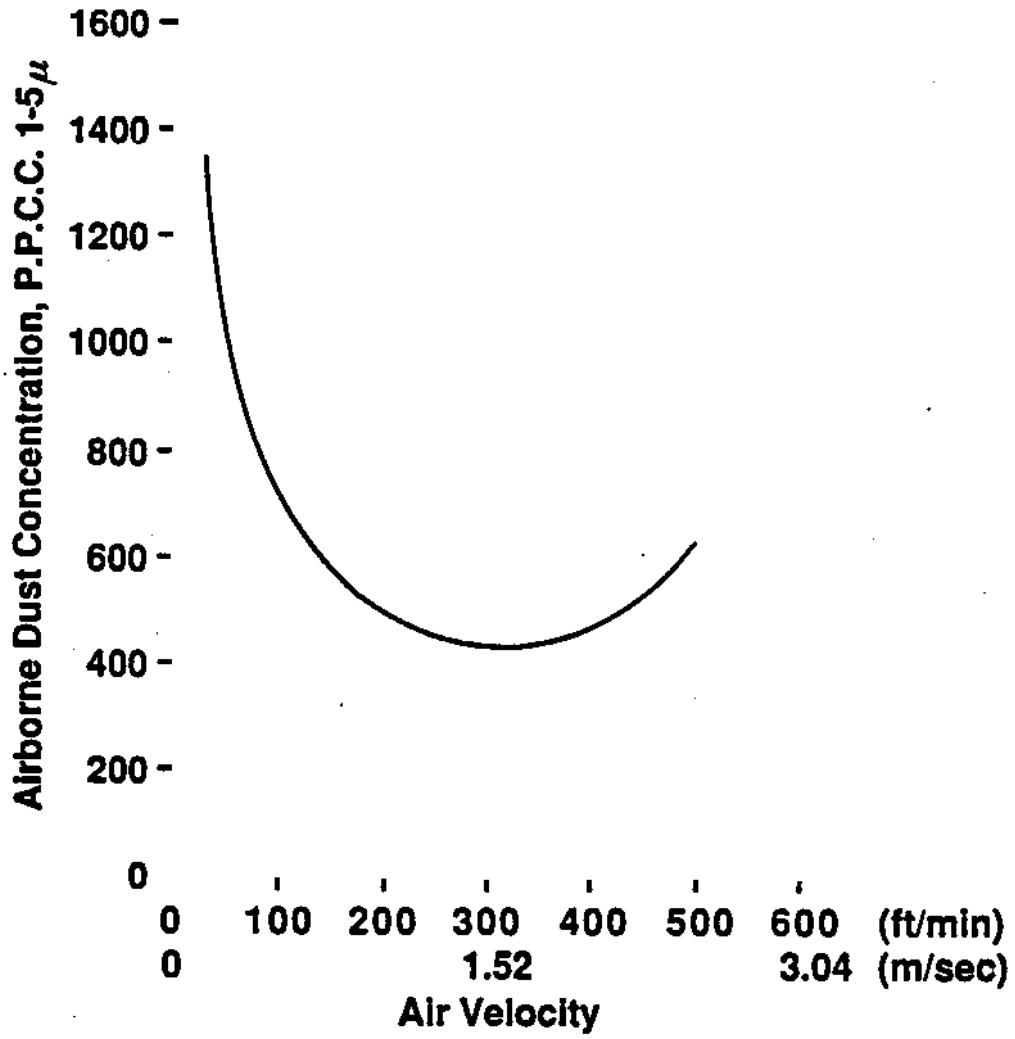

Figure 1. Effect of Velocity on Airborne Dust Concentrations (Hall, 1955).

reentrainment of the deposited dust by the airflow. According to Hall (1955) the threshold velocities for pickup from rough and smooth surfaces are 1.524 m/s and 3.56 m/s, respectively.

Hall (1955) has also presented results of statistical analyses of the dust survey data collected by the National Coal Board. The relationships between (1) the rank of coal and airborne dust conditions, (2) the effects of various dust suppression measures and rank of coal, and (3) the effect of method of mining on dust concentrations in coals of various ranks. The data show that when the inherent moisture is greater than 2%, it has been possible to achieve 100% success in meeting the British regulations on dust levels in effect at that time. The author has presented data (Table 1) which indicate increasing difficulty in wetting coal with increase in rank. The greatest difficulty occurs with coals having an inherent moisture content of less than 1%. The contact angle method was used to measure wettability. Presently, several techniques such as immersion/sink time, induction time and capillary rise methods are used to measure the wettability of coals. Mohal and Chander (1986) have applied these methods to study the wettability of different ranks of coal with and without surfactants.

In terms of suppression wettability is at a minimum for strongly coking coals (Hall, 1955). The most easily wetted coals were found to be low-rank lignites, while the least readily wetted were high-rank bituminous coals, with anthracite in between. The studies were carried out with coal of size greater than 2 μm. It has been shown in recent studies that wettability is a function of several factors, especially particle surfaces properties (Mohal and Chander, 1986).

Table 1. Effect of Coal Rank on Wettability.

Coal Rank and Source			% Carbon (dry ash free)	Contact Angles
100	(Anthracite)	South Wales	>93	43
200	(Carbonaceous)	South Wales	92	47
301	" "	South Wales	89	60
402	" "	West Yorkshire	86	57
802	" "	East Midlands	82	27
902	" "	Midlands	80	10
	Lignite	Devon	<75	0

It was also found by Hall (1955) that as the height of the seam increased, the number of faces in compliance with the then British regulations increased. For workings with heights between 0.3 and 2.1 meters, only 11.7% were in compliance while for seams higher than 2.1 m, 100% of the faces were in compliance.

Dust reentrainment studies were conducted by Hodkinson (1960) in laboratory wind tunnels. Hodkinson studied the effect of velocity on dust which was (1) spread flat on a horizontal surface, (2) heaped on the floor and (3) mechanically agitated. Also, he dropped the coal dust as a stream into the airstream and determined the entrainment of the dust in the airstream. The entrainment for mechanically agitated dust was appreciable at a threshold velocity between 1.524 m/s to 2.032 m/s. However, a velocity of more than 5.08 m/s was needed to generate appreciable airborne dust concentrations from undisturbed deposits. In all the experiments, the size distribution of the airborne dust did not vary with flow velocity.

Experiments to determine deposition of dust in mine airway surfaces were conducted by Bradshaw and Godbert (1954), Bradshaw, Godbert and Leach (1954), Dawes and Slack (1954), Ford (1971), Reinhardt (1972) and Courtney, Kost and Colinet (1982) and Colinet, Shirey and Kost (1985). The studies examined deposition from either explosion hazard or worker exposure points of view.

Bradshaw and Godbert (1954) measured deposition in return airways at various heights across the roadway cross-section. The height of the test section was 1.83 meters. The dust collected on trays held horizontally but close to the sides and roof was considered as the amount of side and roof deposition. In effect, their data gives an idea of the concentration at various points in a cross-section rather than

deposition on the sides or roof. Sample collection time varied from a few days for samples close to the face to a week for samples further downstream. Variations in the deposition along the road were also measured. On a semi-log graph, the deposition of each of the dusts (coal and shale) fell linearly with distance after about 22 meters from the face, i.e., beyond this distance the decay in the deposition was exponential with distance (Figure 2). Near the face, the deposition was less regular, either increasing or decreasing with distance faster than further away from the face. The authors also determined the ash content of the coal which did not vary more than 5% for 365 meters from the face.

Bradshaw, Godbert and Leach (1954) studied three aspects: (1) dust deposition on the surfaces of the roadway, (2) dust deposition on the conveyor structure from the top belt and on the floor from the bottom belt, and (3) dust carried by the load on the belt. There was, in general, an exponential decrease in deposition close to the source. Considerable fluctuation was obtained for deposition beneath the conveyors, though in general, dust deposition decreased with distance from the loading point.

Relationships between the airborne concentration of coal dust and deposition on the floor, roof and sides were determined by Dawes and Slack (1954) in an experimental laboratory wind tunnel and in mine airways. Glass slides were used to measure deposition while thermal precipitators were used for determining airborne concentration. The authors showed a dependence of concentration on particle size and also noted a linear relation between airborne concentration with distance from the source when using number concentrations. Side and roof

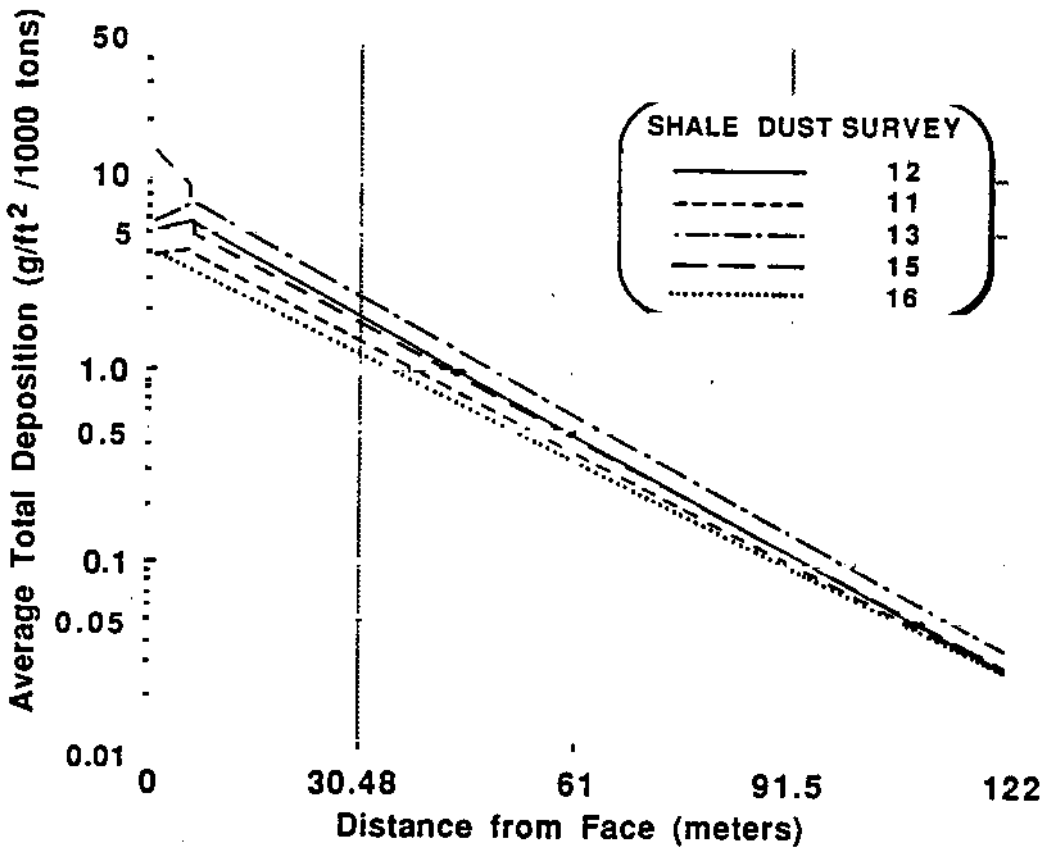

Figure 2. Variation of Dust Deposition Along Return Airways (After Bradshaw and Godbert, 1954).

depositions were obtained using microscopic slides coated with petroleum jelly. The use of jelly alters the characteristics of the deposition surfaces and is not therefore representative of the actual roadway deposition. The authors have stated that there were no significant differences between the depositions obtained on clean and sticky surfaces.

Studies by Reinhardt (1971) examined deposition and distribution of suspended dust in a roadway cross-section and its behavior in the direction of flow. Tests were conducted in both experimental wind tunnels and operating longwall mines. The author concluded that fine dust concentration generally levels out at a shorter distance than coarse dust, with airspeed not playing any role in the leveling out of the dust at Reynolds numbers commonly encountered in mines. The greatest reduction occurred within the first ten hydraulic diameters. The author noted that the distribution of dust over the cross-section by concentration and composition was governed by airspeed; other conditions such as intersections, and initial dust concentration had no recognizable influence.

The effect of varying ventilation air quantities on respirable dust concentration and deposition in a longwall section, both at the face and in the intake and return airways were determined by Ford (1971). To obtain an idea of the effect of particle size on deposition rate, measurements were made using both stone and fluorescein dusts dispersed into the ventilating air. Two types of MRE gravimetric samplers with different elutriators were used for measurements. The size cutoff for each instrument was different. One was at 7.1 μm and the other at 14.2 μm. The coarseness of the samples were determined by taking the ratio

of concentration measured by the two instruments. The closer the ratio was to unity, the finer was the dust. The tests showed that 35% of the intake dust settled along the face, with a further 25% reduction occurring around the face end. The deposition was estimated for a single air velocity. A tracer dust cloud of sodium fluorescein spheres in the respirable range was used to determine deposition in the intake and return airways. Depositions between 24-70% when using sodium fluorescein particles occurred between the intake and return airways, the experiments being conducted in advancing and retreating faces (Figure 3). Reduction of up to 30% in 300 m for intakes and 20% in 100 m were noticed in the returns. Dust deposition was calculated from the reduction in concentration between the stations.

Courtney et al. (1982) conducted studies in eight operating mines to determine the amount of airborne coal dust, size distribution and deposition. The authors also conducted a study using a trickle duster to generate source dust and measured floor deposition. Andersen cascade impactors were used to measure airborne concentration. The study represents an extensive effort to measure dust concentrations in mines. The results showed considerable deposition in the first fifty feet compared to the other parts of the airways (Figure 4). The authors noted an apparent independence of dust deposition rate from the size of the airborne particles and attributed this to a possible well stirred dust cloud.

Experiments on dispersion of dust in a mine airway have been conducted since the fifties. Taylor (1954) developed a general formula for dispersion using brine injections in a pipe. Several mine related studies have been conducted by Hodkinson (1957, 1959). In his 1957

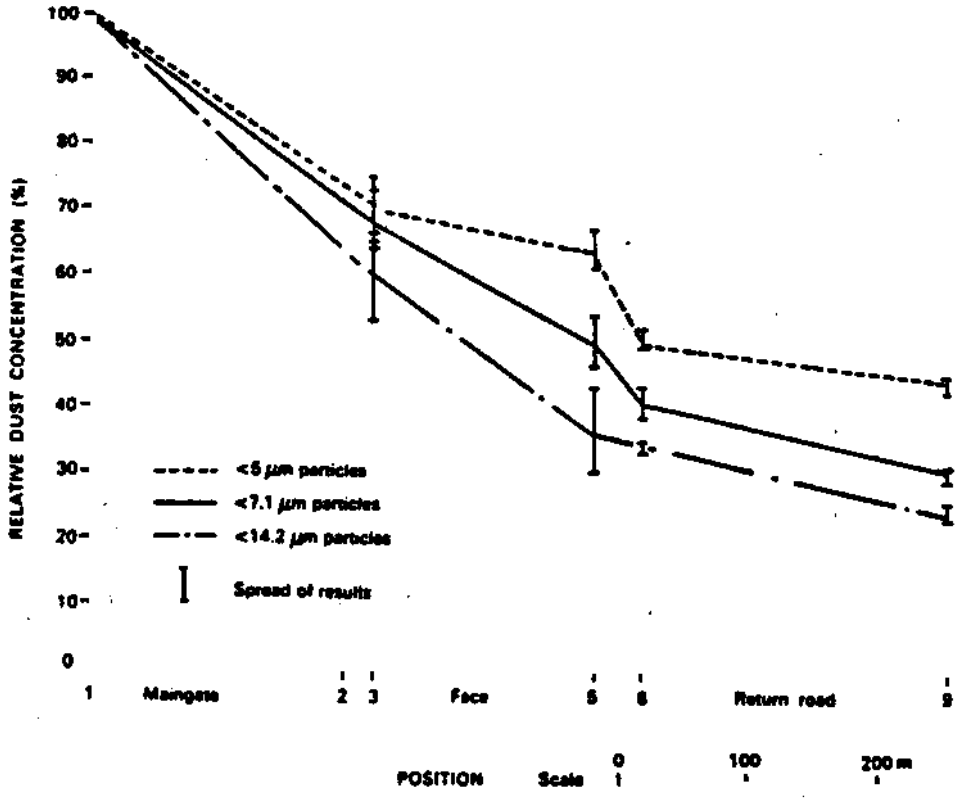

Figure 3. Relative Concentration in Longwall Section (Ford, 1976).

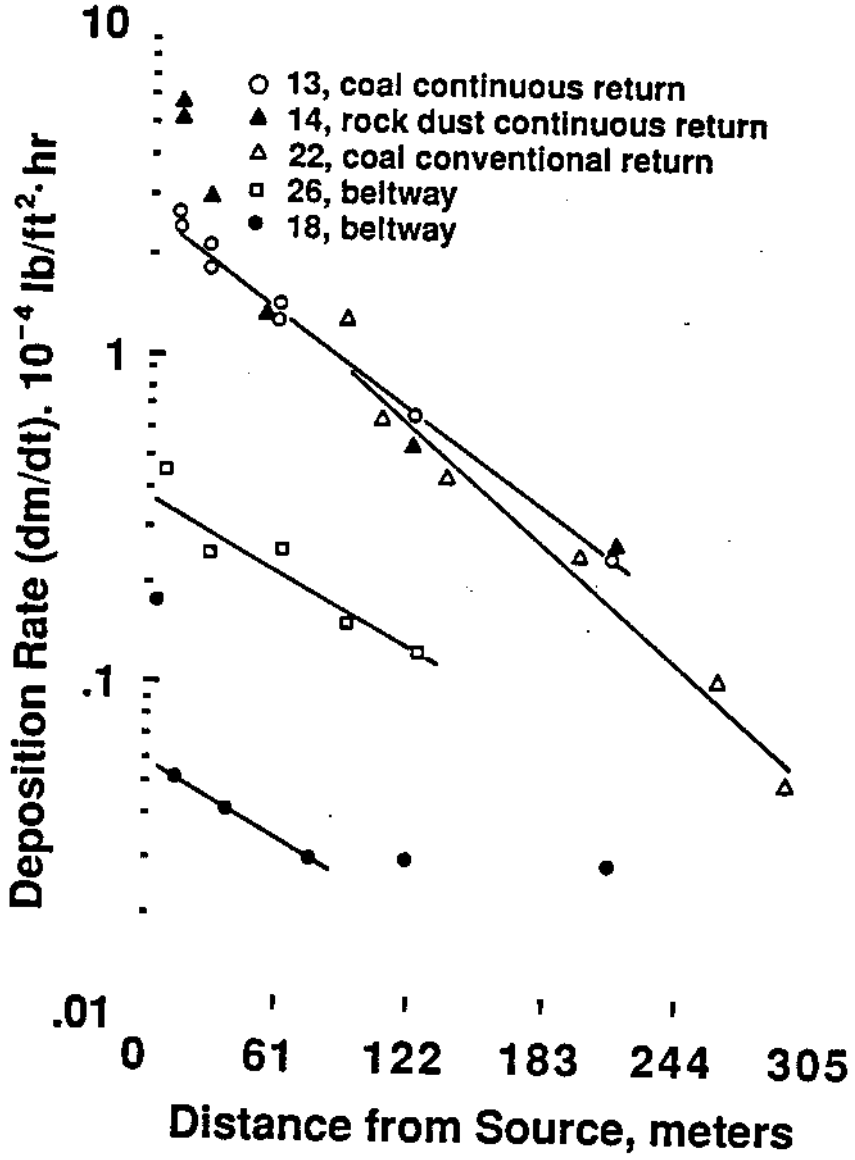

Figure 4. Deposition Along Mine Airway (Courtney, et al., 1982).

paper, Hodkinson stated that since respirable dust particles follow the turbulent motion of the ventilating air more closely, tracer gas can be used in experiments to determine dust dispersion rates in mines. Several studies were performed in Russia in the seventies (Airuni and Skobunov, 1974; Skobunov, 1970, and 1973; Klebanov and Martynyuk, 1974; and Laigna and Potter, 1983). Skobunov (1973) used the experimental data obtained from several studies to propose the following relationship for the longitudinal dispersion coefficient E_x given by

$$E_x = 15.8UDSc_i^{-0.6} Sc_t \sqrt{\lambda/\lambda_r} \qquad (1)$$

where,

U - stream velocity

D - hydraulic diameter

Sc_i - molecular Schmidt Number

Sc_t - turbulent Schmidt Number

λ - Darcy's coefficient of friction for smooth airways

λ_r - Darcy's coefficient of friction for rough airways

This relationship is used in the convection-diffusion model developed by Bhaskar (1984). Klebanov and Martynyuk (1974) describe several methods to experimentally determine the coefficient of turbulent diffusion. Two relevant methods, one for instantaneous entry of gas and another for a finite release time are described in Chapter 4.

2.4 Summary

The literature survey indicates that some work has been done on the subject of optimal flow velocities and deposition of dust. In studies relating to optimal flow velocities, the experiments were conducted under varying experimental conditions, with more than one parameter differing from study to study. As such, the optimal flow velocities

suggested by the studies vary considerably. However, these studies provide useful qualitative data. Studies pertaining to deposition suffer from similar experimental situations and the results are situation specific. The studies did not establish general relationships that could be used independent of location. The need exists to design and perform a set of experiments aimed at providing a better understanding of dust flows in mine airways. The experiments need to be designed so that some of the drawbacks of the reported studies are avoided and better relationships between the various mechanisms affecting dust flow and ambient concentration are established. Three factors that are considered as important to the present study are:

(1) recent advances in aerosol sciences that have contributed to a better understanding of aerosol behavior,

(2) development of instruments such as the Microtrac Small Particle Analyzer and Real-time Aerosol Monitors (RAM-1) and associated dataloggers which improve considerably the quality of data obtained as well as the speed with which the data can be analyzed, and

(3) availability of the Lake Lynn facility of the U.S. Bureau of Mines where the studies were conducted. The complete control over important parameters enabled better data collection.

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EQUIPMENT AND FACILITIES

EQUIPMENT AND FACILITIES **Chapter 10**

INTRODUCTION

Many of the facilities and much of the equipment available to the Generic Mineral Technology Center for Respirable Dust are highly specialized and therefore, unique to the universities associated with the Center as illustrated in FIGURES 30 through 39.

For example, a sample bank of 1300 U.S. coal specimens housed in the Coal Research Section, Deike Building of The Pennsylvania State University has been characterized for physical, elemental, mineralogical and maceral compositions. The results of this research have been used to initiate a study of the relationship between pneumoconioses and coal properties. Selected samples from this bank have been used in animal (primate) studies at the Milton S. Hershey (Penn State) and West Virginia University Medical Centers. These laboratory facilities for research in the medical and biological disciplines is state-of-the-art and includes a primate colony where dust research is currently underway. The Materials Research Laboratory and the Rock Mechanics Laboratory at PSU, and the Mechanical Systems Design and Control Laboratory, the Rock Mechanics Laboratory and the Mine Electronic System Laboratory at WVU are equipped for fundamental research on dust generation and

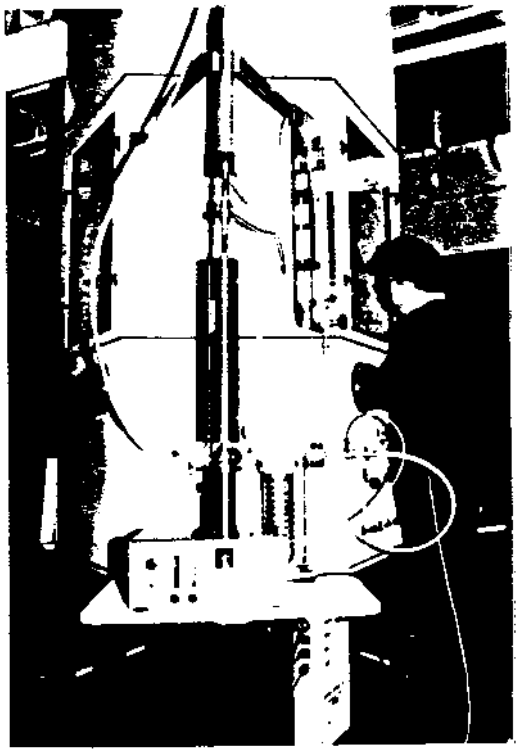


FIGURE 30 Elpram Systems Inc. aerosol test chamber and auxilliary equipment in use at Penn State.

characterization. While the majority of respirable dust research projects fall into these two categories, dust generation and characterization and interaction of dust and lung, there are other laboratory facilities available to the Center which are unparalleled in the type of equipment and expert personnel that they contribute to the

program. The Mine Particle Laboratory located at the University of Minnesota and the Diesel Engine Laboratory at Michigan Technological University are examples. They house equipment and instrumentation that is unique to these facilities, much of it having been developed specifically for dust research by the research scientists there. The dust collection equipment and the fine particles measurement, characterization and analysis apparatus are essential to research in the areas of dust collection, particle characterization and diesel particulates. In addition to university laboratories, the research facilities of the National Institute for Occupational Safety and Health (NIOSH) are available to the Center through its relationship with West Virginia University.

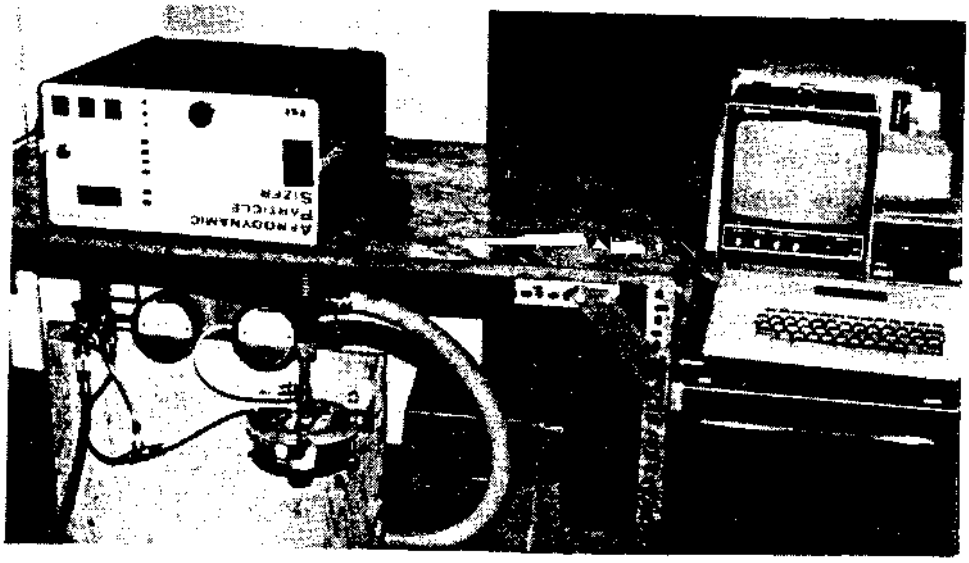


FIGURE 31 The aerodynamic particle sizer system at the University of Minnesota.
Dust Dispersion/Aerodynamic Particle Sizer (DAPS)
The aerodynamic particle sizer (APS) is an instrument recently developed by TSI Inc. to measure the aerodynamic particle size of aerosol particles. The major problem with the instrument being used in the mine is that it is quite large, heavy and not permissible.Therefore, it is necessary of develop a technique by which dust can be brought from the mine to the APS for analysis. To accomplish this, a device has to be developed to redisperse particles from a filter and introduce them into the APS so that particles could be collected out of the mines face on a filter, transported to the surface or laboratory, and analyzed by the DAP system.

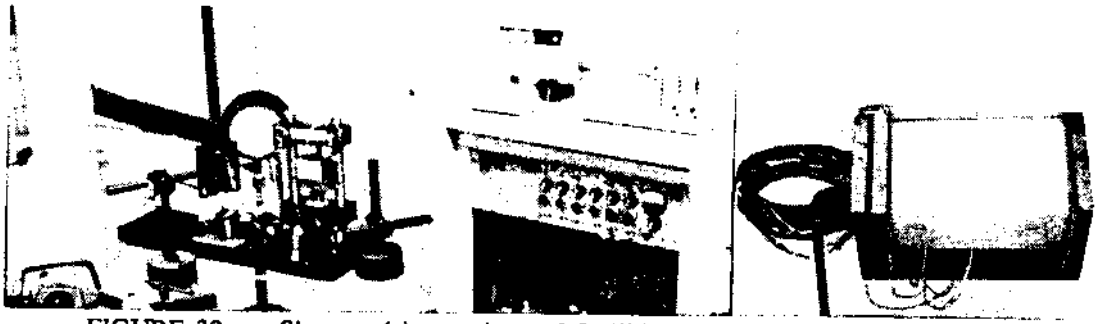


FIGURE 32 Shows: (a) experimental facilities; (b) confining chamber at West Virginia University.

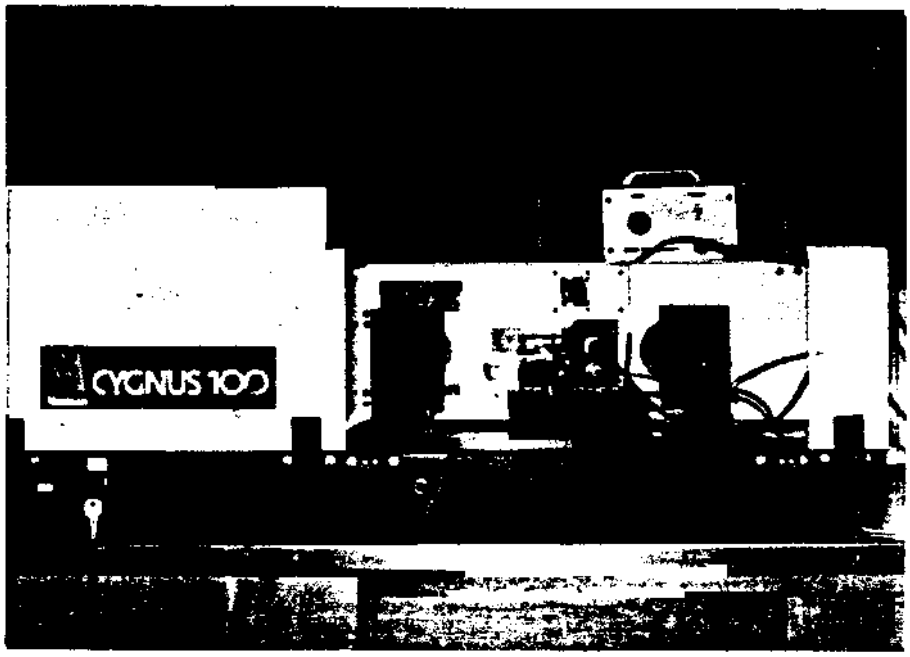


FIGURE 33 Photograph of the Cygnus 100 (Mauson Instruments) FTIR/Photoacoustic Spectrometer.

FIGURE 34 Test and monitoring facilities for dynamic indentation in use at West Virginia University.

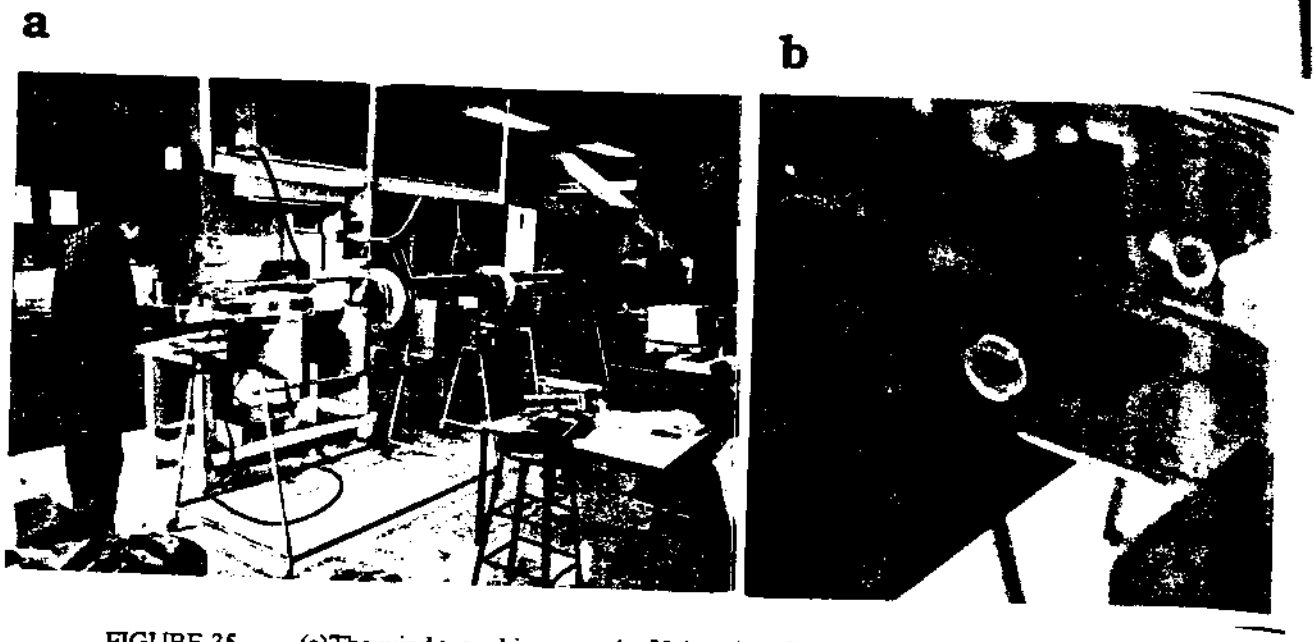


FIGURE 35 (a)The wind tunnel in use at the University of Minnesota.
(b)Detail of the wind tunnel.

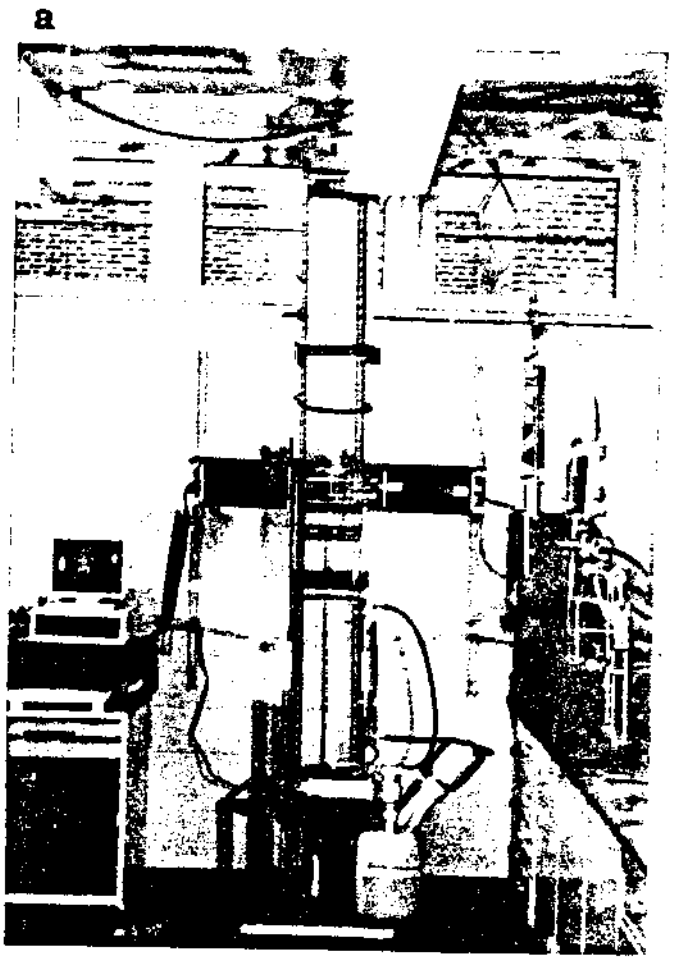
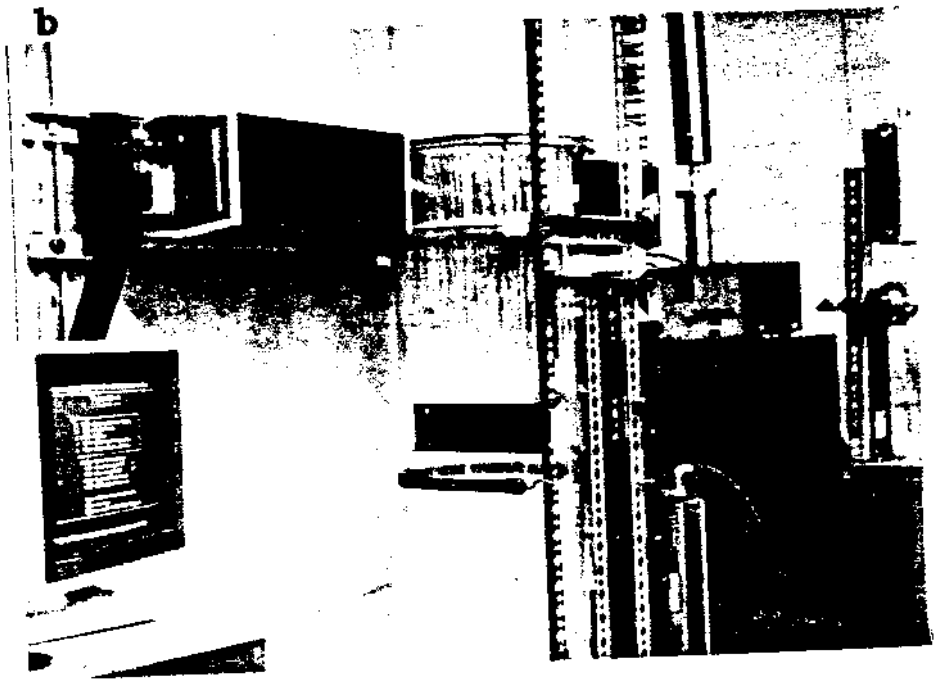


FIGURE 37 (a)The dust chamber equipped with water spray in use at The Pennsylvania State University.
(b)Shows detail of the particle/droplet sixe measurement system.



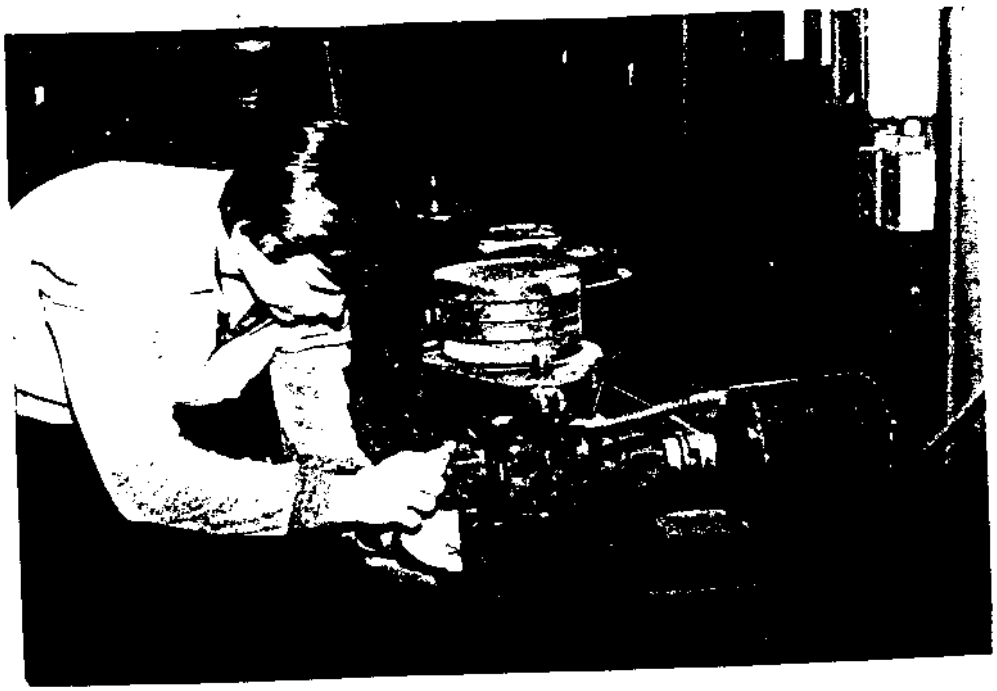


FIGURE 38 Hardgrove grinding index (HGI) device for determining grindability of different rank coals in use at The Pennsylvania State University.

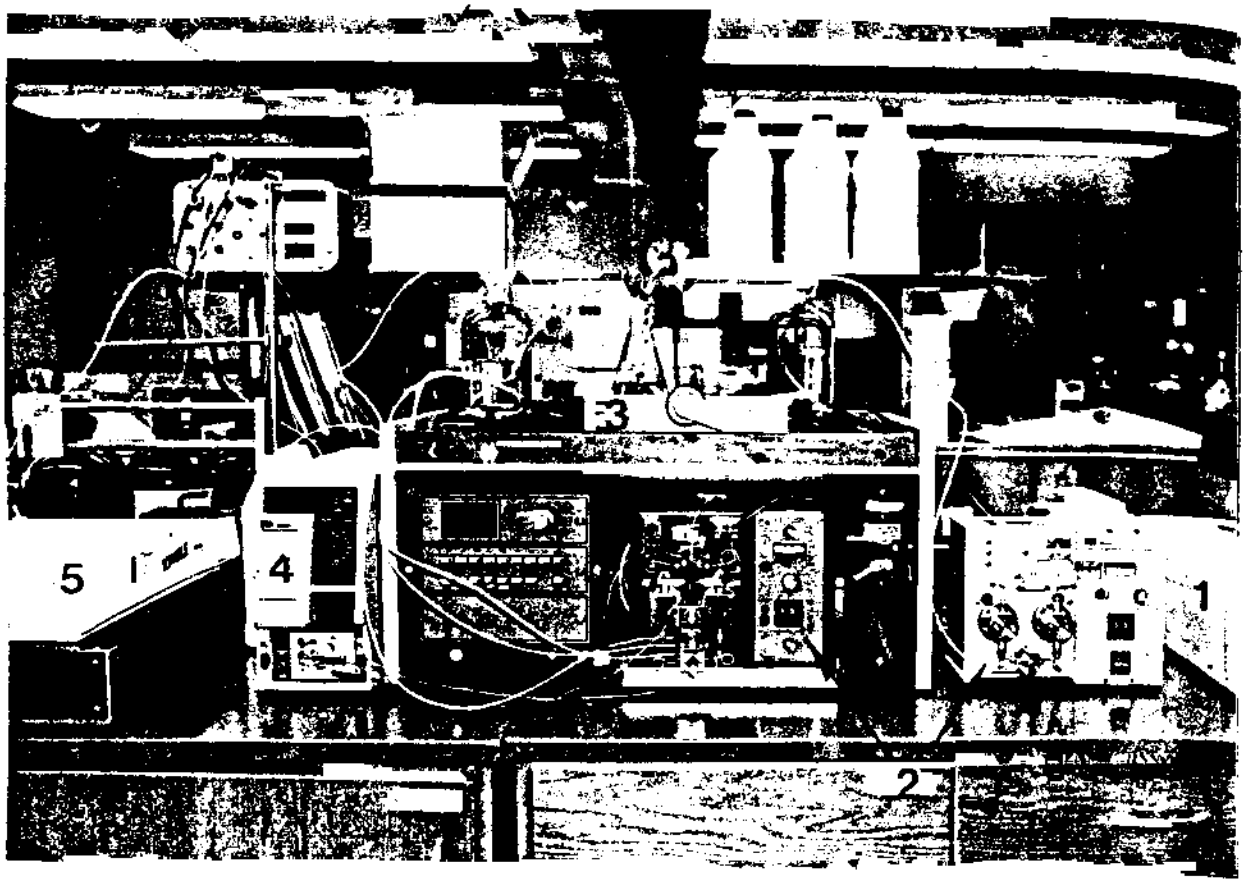


FIGURE 39 High performance liquid chromatography system for the separation and identification of arachidonic acid metabolites in normal and dust -exposed alveolar macrophages. Components include system controller (#1), pumps (#2), separating column (#3), U.V. detector (#4), and fraction collector (#5) in use at the Hershey Medical Center (PSU).

KEY LABORATORIES, FACILITIES AND PROBLEMATIC RELATIONSHIPS

Laboratory	Major Equipment and Facilities	Relationship to Problematic Research
The Pennsylvania State University		
Rock Mechanics Laboratory, Deike Building, University Park	Most modern testing equipment for material properties and for studying fracture mechanics	Control of dust generation
Coal Research Section, Deike Building, University Park	Up-to-date, largest and best-equipped coal petrology laboratory houses the Penn State Coal Data Bank	Coal seam characteristics
Particle Technology Laboratory, Steidle Building, University Park	Outstanding laboratory facility for fine particle characterization	Dust particle characterization
Mine Ventiliation Laboratory, Steidle Building, University Park	In-place tunnels, fans, and monitoring equipment	Dilution and dispersal of dust
Materials Research Laboratory, University Park	Internationally recognized facility for preparation, characterization and studying properties of minerals/materials	Dust character-ization, particle characterization
Center for Air Environment Studies, University Park	Equipment and facilities to study the effects of toxic and other pollutants	Interaction of dust and lungs
Computation Center, University Park	Access to IBM 370/3081 computer processor complex, several micro and mini-computers	Mathematical modeling, computer simulation, data analysis and synthesis
Laboratory of Experimental Pathology, Hershey Medical Center	Fully equipped for cell and tissue cultures, immunofluorescence, radioisotopic studies and experiments in laboratory animals: primate center	Study of dust-lung interrelationships in living cells

Laboratory	Major Equipment and Facilities	Relationship to Problematic Research
West Virginia University		
In vivo Microscopy Laboratory WVU Medical Center, Morgantown	Uniquely equipped for study of biological events in living cells, tissues and organs. Full support equipment includes TV monitors, high speed cameras, and cinema photography. Analyzes insity processes, including uptake of particles by cells and blood flow.	Dust-lung interaction
Pulmonary Function Laboratory WVU Medical Center, Morgantown	Fully equipped for human subjects. Complete bronchoscopy suite for performing fiberoptic bronchiscopes, equipment for local anesthesia and specimen collecting apparatus.	Dust-lung interaction
ENT Laboratory WVU Medical Center, Morgantown	Viral and tissue culture laboratory with special equipment and staff experienced in isolating, culturing and indentifying viruses from human tissues.	Dust-lung interaction
Biochemistry Section of WVU Hospital-Clinical Laboratories, Morgantown	Special equipment and experience with digestive enzymes that are important in the destruction of lung tissue.	Dust-lung interaction
Multiphase Flow Laboratory Engineering Sciences Building, Morgantown	Capabilities for measuring solid deposition on probes and dynamics of spherical and non-spherical particles in air and liquid flows.	Dilution and dispersal of dust
Mechanical Systems Design and Control Laboratory Engineering Sciences Building, Morgantown	Capabilities to strength evaluate materials as well as to vibrationally test and dynamically balance components. Particular capabilities include a low cycle hydraulic system and a sine-random shaker system.	Control of dust generation
Industrial Hygiene Laboratory Engineering Sciences Building, Morgantown	Provides for user training and equipment for gathering data in the field including mines. Portable equipment for dust, gases, ventilation, noise, lighting and ergonomics parameters. Under direction of Certified Industrial Hygienist.	Coal seam characterization

EQUIPMENT AND FACILITIES

Laboratory	Major Equipment and Facilities	Relationship to Problematic Research
Mining Engineering Computer Laboratory White Hall, Morgantown	Special computer facilities including graphics, personal computers and terminalswith stand alone and network access capabilities for exclusive use of mining engineering students and faculty.	General support to all areas
Rock Mechanics Laboratory White Hall, Morgantown	Capability to perform state-of-the-art and all routine physical tests on coal.	Control of dust generation
Mine Ventilation Laboratory White Hall, Morgantown	Physical models for a variety of mine conditions with ability to measure and control ventilation parameters. Full scale model for study of mine ventilation fans.	Dilution and dispersion of dust
Health and Safety Laboratory White Hall, Morgantown	Routine equipment for measuring respirable dust, methane, noise, etc. Special chambers for dust methane explosion studies.	Dilution and dispersion of dust; Seam correlation study
Magnetic Resonance Laboratory Chemistry Annex, Morgantown	Microwave and Radiofrequency Spectro -meters for characterization of Metallic and Free Radical Moieties in Coal Dust and Lung Tissue. ENDOR measurements can be performed in liquid and solid phases at temperatures from -196 to 800°C.	Major in dust-lung interaction and coal seam characterization
Mine Electronic System Laboratory Engineering Sciences Building, Morgantown	Wide range of state-of-the-art sensing, signal processing and electronic control design and construction capabilities. Staff with extensive experience in coal/ non-coal mine applications.	Control of dust generation
Coal Research Bureau WV Geological Survey White Hall, Morgantown	Wide range of coal, mineral and related analytical capabilities with high through-put capacity. Available for general support for overall program.	Characterization - general support to all areas
Mossbauer Laboratory Hodges Hall, Morgantown	Equipment and staff with state-of-the-art capability in use of nuclear gamma-resonance and extended x-ray adsorption fine structure (EXFAS) in coal and minerals and dust-lung interactions. Through this research team, access also available to Brookhaven synchrotron for high resolution and selectivity EXFAS measurements.	Characterization - dust-lung interaction

Laboratory	Major Equipment and Facilities	Relationship to Problematic Research
Inhalation Exposure Facility Agriculture Sciences Building, Morgantown	Unique facility with special chambers for exposing small animals to a controlled environment including respirable particulates. Developed through the close cooperation of NIOSH and DOE, this facility is ideally suited for modification to meet the small animal needs of the proposed program.	Dust-lung interaction
University of Minnesota		
Particle Technology Laboratory Mechanical Engineering, Minneapolis	Most modern aerosol and dust generation and analyzing instruments plus a dust chamber and an image analyzer	Characterization of dust particles
Mechanical Engineering Computer Center Mechanical Engineering Building, Minneapolis	Digital Equipment VAX 780 Computer systems	Numerical modeling of air flows and particle trajectories in aerosol
University of Minnesota Computer Center, Minneapolis	Cray 1, CDC Cyber 720, plus other computer systems	Mathematical modeling
Engine Emission Test Laboratory Mechanical Engineering Building, Minneapolis	Several gas and diesel engines plus latest instruments to analyze particles and gases	Generation of diesel particulates for test purposes
NSF Regional Instrumentation Facility for Surface Analysis, Minneapolis	Several types of electron microscopes and modern complement of surface analysis instruments	Characterization of dust particles

Laboratory	Major Equipment and Facilities	Relationship to Problematic Research
Massachusetts Institute of Technology		
Center for Materials Materials Science and Engineering, Cambridge	Scanning electron microscopes, scanning Auger spectrometer, electron microprobe, and x-ray diffraction equipment	General support for dust characterization and dust generation activities
Materials Processing Center, Cambridge	Equipment for mineral processing and characterization	Particle processing and characterization capability
Michigan Technological University		
Underground Experimental Mine, Houghton	Instrumentation for carrying out mine air pollutant monitoring studies	Characterization and control of mine air pollutants
Diesel Engine Laboratory, Houghton	Extensive analytical instrumentation for physical, chemical and biological characterization of diesel exhaust	Characterization and control of diesel exhaust particulates